VOL. 11. NO. 3 FEBRUARY 2026
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
DOI: 10.33480 /jitk.v11i3.5724

JITK (JURNAL ILMU PENGETAHUAN DAN TEKNOLOGI KOMPUTER)

WEB-BASED FACIAL SKIN TYPE CLASSIFICATION SYSTEM BASED ON BAUMANN'S THEORY

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Abstract— *The skin is a crucial organ in the human body, serving not only as the primary protective barrier but also exhibiting diverse characteristics such as specific types and conditions. Increasingly, people are recognizing the importance of skin care in their daily routines. However, a lack of understanding about different skin types and appropriate skin care products can pose challenges. This research aims to develop a facial skin type classification system based on the existing system. The development of this facial skin type classification system refers to Baumann's Theory, which categorizes skin into four characteristics: Hydration, Sensitivity, Pigmentation, and Aging. The system was developed using the Waterfall methodology and tested using Black Box Testing. The results of Black Box Testing demonstrate that the system functions well and meets the specified requirements. All features and functionalities operate optimally without significant bugs, indicating the success of the Waterfall approach in producing a reliable and ready-to-use system. This system is expected to assist users in accurately identifying their skin type and receiving appropriate skincare solutions, thereby improving the health and appearance of their facial skin.*

Keywords: *Baumann Theory, Black Box Testing, Skin Type Classification, Waterfall.*

Intisari— *Kulit merupakan organ yang berperan penting dalam sistem tubuh manusia, tidak hanya sebagai pelindung utama, tetapi juga memiliki karakteristik yang beragam seperti jenis dan kondisi tertentu. Masyarakat semakin menyadari pentingnya perawatan kulit dalam rutinitas harian mereka. Namun, kurangnya pemahaman tentang berbagai jenis kulit dan ketidakpahaman terhadap produk perawatan kulit yang sesuai dapat menjadi hambatan. Penelitian ini bertujuan untuk mengembangkan sistem klasifikasi jenis kulit wajah pada sistem yang sudah ada sebelumnya. Pengembangan sistem klasifikasi jenis kulit wajah yang dilakukan merujuk pada Teori Baumann, yang membagi kulit menjadi empat karakteristik: Hidrasi, Sensitivitas, Pigmentasi dan Penuaan Kulit. Sistem dikembangkan dengan metode Waterfall dan diuji menggunakan Black Box Testing. Hasil pengujian Black Box menunjukkan bahwa sistem berfungsi baik dan sesuai spesifikasi. Semua fitur dan fungsionalitas beroperasi optimal tanpa bug signifikan, menunjukkan keberhasilan pendekatan Waterfall dalam menghasilkan sistem yang andal dan siap digunakan. Sistem ini diharapkan membantu pengguna mengidentifikasi jenis kulit mereka secara akurat dan mendapatkan solusi perawatan yang tepat, sehingga meningkatkan kesehatan dan penampilan kulit wajah mereka.*

Kata Kunci: *Black Box Testing, Klasifikasi Jenis Kulit, Teori Baumann, Waterfall.*

Accredited Rank 2 (Sinta 2) based on the Decree of the Dirjen Penguatan RisBang Kemenristekdikti No.225/E/KPT/2022, December 07, 2022. Published by LPPM Universitas Nusa Mandiri

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INTRODUCTION

All organs in the human body suffer a complex aging process characterized by a gradual decline in cellular functionality and regenerative capacity. The most evident and observable effects of bodily aging are reflected in the skin. The skin is the biggest organ in the human body, with an approximate surface area of 2 m^2 in adults. The thickness varies from 0.8 to 5 mm depending on the anatomical position. Aging encompasses the cellular and histological alterations of the epidermis, dermal-epidermal junction, and dermis. The multilayered structure is closely associated with skin functions [1]. The skin serves as the outermost protective layer of the human body. It makes up approximately 15% of the total human body weight and covers almost the entire body. The skin is also a crucial organ of the human body, acting as a protective barrier against different external elements while also perceiving and reacting to mechanical signals [2].

The skin constitutes the largest organ in the human body [3]. The skin comprises three layers: the epidermis, dermis, and hypodermis [4]. The epidermis is the outermost layer, consisting of a stratified squamous epithelium primarily made up of keratinocytes, along with dendritic cells such as melanocytes, Merkel cells, and Langerhans cells. The epidermis consists of four layers categorised by keratinocyte morphology and the extent of differentiation into cornified cells, with the outermost layer identified as the stratum corneum. The dermis is the intermediate layer primarily composed of collagen and amorphous connective tissue, which includes nerve and vascular networks, epidermal appendages, fibroblasts, macrophages, and mast cells. The hypodermis, also known as subcutaneous tissue, functions as an endocrine organ consisting of lobules of adipocytes interspersed with fibrous septa composed of collagen and blood vessels. The skin and its components can communicate with other tissues and self-regulate by producing cytokines, neurotransmitters, hormones, and their respective receptors. The findings highlight disparities in pressure ulcer detection and care. [5]

The skin is also known as the foundation of attraction, as the more spotless the skin appears, the more beautiful one is perceived, and this is especially true for the facial skin [6]. Most people, especially women, want their skin to look healthy, clean, and well-groomed. Multiple internal and environmental causes can cause skin aging, including the loss of dermal collagen and elastic fibres [7]. Skin aging is also caused by both intrinsic and external factors as we age. Intrinsic ageing is a natural process that causes thin, dry, and wrinkled skin, whereas extrinsic ageing is caused by external factors such as sun exposure, smoking, and air pollution [8]. Therefore, skin care is needed to achieve this goal. Nowadays, people realize that skin care is an important part of their daily routine, despite the limited access to beauty clinic services and high costs [9]. To get maximum skincare results, one must also pay attention to their own respective skin type. Should they fail to realize this, the possibility of developing new problems such as acne and other skin-related issues will increase.

A study finding emphasize the dynamic properties of skin, revealing substantial relationships between biomarker expression levels and noninvasive skin measurements across multiple parameters. Prominent biomarkers of aging have surfaced, indicating alterations in collagen integrity and skin elasticity over time, while additional biomarkers have been recognized as essential for evaluating skin dryness, underscoring the significance of epidermal barrier function and moisture levels [10].

Considering an increasing number awareness of skincare, numerous individuals are emphasizing customized skincare regimens. A 2021 survey conducted by ZAP Beauty Clinic and Mark Plus Inc involving around 6,000 Indonesian women indicated that 86.2% of participants believed skincare products had to be customized to their individual skin types [11]. This awareness tripled by 2023, with a similar survey showing an even greater understanding of skincare content and the need for customized skincare routines. Despite this rising awareness, many people still avoid consulting dermatologists due to high costs and limited access to specialists. Consequently, individuals often rely on self-diagnosis and select products based on incomplete knowledge of their skin type, leading to ineffective treatments [12].

In reaction to this difficulty, dermatologists especially Dr. Leslie Baumann have created more comprehensive skin classification systems. Baumann's Skin Type Indicator (BSTI) classifies skin according to four principal attributes [13]. By assessing skin based on these criteria—dry or oily, sensitive or resilient, pigmented or nonpigmented, and wrinkled or unwrinkled—consumers can more readily discern the most appropriate topical treatments for their skin among the 16 possible skin type permutations. This article delineates the four criteria constituting the BSTI, emphasizing fundamental science and defining traits while describing the 16 variations of skin types estimated dermal absorption doses [14]. Several skin-type

biomarkers are linked to age, non-invasive device measures, LAST score, and acne lesion visual assessment. For example, COL1A1 (Collagen type 1 alpha 1 chain), FN1 (Fibronectin 1), and PINK1 (PTEN-induced putative kinase protein 1) are associated with skin aging; FLG (Filaggrin), KLF4 (Kruppel-like factor 4), and LOR (Loricrin) relate to skin hydration; GPNMB (Glycoprotein non-metastatic melanoma protein B), MLANA (Melan-A), and TYR (Tyrosinase) pertain to skin pigmentation; IGF1 (insulin-like growth factor-1), MPZL3 (Myelin protein zero like 3), and AQP3 (Aquaporin 3) are linked to oily skin; and PGF (placental growth factor), CYR61 (cysteine-rich angiogenic inducer 61), RBP4 (retinol-binding protein 4), TAC1 (Tachykinin precursor 1), CAMP (Cathelicidin antimicrobial peptide), MMP9 (Matrix metallopeptidase 9), MMP3, MMP12, and CCR1 (C-C motif chemokine receptor 1) are relevant to sensitive skin [10].

The Baumann Skin Type Indicator (BSTI) is a facial skin type classification system that combines the two Rubinstein categories into four distinct components. This characterization involves four main indicators: Skin Hydration, Skin Sensitivity, Skin Pigmentation, and Skin Aging. Baseline Skin Type Identification, or BSTI for short, is a comprehensive questionnaire with 64 elements. The main purpose of this procedure is to analyze and determine a person's skin type, as well as assess any changes that may have occurred as a result of the influence of life experiences [14]. The majority of analysis samples are obtained from serum and blood in conventional clinical disease diagnosis and screening that rely on biomarker detection [15]. Nevertheless, these invasive collection methods necessitate specialized instruments and professionals, and they may result in infection risks [15]. To optimize the functionality of the skin, it is essential to provide appropriate care and maintenance for this organ [16]. The impact of skincare on facial skin can also differ depending on each individual's skin type. Therefore, proper skin analysis knowledge is required, including the ability to identify facial skin types.

A web-based cross-sectional survey was implemented with the authorization of the Institutional Review Board of the Thai Moogambigai Dental College and Hospital in Chennai. A total of 32 images were generated by digitally modifying standardised smile photographs of two South Indian models (one male and one female) to exhibit four distinct tooth tints and four distinct skin tones. The photographs were integrated into a Google Form alongside a questionnaire and a Visual Analogue Scale for attractiveness assessment [17].

In previous studies, several expert systems have been successfully created, including an expert system by applying the Certainty Factor method with an accuracy rate of 91% [14]. In addition, research implements the Naïve Bayes method to determine skin type which produces an accuracy rate of 90% [18]. Furthermore, an expert system has also been successfully developed for identifying skin types based on symptoms experienced by users using the web-based Forward Chaining method [19]. Another study using the K-Nearest Neighbor method to identify facial skin types resulted in an accuracy rate of 60% [20]. Further research, conducted by Young Bin Lee and others who identified skin types in men in Korea based on region and age using the Baumann method, namely: oily (O) or dry (D), sensitive (S) or resistant (R), pigmented (P) or non-pigmented (N), and wrinkled (W) or tight (T) [21]. The study found that out of 1000 Korean men who had been surveyed, between the ages of 20-60 years based on age and region, skin type O had a percentage of 53.5%, skin type S of 56.1%, skin type N of 84.4%, and skin type W of 57.5%. From these results, it has been proven that the skin types of men in each region in Korea are different.

Given the limitations of existing approaches and the growing need for personalized skincare solutions, this research aims to develop a web-based system that adopts the Baumann Skin Type Indicator. This system will help users identify their specific skin type with greater accuracy and provide tailored skincare recommendations. This study improves the precision of skin type categorization by incorporating Baumann's Skin Type Indicator into the detection algorithm [22], thereby addressing many skin characteristicsconcurrently. The proposed method's capacity to incorporate sensitivity, pigmentation, and age, in addition to conventional characteristics suchhydration, facilitates a more thorough comprehension of the skin's condition. This review examines the clinical relevance of elastin in skin structure and function, emphasizing its role in wound healing, scarring, and aging. It also explores innovative treatment approaches aimed at replenishing and repairing the skin's elastic fiber network.

Furthermore, new strategies are introduced to enhance elastin production, elastic fiber formation, and network restoration. A key contribution of this research is the integration of Baumann's structured scoring method to refine skin type classification. By providing explicit and quantifiable results across all four dimensions, this model improves classification accuracy, addressing limitations in existing diagnostic methods. This

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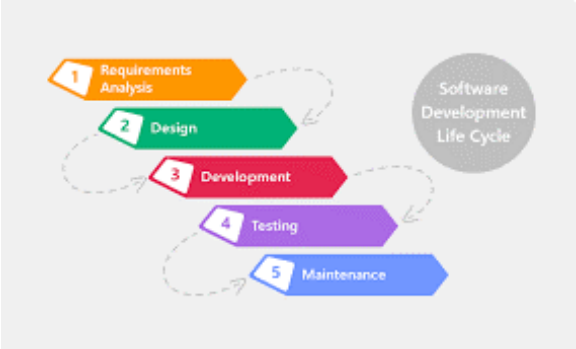
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
DOI: 10.33480/jitk.v11i3.5724

advancement enables more precise skincare recommendations tailored to individual needs, bridging the gap between generic skincare solutions and personalized treatment. By extending beyond simple classification, this study responds to the growing demand for customized skincare solutions, as highlighted in recent consumer surveys. The findings contribute to both dermatological research and practical skincare applications, helping users maintain healthier skin while reducing the risk of skin-related conditions.

MATERIALS AND METHODS

The research uses the waterfall development method which includes several stages, namely Requirements Analysis, System Design, Implementation, System Testing, and Maintenance which can be seen in the following figure.



Source : (Research Results, 2025)

Figure 1 Waterfall Model

The development of a web-based facial skin type classification system based on Baumann's theory can be effectively structured using the waterfall model, a systematic approach to software development. This model is characterized by its sequential phases, where each stage must be completed before moving on to the next, ensuring a structured progression through the system development life cycle (SDLC) [23][24].

1. Requirements Analysis

The first phase of this process, known as user needs analysis or requirements analysis, is dedicated to identifying the specific needs of the end user[25]. The first phase of the waterfall model involves requirements gathering, which is crucial for understanding the specific needs of users seeking skin type classification. The Baumann Skin Type Indicator (BSTI) serves as the foundational framework for this classification system, categorizing skin into 16 types based on four parameters: oily or dry, sensitive or resistant, pigmented or non-pigmented, and wrinkled or tight [26]. This framework has been validated across various ethnicities, demonstrating its applicability in diverse populations [26]. The questionnaire utilized in the BSTI can be integrated into the system to collect user data effectively.

2. System Design

The Design stage is the process of planning and problem-solving for a software solution[27]. In this stage, the researchers will process the data that has been collected previously and start designing the system. After all the data has been collected to meet the requirements of the system, the system modeling will be carried out with the Unified Modeling Language (UML) in the form of Use Case Diagrams and Activity Diagrams. Lastly, the author will create an interface design using Figma, which aims to show the visualization of the appearance of the system created.

3. Development

At this stage of development is the process of transforming design requirements and specifications into real and functional programs, databases, websites, or software components through programming and implementation[27]. After the system design stage is complete, the next process is the implementation or development stage. The goal of this stage is to ensure that the system functions properly and meets all expectations and specifications that have been set. Developers will focus on creating and integrating various components, testing functionality, and optimizing performance so that the system can run efficiently and provide an optimal user experience.

4. System Testing

This process, also known as verification and validation, is used to ensure that the software solution fulfills its intended purpose and complies with the initial requirements and specification improving clinical reliability [23]. Testing is the next critical phase, where the system is evaluated for functionality, usability, and accuracy. This phase is essential to identify any bugs or issues that may arise during the classification process[28][24]. In this stage, testing of the system that has been developed will be carried out. The author does this to test whether or not the system runs accordingly. If a problem that is not in accordance with the system criteria in planning and design is found, it must be re-examined from the planning stage. The tests carried out in this study will use the Black Box Testing method to evaluate system functionality, as

well as to ensure that components can run according to the predetermined criteria.

5. Maintenance

In this phase it is possible to carry out additional maintenance tasks, such as adapting the software to its environment, meeting new user demands, and increasing the reliability of the software[27]. Continuous maintenance and updates will be necessary to adapt to user feedback and advancements in machine learning techniques, ensuring the system remains relevant and effective over time [29]. At this stage, the researcher will make modifications to the system after it has been developed should any problem occur during the running of the system, with the aim of increasing output, fixing problems, and improving performance and quality.

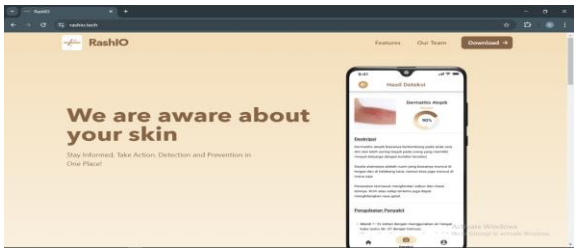
RESULTS AND DISCUSSION

The method used in conducting software development is the waterfall method or model. The following are the stages carried out by researchers in designing the system development for Baumann skin type classification.

1. Requirements Analysis

A. Description of the Current System

The website system is currently running well and stable which can be accessed through the page https://rashio.tech/. This website was previously built using Next.js version 14 and currently functions like a profile to offer skin health applications. Several services are available on the current website, ranging from an explanation of the features in the application, the application development team, to a link to download the application.



Source : (Research Results, 2025)

Figure 2 Website RashIO

The author's aim is to develop a facial skin type classification feature using the Baumann method. With the development of this classification feature, the author aims to help users identify their skin type more accurately. The Baumann method allows the categorization of facial skin based on four main parameters: skin hydration, skin sensitivity, skin pigmentation, and skin aging. This information will assist users in choosing skincare products that suit their needs. Moreover, the author hopes that with the addition of this feature, the website will add significant value to users, increase their satisfaction, and help them achieve optimal skin condition.

B. Identification of The Problem

In this stage, researchers identify problems by reading scientific articles or previous research journals related to skin type identification systems and skin health. From these results, the author found that people have limited access and costs to care for their skin health, resulting in many turn to using self-care. Furthermore, the lack of education is the main reason why community members, especially young women, are unaware of various skin types and problems[6]. Moreover, the classification of skin types has evolved to include a total of 16 different skin characteristics. These updated, detailed characteristics are also referred to as the Baumann Skin Type Indicators. These indicators emerged as new measures to identify more specific skin traits. Hence, the identification of the problem in this study.

C. Literature Review

At this stage, researchers conducted a literature study to obtain information about this research, which the authors took from various articles and scientific journals about skin type identification systems. There are several information obtained from previous research on skin type identification systems, such as the development of systems that can use different methods. It was also found that the classification of skin types has developed into details, which include aspects of hydration, sensitivity, pigmentation, and aging, in order to customize products and treatment methods appropriately.

D. Data Collection

The data collection conducted by researchers is in the form of secondary data, namely questionnaire data. The questionnaire data collected is the result of an internet search containing a list of questions referring to Dr. Leslie Baumann's book, Baumann Skin Type Solutions, which is the basis of the skin type theory in this study. The questionnaire contains four opposing characteristics: dry or oily, sensitive or resistant, pigmented or non-pigmented, and wrinkled or tight (no wrinkles).

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P-ISSN: 2685-8223 | E-ISSN: 2527-4864
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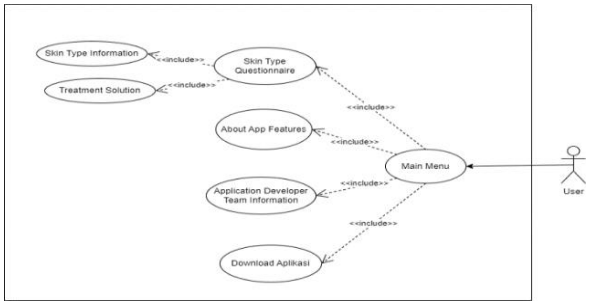
2. System Design

After all the data has been collected enough for the requirements of the system, system modeling will be carried out with the Unified Modeling Language (UML) in the form of Use Case Diagrams and Activity Diagrams. Lastly, the author will create an interface design using Figma, this aims to show the visualization of the appearance of the system to be created.

A. Use Case Diagram

In the system modeling process to describe an interaction that occurs, the author makes a use case diagram in order to ensure all processes that occur between each actor involved in the system can be described. From the case study and the results of problem identification, the system process flow is as described in Figure 3.



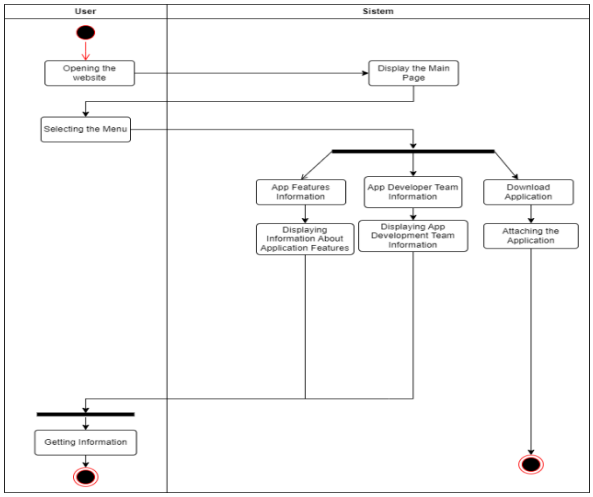
Source : (Research Results, 2025)

Figure 3 Use Case Diagram

B. Activity Diagram

1) Activity Diagram of Current System

In the process of modeling a system that has been running before, researchers will create an activity diagram so that the flow that occurs in the already running system can be understood by the users. The following is the process of the system flow that is already running in Figure 4.

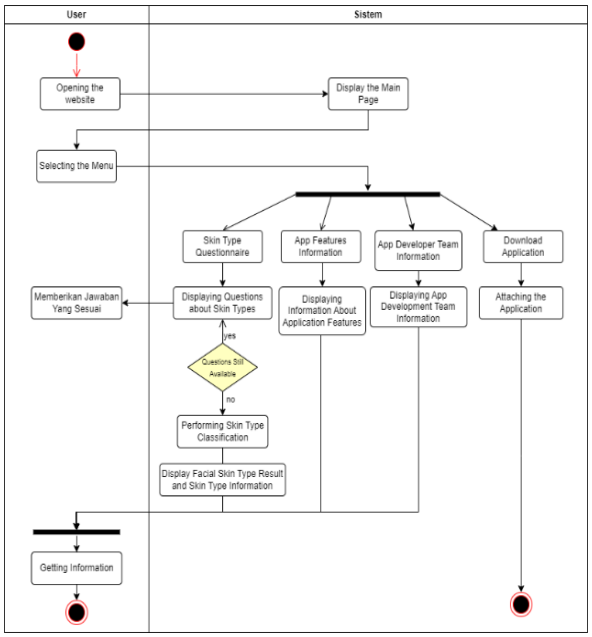


Source : (Research Results, 2025)

Figure 4 Activity Diagram of Current System

2) Activity Diagram of Proposed System

In the system modeling process to describe the flow of using the system created, the authors create an activity diagram so that all the system flows created can be understood by the user or user. From the case study and problem identification, the system flow process is described in Figure 4.

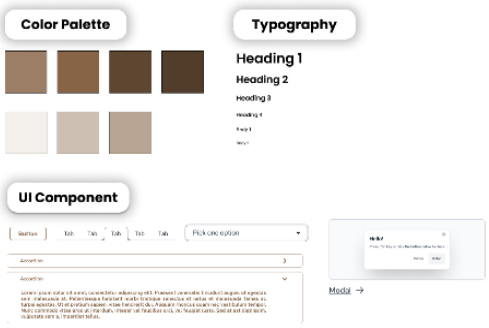


Source : (Research Results, 2025)

Figure 5 Activity Diagram of Proposed System

C. Design of User Interface

Before making the High-Fidelity-Interface of a system, the design guide will be determined first. Figure 5 is the style guide used in making skin type classification features.



Source : (Research Results, 2025)

Figure 6 Style Guide of the System

After determining the style guide of the system, the author designs the High Fidelity Interface of the system created in Figma with the results of 6-page designs for the system features to be created, can be seen in Figure 6.

VOL. 11. NO. 3 FEBRUARY 2026
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
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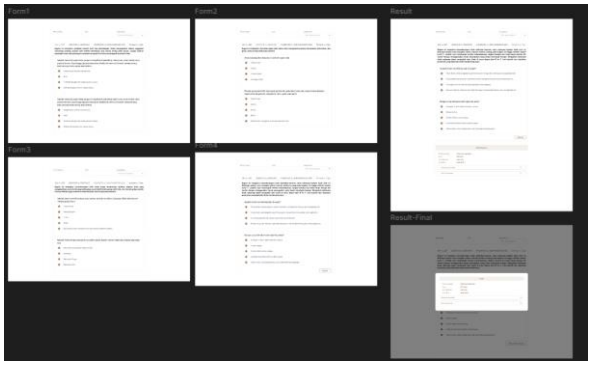


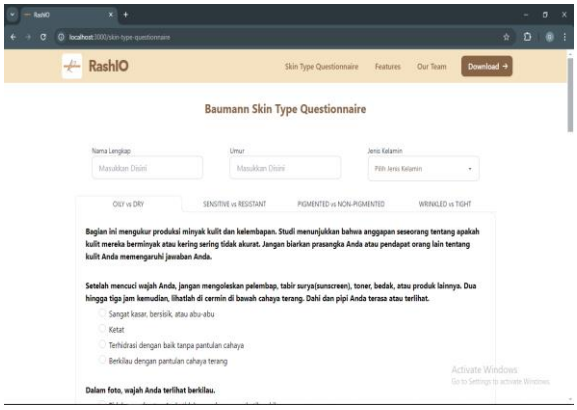
Source : (Research Results, 2025)
Figure 7 High Fidelity of the System

3) Development

In carrying out the implementation that will be developed, the researcher equalizes and updates the library dependencies used from the previous system. After equalizing and updating the library dependencies, the author then updated the code. Coding is done using the Next.js 14 framework to develop the system in accordance with the design and user needs that have been determined previously.

a. Skin Type Questionnaire Page

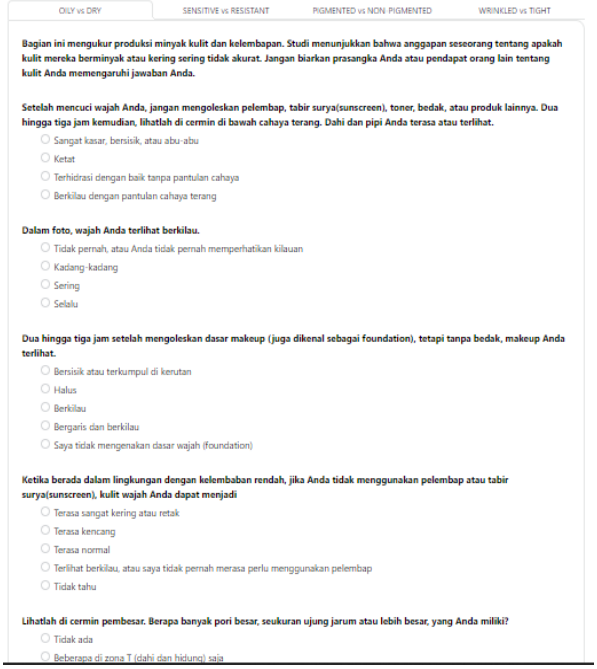
This page will display all parts of the Baumann skin type questionnaire, such as the form used as the user's identity, as well as all tabs containing the 4 sections of the Baumann questionnaire category. The subsequent criteria are outlined in the questionnaire, as cited in Dr. Leslie Baumann's book, Skin Type Solution [29]. The inquiries and regulations were formulated by Dr. Baumann grounded in her research with patients. This questionnaire has been validated based on oil levels or sebum measurements obtained with a Sebumeter [22]. A study involving 100 volunteers demonstrated its criteria validity through correlation with Sebumeter data and confirmed reliability[26].



Source : (Research Results, 2025)
Figure 8 Skin Type Questionnaire Page

b. Skin Hydration tab page: Oily Skin (O) vs Dry Skin (D)

This tab contains explanations and all the questionnaire questions about parts of the characteristics for hydration of one's skin. In her book, Baumann explains that this comprehensive questionnaire determines skin type by summing the scores of individual answers to specific questions she has formulated. Each response is assigned a predefined numerical value, and the total score categorizes an individual's skin into one of 16 types based on the four Baumann dimensions: Oily/Dry, Sensitive/Resistant, Pigmented/Non-Pigmented, and Wrinkled/Tight. The outcomes of the answer selections will be determined by aggregating the values of the responses provided by the individual. The equation is as follows: Furthermore, the result of the calculation will determine a person's skin type with the following scale as follows:
If the score is between 27 - 44 is oily skin (O)
If the score is between 11 - 26 is dry skin (D)



Source : (Research Results, 2025)
Figure 9 Skin Hydration tab page: Oily Skin(O) vs Dry Skin(D)

c. Skin Sensitivity tab page: Sensitive Skin (S) vs Resistant Skin (R)

This page tab contains explanations and all the questionnaire questions about parts of the characteristics for a person's skin sensitivity. In her book, Baumann explains that this comprehensive questionnaire determines skin type by summing the scores of individual answers to specific questions she has formulated. Each response is assigned a

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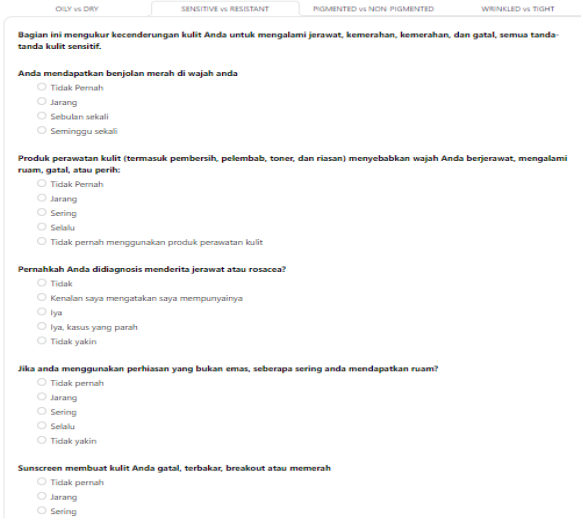
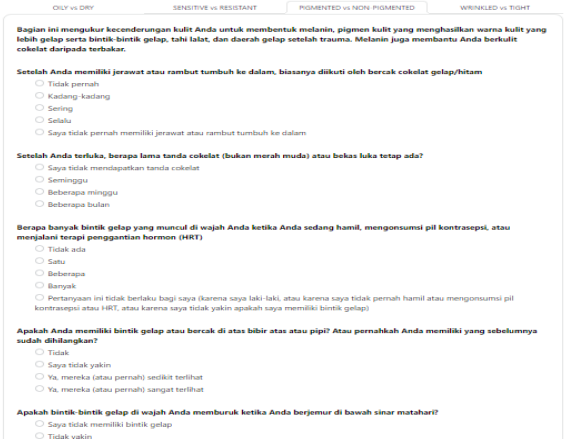
If the score is between 30 - 72 is sensitive skin (S)
If the score is between 17 - 29 is resistant skin (R)



Source : (Research Results, 2025)
Figure 10 Skin Sensitivity tab page: Sensitive Skin(S) vs Resistant Skin(R)

d. Skin Pigmentation tab page: Pigmented Skin (P) vs Non-pigmented Skin (N)

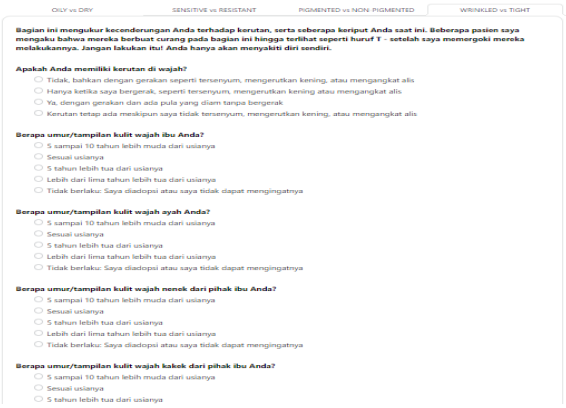
This tab of the page contains explanations and all the questionnaire questions about parts of the characteristics for a person's skin pigmentation. In her book, Baumann explains that this comprehensive questionnaire determines skin type by summing the scores of individual answers to specific questions she has formulated. Each response is assigned a predefined numerical value, and the total score categorizes an individual's skin into one of 16 types based on the four Baumann dimensions: Oily/Dry, Sensitive/Resistant, Pigmented/Non-Pigmented, and Wrinkled/Tight. The outcomes of the answer selections will be determined by aggregating the values of the responses provided by the individual. Furthermore, the result of the calculation will determine a person's skin type with the following scale as follows:
If the score is between 29 - 52 is pigmented skin (P)
If the score is between 13 - 28, it is non-pigmented skin (N)



Source : (Research Results, 2025)
Figure 11 Skin Pigmentation tab page: Pigmented Skin(P) vs Non-pigmented Skin(N)

e. Skin Aging tab page: Wrinkled Skin (W) vs Tight Skin (T)

This page tab contains an explanation and the questionnaire questions about the characteristics part of aging skin. In her book, Baumann explains that this comprehensive questionnaire determines skin type by summing the scores of individual answers to specific questions she has formulated. Each response is assigned a predefined numerical value, and the total score categorizes an individual's skin into one of 16 types based on the four Baumann dimensions: Oily/Dry, Sensitive/Resistant, Pigmented/Non-Pigmented, and Wrinkled/Tight. The outcomes of the answer selections will be determined by aggregating the values of the responses provided by the individual. The equation is as follows: Furthermore, the result of the calculation will determine a person's skin type with the following scale as follows:
If the score is between 20 - 40, it is tight skin (T)
If the score is between 41 - 85, it is wrinkled skin (W)



Source : (Research Results, 2025)
Figure 12 Skin Aging tab page: Wrinkled Skin(W) vs Tight Skin(T)

f. Result Page

The results page will automatically display the results of the skin type classification based on the questionnaire answers given by the user after pressing the submit button. This page will display the form according to what is inputted, the results of skin type, information about skin type and treatment solutions. Let the set of questions in the Baumann questionnaire be denoted as:

$$Q = \{q_1, q_2, \ldots, q_n\} \quad (1)$$

Each question q_i belongs to one of the following four dimensions:

D_1: Oily (O) vs Dry (D)
D_2: Sensitive (S) vs Resistant (R)
D_3: Pigmented (P) vs Non-Pigmented (N)
D_4: Wrinkled (W) vs Tight (T)

Let $Q_j \subseteq Q$ be the subset of questions associated with dimension D_j where j = 1, 2, 3, 4.

Each question $q_i \in Q$ has an answer $r_i \in \{a, b, c, d, e\}$ and is mapped to a numerical score s_i as follows:

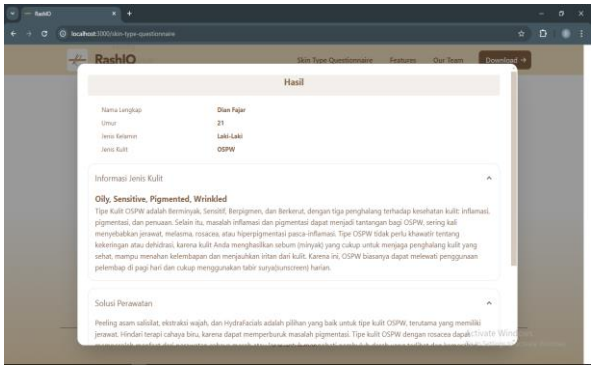
$$f(r_i) \begin{cases} 1 \;\; if \; r_i = a \\ 2 \;\; if \; r_i = b \\ 3 \;\; if \; r_i = c \\ 4 \;\; if \; r_i = d \\ 2.5 \; if \; r_i = e \end{cases} \quad (2)$$

The score for dimension D_j is calculated as the average of all scores from the questions associated with that dimension:

$$S_j = \frac{1}{|Q_j|} \sum_{q_i \in Q_j} f(r_i) \quad (3)$$

After computing S_1, S_2, S_3, and S_4, a 4-letter skin type code is assigned by concatenating the dominant traits of each dimension. For example:

$$Skin\ Type = D_1 D_2 D_3 D_4$$



Source : (Research Results, 2025)

Figure 13 Result Page

4) System Testing

At this stage, testing will be carried out on the system that has been developed. Testing is done using the Black Box Testing method to test the functionality of the system.

Table 1 Black Box Testing of the System

No	Testing Scenario	Expected Results	Test Results
1	The user wants to classify the skin type by pressing the Skin Type Questionnaire menu on the navbar.	The user is directed to the Baumann skin type questionnaire page.	Successful
2	User selects the Oily vs Dry tab section	The system displays all questions and answer options related to skin hydration from the Baumann questionnaire.	Successful
3	User selects the Sensitive vs Resistant section tab	The system displays all questions and answer options related to skin sensitivity from the Baumann questionnaire.	Successful
4	User selects the Pigmented vs. Non-pigmented section tab	The system displays all questions and answer options related to skin pigmentation from the Baumann questionnaire.	Successful
5	User selects the Wrinkled vs Tight section tab	The system displays all questions and answer options related to skin aging from the Baumann questionnaire.	Successful
6	The user has inputted the form fields and filled in all the answers to all the questionnaire questions provided on each tab.	The user can press the submit button, then be directed to the results page which contains inputted data	Successful
7	The user has filled in the answers to all the questionnaire questions, but did not input the form fields provided in the skin type questionnaire page.	Cannot press the submit button.	Successful
8	The user has inputted the form fields, but has not	Cannot press the submit button.	Successful

Accredited Rank 2 (Sinta 2) based on the Decree of the Dirjen Penguatan RisBang Kemenristekdikti No.225/E/KPT/2022, December 07, 2022. Published by LPPM Universitas Nusa Mandiri

VOL. 11. NO. 3 FEBRUARI 2026
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
DOI: 10.33480/jitk.v11i3.5724

No	Testing Scenario	Expected Results	Test Results
	filled in the answers to all the questionnaire questions provided on each tab.		

Source : (Research Results, 2025)

5) Maintenance

At this last stage, researchers will make modifications and improvements to the system after it is developed if problems occur during the run of the system, with the aim of increasing output, fixing problems, and improving website performance and quality.

CONCLUSION

This study successfully developed a web-based facial skin type classification system utilizing Baumann's Skin Type Indicator (BSTI). The system addresses the growing need for personalized skincare solutions by offering more accurate skin type identification compared to conventional methods. By classifying skin into 16 unique types based on hydration, sensitivity, pigmentation, and aging, the system enables users to make informed decisions about their skincare routine. Using the Waterfall development methodology, the system was built through structured phases, from requirements analysis to testing and maintenance. Testing via the Black Box method demonstrated that the system performed accurately and reliably in all functional scenarios. Users were able to navigate the platform, input their skin characteristics, and receive tailored skincare recommendations based on their specific skin type.

However, despite its successful implementation, the system has some limitations, particularly in its lack of real-time skin analysis capabilities. The current system relies on user-input data via a questionnaire, which may not capture immediate changes in skin condition. Upcoming developments aim to transform the system by incorporating cutting-edge technologies. Potential enhancements include AI-driven facial recognition for automatic skin condition assessment and mobile application development with real-time monitoring capabilities. These innovations demonstrates the immense potential of technology in healthcare personalization, bridging the gap between sophisticated skin analysis and user-friendly digital solutions. As the system evolves, it promises to deliver more dynamic, accurate, and accessible skincare guidance, ultimately improving individual skincare outcomes and user experience.

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