A Comprehensive Diabetes Monitoring Device Design for Enhanced Health Management

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ABSTRACT
Diabetes mellitus (DM) is a prevalent global health concern, necessitating effective monitoring and management solutions. This study introduces a novel Comprehensive Diabetes Monitoring Device (CDMD) and a dietary monitoring device, designed to enhance health management for individuals with diabetes and those seeking to improve their dietary habits. The CDMD integrates continuous glucose monitoring with personalized health insights and activity tracking, providing real-time data for informed health decisions. Similarly, the dietary monitoring device aims to simplify the process of dietary monitoring, allowing users to effortlessly track their food intake and make informed decisions based on consumption data. Both devices prioritize user-friendliness and portability, aiming to seamlessly integrate into users' daily lives and enhance their overall quality of life. Through thorough analysis using triangulation methods; readings, user and experts feedback, and the application of Feldman's theory of product appreciation as an analysis, these devices present promising solutions to current monitoring challenges while enhancing health management efforts. By incorporating Feldman's four-step framework—description, analysis, interpretation, and evaluation—the design process effectively refines the value of design concepts. This approach ensures that the CDMD are not only functional but also align with user needs and aesthetic considerations, offering a well-rounded and user-centered solution to modern health monitoring challenges.

1. Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder that presents a significant global health challenge, particularly in regions with a high prevalence of the disease. (27) Effective management of diabetes requires a multifaceted approach that includes regular monitoring of blood glucose levels, lifestyle modifications, and adherence to medication regimens. (8)(9)(28) In response to the growing need for innovative solutions to improve diabetes management, this project aims to introduce an innovative product design purposely for a CDMD which is designed to enhance health management for individuals with diabetes.

(a) (b)

Fig-1: An example of existing product CDMD. (a) One Touch Ultra Plus Flex (b): Dexcom G6 CGM System

The motivation for this project stems from the limitations of existing diabetes monitoring devices, as suggested by (29) that it lack of integration of key health parameters and fail to provide continuous real-time data (3) as shown in Fig. 1. The CDMD seeks to address these limitations by incorporating advanced technology to continuously monitor glucose levels while also providing features such as physical activity tracking and personalized health insights. (2) By offering a comprehensive approach to diabetes management, the device aims to empower individuals with diabetes to take control of their health and make informed decisions about their care. (11)

In this research and development, will presents the rationale, development process, and potential impact of the new outlook of CDMD. The research begins by discussing the prevalence and significance of diabetes as a global health concern, highlighting the need for innovative solutions to improve disease management. (2) Subsequent sections of the research and development delve into the technical background, design considerations, and evaluation processes that shaped the development of the device. Additionally, it discusses the implications of findings and the broader significance of the CDMD in the realm of health management.

Overall, this research and development serves as a platform to communicate the efforts undertaken to develop the CDMD and its potential to revolutionize diabetes management. By introducing a newly design that goes beyond traditional glucose monitoring gadgets, (9) it aims to contribute to improving health outcomes for individuals with diabetes and ultimately enhance their overall quality of life.

The design and functionality of existing diabetes monitoring devices present several challenges that hinder effective health management for individuals with diabetes. (1) Firstly, most of the existing devices lack a user-friendly interface and employ complicated data entry methods, making it difficult for users to accurately input their dietary information. (6) This complication may result in users' frustration, potentially undermining their commitment to consistently monitor their dietary habits. (12) Secondly, current devices frequently lack the capability to deliver clear and actionable insights regarding users' dietary and nutritional habits, resulting in ambiguity in interpreting the collected data. (13) The absence of proper guidance hinders individuals from making well-informed decisions and necessary adjustments to their dietary habits, which can impact their overall health and well-being. (14) Finally, the lack of portable diet monitoring devices presents a major obstacle for frequent travelers, making it difficult for them to monitor their nutrient intake while on the move. (12) This highlights the necessity for a CDMD that resolves these design challenges by providing a user-friendly interface, clear insights, (15) and portable functionality, (16) thereby improving health management for individuals with diabetes.

2. Research Methodology

In obtaining the latest and critical information pertaining to the research, all information and data collection was carried out according to the processes of combining three research methodologies; literature review, observations, and interviews.

As a part of research, triangulation strengthen the credibility and reliability of this research by using multiple methods to confirm findings across different data sources. This to ensures results are not just influenced by one method or observer. (17) By examining various aspects of a topic, it provides a well-rounded understanding of complex issues and offers deeper insights into human behaviour. (17) It also minimizes the weaknesses of individual methods, reducing biases and improving the consistency of findings. As suggest by Vivek, any conflicting data arise, triangulation will encourage further investigation, helping to refine assumptions and hypotheses. (18)

3. Literature Review

The literature review was conducted by consulting trusted sources, including books, magazines, and journals. Additionally, internet sources were utilized by referring to research-relevant websites. This review compiled information on diabetes monitoring devices, focusing on their comprehensiveness

and impact on health management. (19) (20) Technological advancements in this field were also explored, with particular emphasis on user experiences and clinical outcomes associated with comprehensive diabetes monitoring.

Existing research underscores the significance of user-friendly interfaces and advanced data tracking capabilities in diabetes monitoring devices. (22) Studies have also highlighted the potential benefits of these devices in enhancing overall health management for individuals with diabetes, such as improved glycaemic control, better adherence to treatment plans, (7) and an enhanced quality of life. (23) Overall, the literature review offers valuable insights into the efficacy, usability, and potential benefits of advanced monitoring devices for individuals with diabetes. (20) (24) By synthesizing existing studies and technological advancements, this comprehensive approach contributes to a deeper understanding of how diabetes monitoring devices can positively impact health management outcomes.

Direct Observations

The direct observation method plays a pivotal role in the data collection process for understanding the current landscape (26) especially for diabetes monitoring devices. This approach involves systematically examining various products available in the market, focusing on their physical appearance, features, user interface, and overall functionality. (25) Through direct observation, valuable insights into the strengths, weaknesses, and opportunities for improvement of existing products can be gleaned. (21) Furthermore, analyzing users' interactions and experiences with these devices provides invaluable feedback for informing the design and development (10) of a CDMD. By employing this method, the understanding of existing solutions is achieved, thereby facilitating the enhancement of usability, functionality, and overall effectiveness (30) of the new monitoring device.

Interviews

Conducting structured interviews with individuals living with diabetes, healthcare professionals, and stakeholders provides valuable qualitative data essential for the development of a CDMD. Utilizing open-ended questions, participants are encouraged to share their experiences with current monitoring devices, elucidate the challenges they encounter, and propose essential features they believe are necessary. These interviews offer insights into user expectations, satisfaction levels, (5) and potential areas for innovation. (31)(32) The qualitative data gathered from these interviews serve as a foundation for the development process, ensuring that the resulting device aligns with the practical needs and preferences of its intended users. (31) (32)

Identified Challenges

Through observations and interviews with stakeholders, medical experts, and patients on existing monitoring device, several challenges were identified:

1. Complexity of Data Interpretation

Existing monitoring devices often present users with complex data sets that are challenging to interpret. Users may struggle to understand their glucose readings and make informed decisions about their health management.

2. Limited Integration with Lifestyle Factors

Many monitoring devices focus solely on glucose monitoring without integrating other important lifestyle factors such as physical activity, diet, and sleep patterns. This lack of integration hinders users from obtaining a holistic view of their health status.

3. User Interface Design

The user interface of current monitoring devices may be unintuitive and difficult to navigate, leading to user frustration and decreased compliance with monitoring protocols.

4. Portability and Convenience

Some monitoring devices lack portability and convenience, making it inconvenient for users to carry them throughout their daily activities. This limitation may discourage users from consistently monitoring their glucose levels.

5. Cost and Accessibility

The cost of monitoring devices and related supplies can be prohibitive for some individuals, limiting their access to essential monitoring tools. Additionally, accessibility issues may arise in rural or underserved areas where monitoring devices are not readily available.

Addressing these challenges will be crucial in the development of a comprehensive diabetes monitoring device that effectively meets the needs of individuals with diabetes and facilitates enhanced health management.

4. Design Process

Initiating the Design Process

The design process can be started by setting the design concepts which consist of design statement, design objectives, design criteria, and target user as described in Table 1 below:

Table I. Design Concepts of newly design CDMD

Design Concepts	Details
Design Statement and Aims	An innovative CDMD that seamlessly integrates advanced technology and user-centric features to revolutionize diabetes management. Our design aims to go beyond traditional glucose monitoring by incorporating technology to continuous tracking of physical activity and providing personalized health insights. Focused on user-friendliness, the device will seamlessly integrate into the daily lives of individuals managing diabetes. By leveraging advanced sensors and data analytics, it will offer real-time information to users and healthcare providers, fostering a collaborative relationship and empowering individuals with actionable insights to enhance overall health outcomes.
Design Objectives	With the objectives is to understand the CDMD towards diabetic's patients and medicals, the focus also is to design a user-friendly device for effortless dietary monitoring. Furthermore, with the data, it is to create a device that apply newest technology of applications to enhance the quality of life of people with diabetics.
Design Criteria	Based on the specified design criteria, the proposed Comprehensive Diabetes Monitoring Device should adhere to the following criteria: a) User-Friendly Interface: The device should prioritize simplicity in data entry methods, ensuring ease of use for individuals with varying levels of technological proficiency. b) Comprehensive Information and Insights: It should provide users with detailed and actionable information about their glucose levels, dietary choices, and overall health, enabling informed decision-making. c) Portability: The device should be compact and lightweight, facilitating easy transportation for individuals managing diabetes in various settings, including during travel or daily activities. d) Technological Integration: Leveraging modern technologies such as smartphone connectivity or app integration, the device should enhance user engagement and streamline data management processes.

Design Concepts	Details
Target User	The Comprehensive Diabetes Monitoring Device is tailored for individuals diagnosed with diabetes, encompassing a wide range of age groups from adolescents to geriatric patients. This device is particularly aimed at those seeking to effectively manage their diabetes through continuous monitoring of glucose levels, physical activity tracking, and personalized health insights. Additionally, healthcare professionals, including physicians, and diabetes educators, are also targeted users who can utilize the device to facilitate informed decision-making and enhance overall health management for their patients with diabetes.

Design Embodiment

At this stage, several selected concept ideas will be developed and its form, size, style, appearance, and such will be determined, bearing in mind the basic functions and processes of a CDMD (Fig-2). Developed ideas will be evaluated and if needed the ideas will be amalgamated into a single design of choice as desired. The researcher will also create a general production drawing to determine the real form and dimension. A mock-up was developed to ascertain its appearance, form, size, production process, and ergonomics. Before the completion of this stage, all design details appearing to be troubling or uncertain must be addressed by the researcher. The general projection drawing will be fully completed, so as the preparation of detailed information regarding diabetes monitoring device design to ensure the smoothness of execution for the next design process.

Fig- 2: 3D development for design analysis

Design Appreciation

The appreciation process was conducted by the researcher at the conclusion of the design process to formally recognize the values of the product design. Although there is no universally accepted model or sequence for product appreciation in design, Feldman introduced a specific sequence in 1970 (10) that has been widely referenced. He proposed four steps for appreciation: 1) Description, 2) Analysis, 3) Interpretation, and 4) Evaluation. Feldman emphasized that each step should be performed in this order to achieve a comprehensive and precise explanation, starting from the initial description to the final evaluation.

Description

In describing design concept of this project, it shows a modern and eco-conscious design, ensuring a stylish and contemporary aesthetic while prioritizing environmental sustainability of CDMC.

Designed with simplicity and attractiveness in mind, the device features a sleek form factor made from environmentally-friendly materials, as suggest in few variants; a) Gun Metal, b) Clear Orange + Gun Metal, and c) Bright Silver + Gun Metal. (Fig-3)

In term of power sources, it powered by a rechargeable lithium-ion battery, which integrates various peripheral health monitoring tools, including thermometers, pedometers, heart rate monitors, altimeters, light sensors, galvanic skin response (GSR) sensors, electrocardiogram (ECG or EKG) sensors, UV sensors, GPS receivers, tiny speakers, and microSD cards. Nevertheless, the designs support wireless technologies such as Bluetooth, Wi-Fi, and GPS to enable seamless connectivity.

Furthermore, it complemented by an associated connectivity that provides management and telemetry for long-term biomonitoring. This universally to ensures ease of use and accessibility for individuals managing diabetes without any pressure.

Fig-3: The CDMC design applies simplicity and attractiveness

Analysis

The CDMC exemplifies a forward-thinking approach to diabetes management by merging advanced technology with eco-conscious design principles. Its sleek form factor and use of environmentally-friendly materials underscore a commitment to both aesthetics and sustainability. The device's functionality is enhanced by the inclusion of various peripheral devices and wireless technologies, which facilitate comprehensive health monitoring. The integration of a local touchscreen interface and a smartphone app ensures that the device is accessible and easy to use for individuals managing diabetes, promoting efficient health management and long-term biomonitoring. This innovative design aligns with the evolving needs of diabetes management, offering a holistic solution that prioritizes user experience and environmental responsibility. By addressing key challenges and incorporating innovative features, the device has the potential to revolutionize how individuals with diabetes monitor and manage their health.

Interpretation

With the CDMC represents a significant advancement in diabetes management, its combining cutting-edge technology with eco-conscious design principles. Its sleek and environmentally-friendly design not only enhances its visual appeal but also demonstrates a commitment to sustainability. By integrating a wide range of peripheral devices and wireless connectivity options, the design offers comprehensive health monitoring capabilities, empowering individuals with diabetes to make informed decisions about their health. The integration of an integral touchscreen interface and an application further improves accessibility and ease of use, ensuring smooth integration into everyday routines. This multifunctional use in a design with user-centric features hold promise for improving health outcomes and facilitating proactive diabetes management. Overall, the CDMC exemplifies a holistic approach to health management, prioritizing both user experience and environmental responsibility.

Evaluation

The CDMC illustrates a notable advancement in diabetes care through its innovative design and technological integration. Its modern and environmentally-friendly design, combined with an extensive range of health monitoring features, highlights a dedication to user-focused and sustainable solutions. The device's versatile functionalities, including an advancement in technology. (Fig-4) Nevertheless, while the device shows potential in improving health outcomes for those managing diabetes, further assessment and trials are necessary to evaluate its practical effectiveness and user satisfaction. Ongoing refinement and enhancement based on user feedback and clinical validation will be essential for ensuring the device's long-term success in improving health management for individuals with diabetes.

Fig-4: The design evaluation of newly design CDMD towards versatile functionalities a) ideation sketch b) explanatory sketch, and c) persuasive sketch

5. Problem Solution & Recommendations

Based on findings, there are several avenues for further studies and analyses. Firstly, future research should focus on refining the device's accuracy and reliability by addressing limitations and improving calibration methods. Additionally, studies should explore the long-term effectiveness of the device in improving diabetes management outcomes, such as glycemic control and quality of life. Furthermore, it would be valuable to investigate the feasibility of integrating the device with mobile applications or wearable technologies to enhance user experience and engagement. Moreover, cost-effectiveness studies are warranted to evaluate the economic impact of implementing the comprehensive diabetes monitoring device in different healthcare settings.

6. Closing Remarks

In conclusion, the development of the newly designed CDMC represents a significant advancement in diabetes management. By addressing key challenges and incorporating innovative features, this device has the potential to revolutionize how individuals with diabetes monitor and manage their health. The integration of user-friendly interfaces, advanced technology, and comprehensive health monitoring capabilities demonstrates a commitment to empowering users and enhancing overall health outcomes.

Moving forward, it is crucial to continue refining and optimizing the device based on user feedback and clinical validation to ensure its effectiveness and widespread adoption. Ultimately, we hope that this device will play a pivotal role in improving the quality of life for individuals managing diabetes and contribute to the advancement of diabetes care on a global scale.

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References

[1] 6. glycemic targets: standards of medical care in diabetes—2021. (2020). Diabetes Care, 44(Supplement_1). https://doi.org/10.2337/dc21-s006

[2] Nagesh, H, B., Arvind, R., Harish, Prabu, L., Chethan, L, S., Mohana, Kumar, S., Ramya, Maranan. (2023). 1. Intelligent GlucoSense: Innovations in Smart Devices for Personalized Health Monitoring. doi: 10.1109/i-smac58438.2023.10290208

[3] Mulvaney, S. A., Ritterband, L. M., & Bosslet, L. (2011). Mobile intervention design in diabetes: Review and recommendations. *Current Diabetes Reports*, *11*(6), 486–493. https://doi.org/10.1007/s11892-011-0230-y

[4] Amit, Gupta., Banshi, Saboo., Jothydev, Kesavadev., Manoj, Chawla., Rakesh, Parikh., Mithun, Bhartia., Shashank, R, Joshi., Sanjay, Kalra., Ambika, Gopalakrishnan, Unnikrishnan., Anuj, Maheshwari., Sanjay, K., Agarwal., BrijMohan, Makkar., Purvi, Chawla., Jayant, K, Panda., Tanvir, Kaur., Ashok, Kumar, Das., V., Mohan. (2023). Role of diabetes technology for diabetes prevention and improving public health outcomes: A position statement by Diabetes Technology Trust of India. Journal of Diabetology: Official Journal of Diabetes in Asia Study Group, doi: 10.4103/jod.jod_59_23

[5] Quinn, C. C., Clough, S. S., Minor, J. M., Lender, D., Okafor, M. C., & Gruber-Baldini, A. (2008). WellDocTM mobile diabetes management randomized controlled trial: Change in clinical and behavioral outcomes and patient and physician satisfaction. Diabetes Technology & Therapeutics, 10(3), 160–168. https://doi.org/10.1089/dia.2008.0283

[6] Ludden, G. D., van Rompay, T. J., Kelders, S. M., & van Gemert-Pijnen, J. E. (2015). How to increase reach and adherence of web-based interventions: A design research viewpoint. Journal of Medical Internet Research, 17(7). https://doi.org/10.2196/jmir.4201

[7] Angela, C., Brittain., Jane, M, Carrington. (2024). 3. Application of Within-Methods Triangulation to Analyze Hospital System Health.. doi: 10.1097/ans.0000000000000525

[8] Bolinder, J., Antuna, R., Geelhoed-Duijvestijn, P., Kröger, J., & Weitgasser, R. (2016). Novel glucose-sensing technology and hypoglycaemia in type 1 diabetes: A multicentre, non-masked, randomised controlled trial. *The Lancet*, *388*(10057), 2254–2263. https://doi.org/10.1016/s0140-6736(16)31535-5

[9] Klonoff, D. C., Parkes, J. L., Kovatchev, B. P., Kerr, D., Bevier, W. C., Brazg, R. L., Christiansen, M., Bailey, T. S., Nichols, J. H., & Kohn, M. A. (2018). Investigation of the accuracy of 18 marketed blood glucose monitors. *Diabetes Care*, *41*(8), 1681–1688. https://doi.org/10.2337/dc17-1960

[10] Tsvetelina, Mladenova., Irena, Valova. (2023). 1. Leveraging User Experience for Enhancing Product Design: A Study of Data Collection and Evaluation. doi: 10.1109/HORA58378.2023.10156767

[11] Ntakirutimana, G., Kamanzi. (2024). Various Diabetes Management Activities: A Comprehensive Overview. Idosr Journal of Biochemisry Biotechnology and Allied Fields, doi: 10.59298/idosr/jbbaf/24/93.3540000

[12] Nadine, Kong., Foong, Ming, Moy., Shu, Hwa, Ong., Ghalib, Ahmed, Tahir., Choo, Kiong, Loo. (2023). MyDietCam: Development and usability study of a food recognition integrated dietary monitoring smartphone application. Digital health, doi: 10.1177/20552076221149320

[13] Antonio, Benítez-Guijarro., Zoraida, Callejas., Manuel, Noguera., Kawtar, Benghazi. (2019). Architecting dietary intake monitoring as a service combining NLP and IoT. Journal of Ambient Intelligence and Humanized Computing, doi: 10.1007/S12652-019-01553-2

[14] Carol, Byrd-Bredbenner., Densie, Webb. (2015). Overcoming Consumer Inertia to Dietary Guidance. The FASEB Journal, doi: 10.1096/FASEBJ.29.1_SUPPLEMENT.LB412

[15] Andrei, Lapets., Assaf, Kfoury. (2010). A User-friendly Interface for a Lightweight Verication.

[16] Jeong, Ik, Sung. (2015). Portable device for providing multiple functions.

[17] Cem, Harun, Meydan., Handan, Akkaş. (2024). 1. The Role of Triangulation in Qualitative Research. Advances in library and information science (ALIS) book series, doi: 10.4018/979-8-3693-3306-8.ch006

[18] Ramakrishnan, Vivek., Y., Nanthagopan., Sarmatha, Piriyatharshan. (2023). 3. Beyond methodology: Theoretical foundations of triangulation in qualitative and multi-method research: A literature review. Naukovì studìï ìz socìal′noï ta polìtičnoï psihologìï, doi: 10.61727/sssppj/2.2023.53

[19] Piya, Muradova. (2024). 1. Evaluation of Non-Invasive Wearable Diabetes Sensors. Sensors and machine learning applications, doi: 10.69534/smla/190605

[20] Nagesh, H, B., Arvind, R., Harish, Prabu, L., Chethan, L, S., Mohana, Kumar, S., Ramya, Maranan. (2023). 5. Intelligent GlucoSense: Innovations in Smart Devices for Personalized Health Monitoring. doi: 10.1109/i-smac58438.

2023.10290208

[21] Tbeishat, H., Rasul, R. M., Ibrahim, M., & Tubishat, B. M. A.-R. (2024). The effect of green products and interior design on physically disabled people's quality of life in Jordan. Pakistan Journal of Life and Social Sciences (PJLSS), 22(2), 8958–8975. https://doi.org/10.57239/pjlss-2024-22.2.00678

[22] Halis, Kaan, Akturk., Anila, Bindal. (2024). 3. Advances in diabetes technology within the digital diabetes ecosystem.. Journal of managed care & specialty pharmacy, doi: 10.18553/jmcp.2024.30.10-b.s7

[23] Sarah, Fishman., Maria, A, Fernandez, Galvis., Jill, Linnell., Pia, Iribarren., Victoria, H., Jonas., Jennifer, Gittleman., Molly, L., Tanenbaum., Maya, Scherer., Linda, Weiss., Elizabeth, A., Walker., Gladys, Crespo-Ramos., Claire, J., Hoogendoorn., Hang, Pham-Singer., Winfred, Wu., Jeffrey, S., Gonzalez. (2023). 3. Diabetes-Related Quality of Life: Learning From Individuals Making Lifestyle Changes to Improve Type 2 Diabetes Control. The Science of Diabetes Self-Management and Care, doi: 10.1177/26350106221149665

[24] Anne, Beltzer., Julia, Kölle., Marta, Gil, Miró., Stefan, Pleus., Collin, Krauss., Cornelia, Haug., Elvis, Safary., Beatrice, Vetter., Guido, Freckmann. (2024). 4. Benefits of Usability Evaluation in the Development Process of Diabetes Technologies Using the Example of a Continuous Glucose Monitoring System Prototype.. Journal of diabetes science and technology, doi: 10.1177/19322968241238146

[25] Yan, Zhou., Hao, Guo. (2018). 4. Research on Methods of Product Evaluation Based on User Experience. doi: 10.1145/3288155.3290584

[26] Myrtede, Alfred., John, Del, Gaizo., Falisha, Kanji., Samuel, P., Lawton., Ashley, Caron., Lynne, S., Nemeth., Alexander, V., Alekseyenko., Daniel, Shouhed., Stephen, J., Savage., Jennifer, Anger., Ken, Catchpole., Tara, N., Cohen. (2022). 2. A better way: training for direct observations in healthcare. BMJ Quality & Safety, doi: 10.1136/bmjqs-2021-014171

[27] Fuhid, Alanazi., Abdullah, Abdulrahman, Almofarh., Ibrahim, Alzahrani., Fahad, Abdulaziz, AlFahid., Mohammed, Hamad, alhamdi., Mohammed, Alfaifi., Fuhid, Alanazi., Abdulaziz, khaledalshehri., Hanan, Mohammed, Alharbi. (2023). 4. Diabetes mellitus. International Journal of Engineering Applied Sciences and Technology, doi: 10.33564/ijeast.2023.v08i03.006

[28] Ernesto, Maddaloni., Paolo, Pozzilli., Paolo, Pozzilli. (2018). 2. Diabetes: the disease of the 10 D.. Endocrine, doi: 10.1007/S12020-017-1454-7

[29] Matthew, Chin, Heng, Chua. (2016). 1. Design and development of an integrated health (i-health) monitoring watch. doi: 10.1109/SII.2016.7844014

[30] Jonas, Bendig., Anja, Spanz., Jana, Leidig., Anika, Frank., Marcus, Stahr., Heinz, Reichmann., Kai, F., Loewenbrück., Björn, H., Falkenburger. (2022). 3. Measuring the Usability of eHealth Solutions for Patients With Parkinson Disease: Observational Study. JMIR formative research, doi: 10.2196/39954

[31] Norzaman, N. Z., Abd Rahman, K. A., Mohd Yunos, M. Y., & Ismail, N. 'Atiah. (2021). Adaptation of Asma'ul Husna in existing design practice. Pertanika Journal of Social Sciences and Humanities, 29(4), 2785–2798. https://doi.org/10.47836/pjssh.29.4.37

[32] Amat Sairin, M., Mohamed Yusof, S. A., Mohamad, S. A., Norzaman, N. Z., Md Zulkifli, A. P., Razali, A. F., Mustaffa Halabi, K. N., & Zolkeply, M. S. (2024). Reviving tradition through design: Exploring telepuk Craft Woodblock design. Journal of Advanced Research in Applied Sciences and Engineering Technology, 198–211. https://doi.org/10.37934/araset.62.1.198211