



Optimizing Consistency and Efficiency of Simakip's Frontend Architecture Through Implementation of Atomic Design Method

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Abstract—The Research and Community Service Performance Management System (SIMAKIP) is a centralized website that facilitates UHAMKA academicians to report research and community service activities periodically, by submitting valid research and scientific publications to the ristekdikti website for performance assessment. The problem is that centralized information systems have a wide range of feature complexity, making it important to ensure design consistency and efficiency of interface component development. To address the problem, the implementation of an atomic design approach is used as an innovative method that utilizes reusable modular components in five stages namely atom, molecule, organism, template and page for structured and integrated component development across the application. The purpose of this research is to improve the frontend architecture of SIMAKIP UHAMKA to optimize the performance of the development team and SIMAKIP as a whole, which will contribute to the advancement of research and community service within the academic community. Based on User Acceptance Test (UAT) testing by conducting 10 test cases to 10 participants, it was found that the overall SIMAKIP frontend architecture achieved a percentage of conformity of 95.96% in the Very Good category. These results prove the success of the atomic design approach to the consistency and efficiency of UHAMKA SIMAKIP and have the potential to become a model for other institutions as well as a reference for research in the field of other academic information systems.

Keywords: Architecture; Atomic Design Approach; Frontend; Implementation; Information System

1. INTRODUCTION

Human life continues to be faced with rapid technological advances [1]. Various kinds of existing technologies have made human life easy and fast. With technology, humans can work, interact and even get various information from the surrounding environment to environments that are beyond their reach [2]. Information technology is one of the many technologies that are highly developed [3]. Generally, information technology includes the design, planning, development, deployment, and management of computer-based information systems, focusing on applications and software [4].

Information can be obtained with an information system. Information systems are human interactions with information technology that can be accessed universally and flexibly, anytime and anywhere. One of the information systems that is widely used in this digital era is a web-based information system or commonly known as a website [5]. Website is an application that is widely used for data management, communication, and transactions. Many sectors in the world such as Economics, Government, to the Education sector utilize websites [6]. This supports the importance of using the website and makes it very central, because an organization or agency needs to know, examine and process data in its operational management, so that later it can have an impact on increasing the effectiveness and efficiency of system functionality.

However, despite its benefits, centralized web systems face a particular challenge in maintaining consistency across interfaces [7]. The menu in one page interface can be found again in a different page interface in the same application. This certainly needs to be considered so that the implementation in a complex website continues to run effectively and efficiently [8]. In the process, the menu in an application must be displayed consistently, so it is important to pay attention to the system design side of a website [9]. Design system is a set of style guidelines that regulate interface design by bringing together many components that make their use reusable when developing a product, based on fixed and clear criteria from an organization or agency. In the process, the development team must pay attention to the design system according to the standardization that is integrated as a design pattern. This is an important step so that the website can provide a cohesive, appropriate and intuitive service [10].

The Research and Community Service Performance Management System (SIMAKIP) is a centralized website that facilitates UHAMKA academics to report their research and community service activities. The system periodically sends research and scientific publications that have been validated to the ristekdikti website for performance assessment. Thus, it is necessary to build an information system for management that can process data effectively and efficiently due to its complex features and menus. So there are several problems found, namely first, the development team is constrained in making a consistent page interface because it is limited to the absence of system design guidelines.



The second obstacle, making components takes longer because the development team is only fixated on styling the design of each component element one by one according to the style of each individual which causes inconsistency in the page interface. Third, there are obstacles in producing an effective and efficient website. With reusable components, the resulting interface will be consistent and can make it easier and faster for the development team to work on the application, because there is needs to create visual components from scratch and can directly use pre-made components [11].

Consistency in the page interface can also be achieved through the implementation of a good design system, one way is with the innovative Atomic Design approach [12]. The application of Atomic Design on the website can help the page interface to be harmonious and intuitive so that information can be conveyed more clearly effectively and efficiently [13].

Study “Implementation Principles of Components” is a chapter in the book ‘Vue.js Framework’ written by HcySun Yang, published in September 2023. The basic principles in component development using the Vue.js framework, including the concept of reusable components, state management, and best practices in modern web application development. Modularity and separability are important in component development to improve code efficiency and maintainability. “By separating business logic from presentation, components become easier to test and reuse in various application contexts.”

This chapter provides practical guidance for developers who want to utilize the full potential of Vue.js in building dynamic web applications [14]. “Design and Implementation of Dashboards in Healthcare” is a chapter in the book Implementation Science written by Kristiana Ludlow and Johanna Westbrook in 2022. Dashboards can be a solution for integrating fragmented data collected by healthcare. Isolated data is transformed into meaningful information that can be accessed quickly and easily understood to support decision-making and quality improvement activities from the common features of dashboard design and potential uses of dashboards.

Several key factors facilitate and hinder effective dashboard implementation: ease of use, accessibility and alignment with current workflows [15]. “Factory Information System Implementation” is a chapter in the book “Factory Information Systems: Design and Implementation for CIM Management and Control” written by John Gaylord in 2020. Factory information systems are effective for computer integrated manufacturing (CIM) management. Development includes structured system analysis, product tracking and control, and plant information system implementation. Provides guidance for individuals involved in the development and improvement of manufacturing systems. “This book tells how to develop a successful factory information system to manage and control computer integrated manufacturing (CIM) operations.” [16]. “Hybrid Atomic-Scale Interface Design for Materials Functionality” is a study published in a book by Ajit K. Roy in 2021. Hybrid methods are used to optimize the properties of materials by manipulating atomic-scale interfaces to improve material functionality. This research makes a significant contribution to advancements in technology [17]. “System Design” is a chapter in the book “Airborne Circularly Polarized SAR: Theory, System Design, Hardware Implementation, and Applications” written by Josaphat Tetuko Sri Sumantyo and published in 2023. A synthetic aperture radar (SAR) system for environmental monitoring applications, covering the basic theory, hardware design, and software implementation required to build an efficient SAR system. The modular design and data processing efficiency of SAR radar systems using design principles can be customized for a variety of different applications [18].

Although previous studies discussed information systems in various fields such as manufacturing, materials, healthcare and remote sensing, most of these studies focused more on technical aspects and modular principles without further exploration in system design. Meanwhile, the focus on system design, especially in the context of academic information management systems, especially on frontend architecture through the development of consistent and structured interface components, is rarely found in the discussion of academic information system literature. In fact, an information system has high complexity from the many diverse features. Currently, the implementation of innovative approaches such as Atomic Design, which emphasizes the use of reusable components to create consistent and efficient interfaces, is still not widely applied. Therefore, this research seeks to fill the void by applying the Atomic Design method to the development of component-based frontend interfaces for web-based information systems such as SIMAKIP UHAMKA.

The purpose of this research is to implement the Atomic Design method in developing the frontend interface components of SIMAKIP UHAMKA, so that it is expected to make a new contribution in creating a more consistent and structured interface design. In addition, this research also aims to improve the frontend architecture through the use of reusable components, which provides a solution to the problem of interface inconsistency, as well as speeding up the development time of the UHAMKA SIMAKIP system.

2. RESEARCH METHODOLOGY

The data acquisition in this research used a qualitative approach, which is a research method to obtain data in the form of words, or sentences, which are relevant to the research to be analyzed, such as responses and opinions based on perspectives through interviews [19]. The quantitative approach is a data collection method that involves numerical analysis of surveys through tests and questionnaire statements [20]. For the system design in this

research, it is guided by the atomic design approach. The stages of the research methodolog in this study can be seen in Figure 1 below:

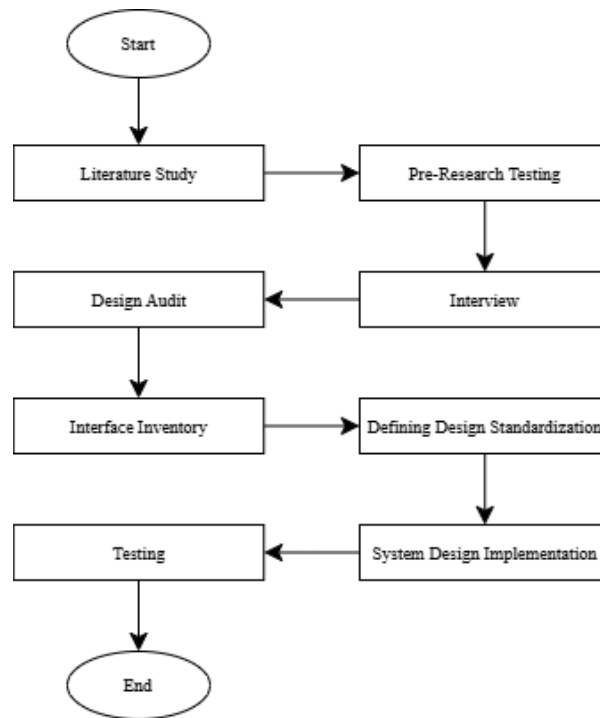


Figure 1. Research Methodology

2.1 Literature Study

The first step was to collect data through articles, books and journals. Relevance to research becomes the main focus of the theoretical basis [21]. The author collected data from Scopus database and trusted web with relevance to design methodology and system interface. These insights defined the research objectives and guided the methodology, especially in adopting an atomic design approach for SIMAKIP UHAMKA.

2.2 Pre-Research Testing

Pre-research testing is a stage carried out to identify problem points. Conducted with the scenario of giving tasks to the SIMAKIP website development team, namely making the login page with the measurement metric is the time to complete the task [22]. The results will be used as reference variables for post-research testing.

2.3 Interview

The next stage is to collect data through interviews. Interview is a method of thorough observation related to the object under study by involving the subjective views of the sources [23]. In this case, interviews were conducted face-to-face with the resource persons, namely the website development team, designers and stakeholders of SIMAKIP UHAMKA who are involved in the project, and have experience in the field of website development and design with the topic measured is interface consistency.

2.4 Design Audit

This stage audits one of the existing designs. This is done by bringing together all the components of the UHAMKA SIMAKIP website interface. After that, the components are classified based on their elements. This aims to ensure consistency and overcome problems on the website display [24].

2.5 Interface Inventory

The next step is to collect the components of the findings when auditing the design. Buttons, icons and other elements are collected specifically based on their type. Later, the results of this interface inventory will be used as a provision for the components that make up the interface [25].

2.6 Defining Design Standardization

At this stage is the determination of the styling guide as a standard for the components that have been classified previously [26]. In this case, atomic design is set as the style guide for the design standard. Atomic design is a method developed and introduced by Brad Frost inspired by chemical elements using the periodic table [27]. Known as an effective guide for developers and designers in creating coherent and maintainable systems, it consists

of five hierarchical elements, starting from the smallest component, the atom, to a page [28]. To implement it, the author uses ReactJS to build a component-based architecture and Tailwind CSS as styling. The integration of Tailwind CSS makes it possible to maintain design consistency through utility-first classes, while React's modular component system supports the Atomic Design hierarchical structure.

HIERARCHY OF ATOMIC DESIGN

The five stages are:

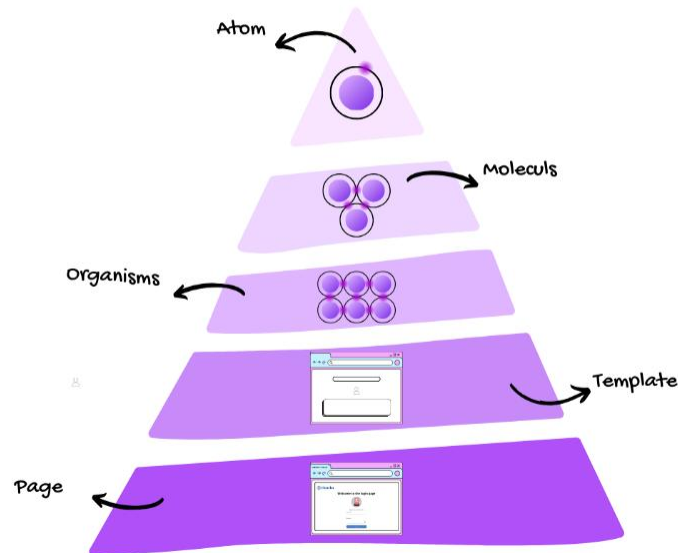


Figure 2. Hierarchy of Atomic Design Methods

In Figure 2, the implementation process of the five elements of the hierarchy begins by organizing components based on the classification of the design audit as follows:

First Atom, this element is the most basic and smallest component of an interface, it is the foundation. Such as buttons, icons, typography, and text labels. For example, buttons with different styles are standardized using the Tailwind class and stored in separate button component files in the atom directory. The second hierarchy is Molecule, which is a group of atoms that combine to form a basic component with the same functionality. For example, when labels, input forms, icons, and buttons are combined, they become a molecule. The third hierarchy is Organism, which is a collection of molecules and even atoms that have different functions, but are still in the same layout. Examples such as search bar (molecule), logo (atom) and navigation (molecule) placed in the header. The next hierarchy is Template, which is a combination of several organisms, such as wireframes, as a design layout on a web page. The last hierarchy is Page, which is the final result, there is real content with coloring, images and others that make the interface clear and understandable the meaning contained in it.

Design audits play an important role in determining style standards. For example, font styles are extracted from existing designs, thus correcting inconsistencies. Audit findings are mapped into Tailwind's folder structure and configuration, to ensure consistency and reuse across the system.

This approach streamlined the development process, ensuring all components aligned with the visual and functional requirements of the project. By combining Atomic Design, ReactJS, and Tailwind CSS, the styling guide provides a robust and maintainable framework for the development of UHAMKA's SIMAKIP frontend architecture.

2.7 System Design Implementation

In the website system design implementation stage, this is the process of applying the atomic design concept described earlier. Starting from forming the smallest component to become a coherent website interface page [29]. This stage marks the completion of the research and application of the design concept that has been implemented.

2.8 Testing

The last stage is testing by giving 10 Likert scale-based questionnaire instruments related to aspects of interface consistency and design efficiency to the development team, designers and stakeholders with a total of 10 participants on the implementation of atomic design on the UHAMKA SIMAKIP website. Testing is carried out with a scheme of participants completing certain tasks on the website and providing feedback according to their respective experiences on the aspects measured. The goal to be achieved is whether the pattern and style library used is in accordance with the needs of the development team or not. The method used during testing is the User

Acceptance Test (UAT). The success of UAT is measured based on the percentage of system conformity to the needs that will be described in detail in the results and discussion section.

3. RESULT AND DISCUSSION

3.1 Pre-Research Testing

In this pre-research test phase, namely testing the development team to create login page. Broken down into several tasks, can be seen in the following Table 1:

Table 1. Pre-Research Test Task Completion Time

Descriptions	Duration
Task 1	30 minutes 15 seconds
Task 2	38 minutes 45 seconds
Total	1 hour 9 minutes
Average	34 minutes 30 seconds

Table 1, the pre-research test task completion results. From the table, the average completion time for the task scenario during the pre-research test is 34 minutes 30 seconds. The author will use this data as a comparison variable in the post-research testing phase.

3.2 Interview

This stage, which is to identify problems face-to-face to discuss with the development team, designers and stakeholders regarding views related to the object under study. As a result, data was obtained in the form of the appearance of the previous UHAMKA SIMAKIP website.

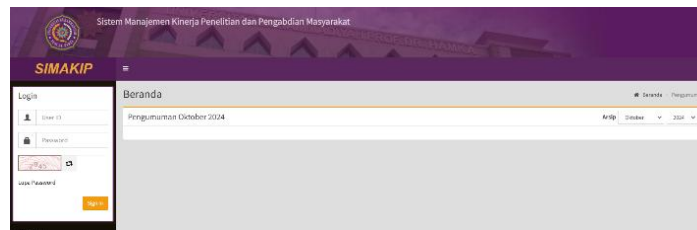


Figure 3. Display of the Previous SIMAKIP Website

Figure 3 is the appearance of the login page on the previous UHAMKA SIMAKIP website. The author makes this data the basis for classifying components to implement atomic design, so that each component on the website interface page is reusable and produces a coherent appearance. From the analysis of the previous discussion, the results are described in the table below:

Table 2. Results of the Interview

No	Interview Results
1	The development team is fixated on working on components one by one following the style of each individual, which often causes conflicts when code unification is carried out.
2	There is no guidance in component styling which makes the interface incoherent
3	Component manufacturing is still done from scratch so the process is time-consuming

3.3 Design Audit

Auditing the design of a website is an important process. In determining the components, everything is categorized based on equivalence. This is aimed at finding design problems such as incoherent visual design.

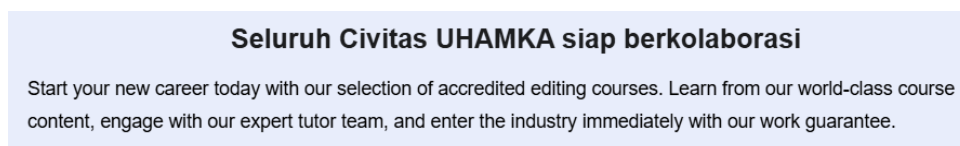


Figure 4. Typography Audit

3.4 Interface Inventory

Design audits play an important role in design standardization to ensure the coherence of each component of the website interface, including differences in color and style of elements. These findings will serve as a style guide for interface inventory where components, such as buttons, are classified and redefined using atomic design

methodology and standardized using Tailwind classes to ensure consistency [30]. An example here is the dropdown button and add button on the SIMAKIP UHAMKA website in Figure 5 below:

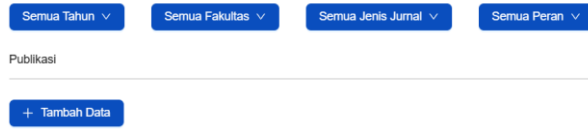


Figure 5. Button Inventory

3.5 Defining Design Standardization

Design standardization is done to ensure the coherence of each website interface component. The results of the design audit are translated into an atomic design-based component hierarchy in the folder structure stage as a guide in placing an interface component [31]. This structure ensures that each element that has been redefined during the inventory is placed according to its category, from atoms to pages. For example, logo and typography elements are stored in the atom folder, search bar and login form are grouped in the molecule directory. The structure of the component folders is as shown in Figure 6 below:

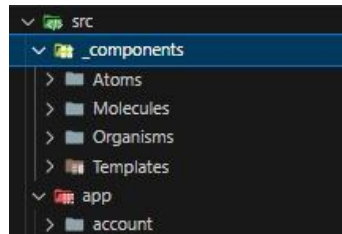


Figure 6. Folder Structure with Atomic Design Method

With a standard like this, the development team gets a reference so that the components created are appropriate and aligned based on predetermined provisions [32]. The results of the previous stage also support the organize perceptual pattern process, which identifies key visual patterns during the audit (such as typography and color) as basic elements in the design. In addition, the audit results also help in organizing functional patterns, by documenting components in libraries that can be reused by the development team [33].

The integration of these results ensures that each stage in the process, from audit to library documentation, runs cohesively. Thus, the atomic design methodology not only corrects inconsistencies but also creates a strong guide for the development of the UHAMKA SIMAKIP website interface.

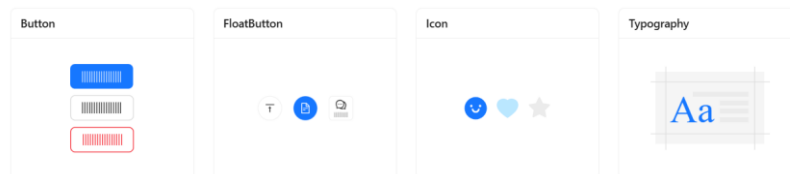


Figure 7. Library and Interface Components with Atomic Design Method

3.6 System Design Implementation

At this stage, start applying the atomic design method by outlining the design components. Arranged according to categories and combined with other components to form interface pages [34]. For example, here the author uses the login display of the SIMAKIP UHAMKA website. According to the basic data at the time of observation for the explanation of the elements of atoms, molecules, organisms, templates, to pages, to form an interface: First, Atom, The first component is the atom, which is the category of basic components that make up the interface, as shown below:

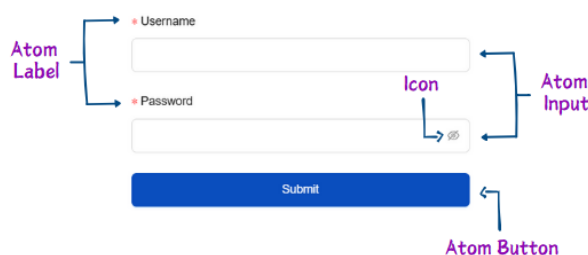


Figure 8. Atom Components on the UHAMKA SIMAKIP Website Login Page

Figure 8 shows the atomic components used on the SIMAKIP UHAMKA website, including labels, text inputs, buttons, and icons. These basic elements form the foundation of reusable and more complex components, ensuring design consistency.

Secondly, Molecules, Molecules are the combination of several atoms that make a functional unit with the same purpose, as shown below:

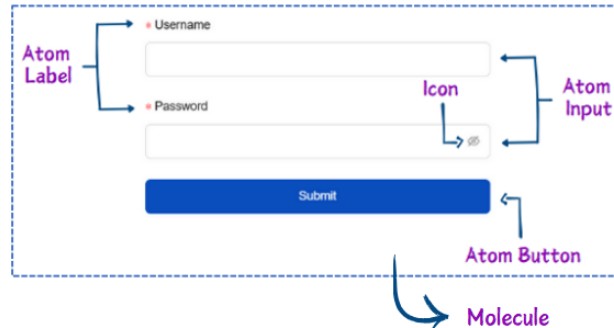


Figure 9. Molecule Components on the Login Page of the UHAMKA SIMAKIP Website

Figure 9 is a combination of several atomic components including labels, text input, buttons, and icons. The combination of these components forms a login form molecule to provide complete information about what the user must do when logging into the SIMAKIP UHAMKA website.

Next is the Organism. Organism is a more complex interface element, consisting of a combination of molecules and atoms and visual elements that form one part of a functional whole, as shown below:

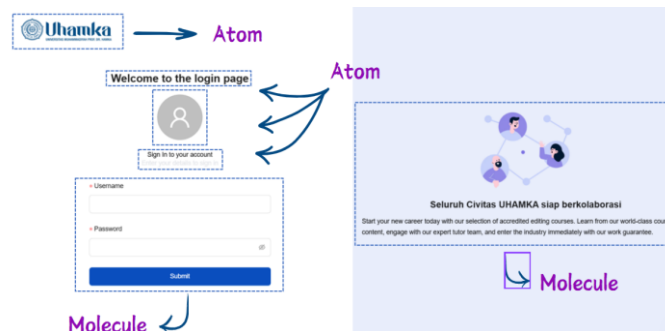


Figure 10. Organism Component on the Login Page of the UHAMKA SIMAKIP Website

Figure 10 is a combination of atoms including avatars, heading “Welcome to the login page”, placeholders and molecules including the login form, as well as visual and text elements on the right side that form a more complex interface on the SIMAKIP UHAMKA website. Then Templates. A template is a set of organisms that defines the layout of a page, as shown below:

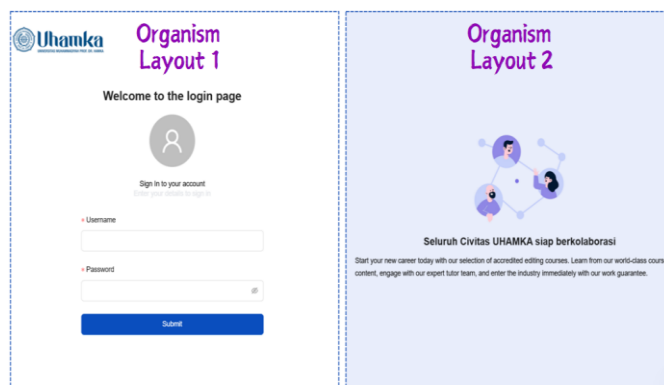


Figure 11. Components of UHAMKA SIMAKIP Website Login Template.

Figure 11 is a template of the UHAMKA SIMAKIP login page, which integrates the arrangement of the organisms on the right side, the visual elements and application description, with the organisms on the left side, the login form, to ensure a cohesive and informative interface.

Finally, there is the Page. Page is the display of the final results of the entire interface complete with content consisting of templates, organisms, molecules, and atoms with the same goal of forming a ready-made login page interface, as shown below:

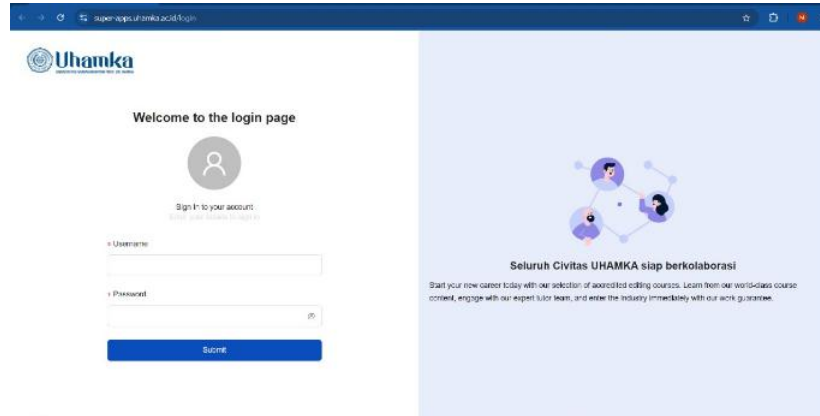


Figure 12. Login Page of the UHAMKA SIMAKIP Website

Figure 12 is the final view of the login page on the SIMAKIP UHAMKA website complete with content. The preparation process uses the atomic design method. After describing the stages of preparing components from basic to complex components, the following are some views of the interface pages of the SIMAKIP UHAMKA website application with the implementation of atomic design:

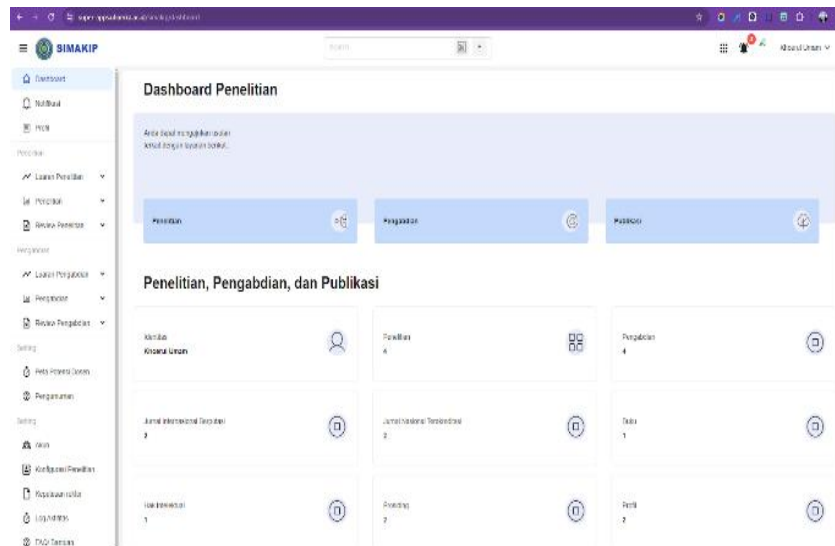


Figure 13. Dashboard Page of the UHAMKA SIMAKIP Website

Figure 13 is a view of the dashboard page on the UHAMKA SIMAKIP website. The display is equipped with navigation and sidebar. The content contains information and the preparation process uses the atomic design method.

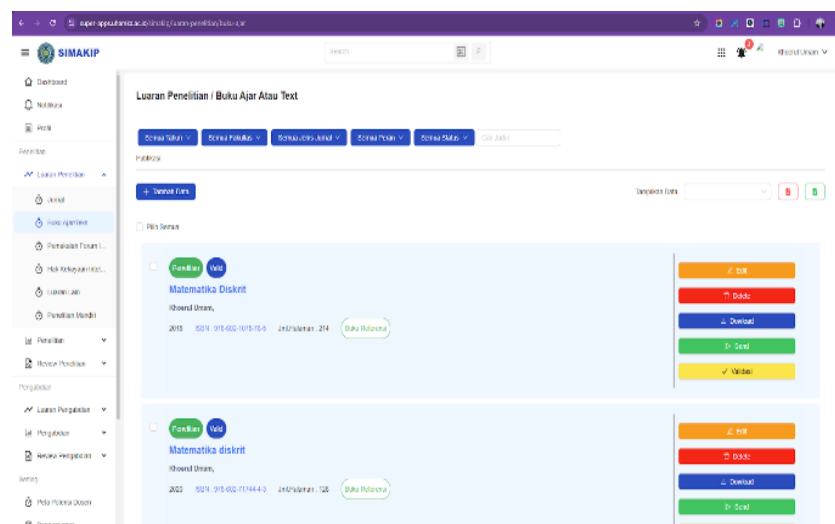


Figure 14. Textbook Page on the Research Output Menu of the UHAMKA SIMAKIP Website

Figure 14 is a view of the research output menu page. The menu displayed is the Textbook. The arrangement of the content in it uses the atomic design method so that the interface is coherent.

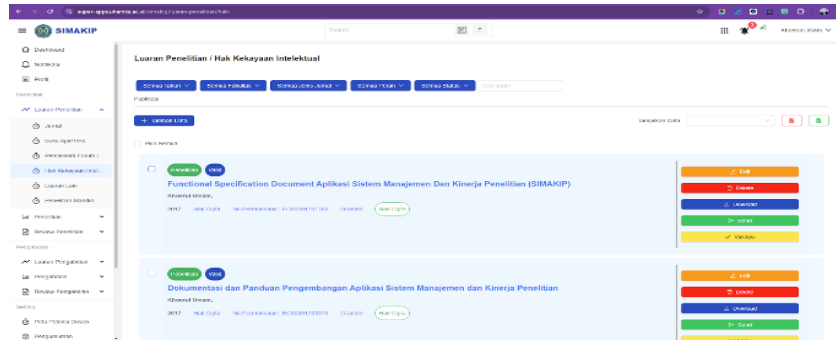


Figure 15. Intellectual Property Rights Page on the Research Output Menu of the UHAMKA SIMAKIP Website

Figure 15 is a display of the research output menu page, namely Intellectual Property Rights. The arrangement of the content in it uses the atomic design method. It can be seen that the overall appearance of the Intellectual Property Rights interface is coherent with the Textbook. This proves that, the development of interface components with an atomic design approach is effective and efficient, because any existing components can be reused and the development team does not need to create from scratch again.

3.7 System Design Testing

In this study, system design testing was carried out using the User Acceptance Test (UAT) method. UAT is a test that is carried out by interacting directly by end-users, namely the development team, designer team and stakeholders to ensure that the components function properly [35]. The following is the weight of the UAT test assessment in table 3.

Table 3. UAT Test Value Weight

Value	Description
5	Strongly Agreed (SA)
4	Agree (A)
3	Moderately Agreed (MA)
2	Disagree (D)
1	Strongly Disagreed (SD)

This application testing was carried out by 6 development teams, 3 designer teams and 1 stakeholder, with the following results:

Table 4. Assessment Recapitulation

No	Question	Percentage of Assessment (Score)				
		5	4	3	2	1
1	Is it easy to use the application?	50%	50%	0%	0%	0%
2	Is the menu position easy to reach?	40%	40%	20%	0%	0%
3	Has the suitability of the functions and menus in the application been achieved?	50%	40%	10%	0%	0%
4	Is the color scheme used consistent throughout the page?	40%	60%	0%	0%	0%
5	Are the font size, type, and style consistent across the app?	40%	50%	10%	0%	0%
6	Are the navigation elements clear and easy to use throughout the app?	30%	40%	20%	0%	0%
7	Do all interactive elements, such as buttons or links, appear in a consistent style?	40%	50%	10%	0%	0%
8	Does each page have a clear and relevant title at the top?	30%	30%	40%	0%	0%
9	Are the icons and other graphic elements easily recognizable and consistent?	60%	40%	0%	0%	0%
10	Does the overall layout of the interface look consistent across all pages?	90%	50%	10%	0%	0%

The test results shown in Table 4, show the percentage level of system suitability. It is obtained by dividing the total assessment score and the highest score of the scale. Next is, setting the Likert scale boundaries. From bad



to excellent criteria. With a percentage to measure the value of the interface whether it is good or not. The measurement method is as follows:

$$I = \frac{100\%}{\text{Number of Likert Scale}} \tag{1}$$

With I being interpretation. It is an inferred opinion about something. Expressed for ease of understanding [36].

$$I = \frac{100\%}{5} = 20\%$$

Using the lowest rated of 0% and the highest rated of 100%, an interval scale was created as shown in table 5 below:

Table 5. Scale Assessment Measure

No	Scale	Rate (%)
1	Very Good	81-100
2	Good	61-80
3	Average	41-60
4	Less Good	21-40
5	Poor	0-20

After knowing the assessment interval, the last stage is the measurement of the suitability of the resulting interface [37]. From these measurements, the results will be compared with the assessment interval table. The goal is to find out how the interface suitability results are obtained. The measurement is as follows:

$$\text{Suitability} = \frac{\text{Total Score}}{\text{Highest Score}} \times 100\% \tag{2}$$

$$\text{Suitability} = \frac{451}{470} \times 100\% = 96,95\%$$

Based on the results of testing using the User Acceptance Test (UAT) conducted by 10 respondents, it shows a percentage level of suitability of 95.96%. When compared to the assessment interval, it falls into the EXCELLENT category. From these results it can be concluded that Optimizing Consistency and Efficiency of Simakip’s Frontend Architecture Through Implementation of Atomic Design Method is in accordance with the research objectives. This successful implementation of atomic design in SIMAKIP demonstrates its potential to improve interface consistency and efficiency in other academic or enterprise web applications. Future research can explore its ability to adapt to platforms with greater complexity.

4. CONCLUSION

Based on the results of research on the implementation of the design system on the SIMAKIP UHAMKA website using the atomic design method, it produces product elements consisting of perceptual patterns which include typographic components and functional patterns which include components such as forms, pagination, icons, buttons and tabs. All of them are components that make up the interface of a page on the website, which has been confirmed using the UAT testing method, namely with the scenario of providing ten questionnaire survey instruments tested on 10 respondents and the results are proven by the suitability value which reaches a percentage of 95.96% in the Very Good category. This means that the frontend architecture of SIMAKIP UHAMKA has improved based on the application of system design on the website which has an impact on the effectiveness and efficiency of system performance. Therefore, it can be concluded that the implementation through the atomic design method on the SIMAKIP UHAMKA website is successful and has brought significant improvements to the frontend architecture because the main objective of consistency on each interface page is achieved as well as increased effectiveness and efficiency from the use of standardized guidelines and component elements that have an impact on the development team in developing fronted interface components. The success of this approach shows that atomic design methods can be effectively applied to other academic or enterprise systems that require interface consistency and development efficiency. The output of this implementation is a pattern library and style guide.

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REFERENCES

- [1] J. C. Bauer and M. Wolff, “The Deinstitutionalization of Business Support Functions through Artificial Intelligence,” *Information (Switzerland)*, vol. 13, no. 8, 2022, doi: 10.3390/info13080352.
- [2] T. Praveena and R. L. N. Raju, “Achieving Environmental Harmony: An Analysis Based on the Narratives From Mahabharata,” *Theory and Practice in Language Studies*, vol. 13, no. 2, 2023, doi: 10.17507/tpls.1302.19.
- [3] P. Mesároš, T. Mandičák, and A. Behúnová, “Use of BIM technology and impact on productivity in construction project management,” *Wireless Networks*, vol. 28, no. 2, 2022, doi: 10.1007/s11276-020-02302-6.
- [4] D. Y. Park, J. Choi, S. Ryu, and M. J. Kim, “A User-Centered Approach to the Application of BIM in Smart Working Environments,” *Sensors*, vol. 22, no. 8, 2022, doi: 10.3390/s22082871.
- [5] X. Zhai, X. Wang, A. Han, J. Tong, Y. Nie, and Y. K. Xu, “Identification and simulation of key influencing factors of online health information service quality from the perspective of information ecology,” *Libr Inf Sci Res*, vol. 45, no. 1, 2023, doi: 10.1016/j.lisr.2022.101218.
- [6] D. P. Sakas, D. P. Reklitis, M. C. Terzi, and C. Vassilakis, “Multichannel Digital Marketing Optimizations through Big Data Analytics in the Tourism and Hospitality Industry,” *Journal of Theoretical and Applied Electronic Commerce Research*, vol. 17, no. 4, 2022, doi: 10.3390/jtaer17040070.
- [7] I. Yaqoob, K. Salah, R. Jayaraman, and Y. Al-Hammadi, “Blockchain for healthcare data management: opportunities, challenges, and future recommendations,” *Neural Comput Appl*, vol. 34, no. 14, 2022, doi: 10.1007/s00521-020-05519-w.
- [8] D. Pickering, A. Serafimovska, S. J. Cho, A. Blaszczynski, and S. M. Gainsbury, “Online self-exclusion from multiple gambling venues: Stakeholder co-design of a usable and acceptable self-directed website,” *Internet Interv*, vol. 27, 2022, doi: 10.1016/j.invent.2021.100491.
- [9] X. Xu, H. H. Deng, J. Gateno, and P. Yan, “Federated Multi-Organ Segmentation With Inconsistent Labels,” *IEEE Trans Med Imaging*, vol. 42, no. 10, 2023, doi: 10.1109/TMI.2023.3270140.
- [10] D. Park, W. C. Yoon, and U. Lee, “Cognitive states matter: Design guidelines for driving situation awareness in smart vehicles,” *Sensors (Switzerland)*, vol. 20, no. 10, 2020, doi: 10.3390/s20102978.
- [11] G. L. Zhuang, S. G. Shih, and F. Wagiri, “Circular economy and sustainable development goals: Exploring the potentials of reusable modular components in circular economy business model,” *J Clean Prod*, vol. 414, 2023, doi: 10.1016/j.jclepro.2023.137503.
- [12] S. J. Niepostyn and W. B. Daszczuk, “Entropy as a Measure of Consistency in Software Architecture,” *Entropy*, vol. 25, no. 2, 2023, doi: 10.3390/e25020328.
- [13] M. Nkadameng and P. Ankiewicz, “The Affordances of Minecraft Education as a Game-Based Learning Tool for Atomic Structure in Junior High School Science Education,” *J Sci Educ Technol*, vol. 31, no. 5, 2022, doi: 10.1007/s10956-022-09981-0.
- [14] H. Yang, Implementation Principles of Components, 2023, doi: 10.1007/978-981-99-4947-2_12.
- [15] K. Ludlow and J. Westbrook, “Design and implementation of dashboards in healthcare,” in *Implementation Science*, 2022, pp. 142–144, doi: 10.4324/9781003109945-42.
- [16] J. Gaylord, “Factory Information System Implementation,” in *Factory Information Systems*, 2020, pp. 213–234, doi: 10.1201/9781003065418-8.
- [17] A. K. Roy, “Hybrid material design issues and challenges for materials functionality for microdevices,” in *Hybrid Atomic-Scale Interface Design for Materials Functionality*, 2021, pp. 1–17, doi: 10.1016/b978-0-12-819117-0.00011-5.
- [18] J. T. S. Sumantyo, System Design, 2023, doi: 10.1201/9781003282693-3.
- [19] L. Busetto, W. Wick, and C. Gumbinger, “How to use and assess qualitative research methods,” 2020. doi: 10.1186/s42466-020-00059-z.
- [20] Haudi *et al.*, “The role of e-marketing and e-crm on e-loyalty of indonesian companies during covid pandemic and digital era,” *Uncertain Supply Chain Management*, vol. 10, no. 1, 2022, doi: 10.5267/j.uscm.2021.9.006.
- [21] C. M. Dieteren, N. J. S. Patty, V. T. Reckers-Droog, and J. van Exel, “Methodological choices in applications of Q methodology: A systematic literature review,” *Social Sciences and Humanities Open*, vol. 7, no. 1, 2023, doi: 10.1016/j.ssaho.2023.100404.
- [22] R. Sin, T. Harris, S. Nilsson, and T. Beck, “Dark patterns in online shopping: do they work and can nudges help mitigate impulse buying?,” *Behavioural Public Policy*, pp. 1–27, May 2022, doi: 10.1017/bpp.2022.11.
- [23] M. D. C. Reñosa *et al.*, “Selfie consents, remote rapport, and Zoom debriefings: Collecting qualitative data amid a pandemic in four resource-constrained settings,” *BMJ Glob Health*, vol. 6, no. 1, Jan. 2021, doi: 10.1136/bmjgh-2020-004193.
- [24] T. Gajewska and D. Walczyk, “Development of Transport Management Software,” *Sustainability (Switzerland)*, vol. 15, no. 15, Aug. 2023, doi: 10.3390/su151512083.
- [25] R. Rajkumar and V. Ganapathy, “Bio-Inspiring Learning Style Chatbot Inventory Using Brain Computing Interface to Increase the Efficiency of E-Learning,” *IEEE Access*, vol. 8, pp. 67377–67395, 2020, doi: 10.1109/ACCESS.2020.2984591.
- [26] B. Sun, Y. Chen, and L. Tang, “Research on formulation of data storage template of spark discharge atomic emission spectrometry,” *Yejin Fenxi/Metallurgical Analysis*, vol. 43, no. 4, pp. 90–95, Apr. 2023, doi: 10.13228/j.boyuan.issn1000-7571.011984.
- [27] M. Lugovy, V. Slyunyayev, and M. Brodnikovskyy, “Solid solution strengthening in multicomponent fcc and bcc alloys: Analytical approach,” *Progress in Natural Science: Materials International*, vol. 31, no. 1, pp. 95–104, Feb. 2021, doi: 10.1016/j.pnsc.2020.11.006.
- [28] O. R. Smits, P. Indelicato, W. Nazarewicz, M. Piibeleht, and P. Schwerdtfeger, “Pushing the limits of the periodic table — A review on atomic relativistic electronic structure theory and calculations for the superheavy elements,” 2023. doi: 10.1016/j.physrep.2023.09.004.



- [29] L. Chen, Y. Zhao, M. Li, L. Li, L. Hou, and H. Hou, “Reinforced AZ91D magnesium alloy with thixomolding process facilitated dispersion of graphene nanoplatelets and enhanced interfacial interactions,” *Materials Science and Engineering: A*, vol. 804, Feb. 2021, doi: 10.1016/j.msea.2021.140793.
- [30] S. S. Kamble, A. Belhadi, A. Gunasekaran, L. Ganapathy, and S. Verma, “A large multi-group decision-making technique for prioritizing the big data-driven circular economy practices in the automobile component manufacturing industry,” *Technol Forecast Soc Change*, vol. 165, Apr. 2021, doi: 10.1016/j.techfore.2020.120567.
- [31] M. Aghdasifam, H. Izadkhah, and A. Isazadeh, “A New Metaheuristic-Based Hierarchical Clustering Algorithm for Software Modularization,” *Complexity*, vol. 2020, 2020, doi: 10.1155/2020/1794947.
- [32] T. Wulfert, R. Woroch, G. Strobel, S. Seufert, and F. Möller, “Developing design principles to standardize e-commerce ecosystems: A systematic literature review and multi-case study of boundary resources,” *Electronic Markets*, vol. 32, no. 4, pp. 1813–1842, Dec. 2022, doi: 10.1007/s12525-022-00558-8.
- [33] V. M. Romero and E. B. Fernandez, “Towards a Reference Architecture for Cargo Ports,” *Future Internet*, vol. 15, no. 4, Apr. 2023, doi: 10.3390/fi15040139.
- [34] A. Wasilewski, “Functional Framework for Multivariant E-Commerce User Interfaces,” *Journal of Theoretical and Applied Electronic Commerce Research*, vol. 19, no. 1, pp. 412–430, Mar. 2024, doi: 10.3390/jtaer19010022.
- [35] J. Rahmadoni, R. Akbar, and R. Ulya, “ANALYSIS OF NAGARI MANAGEMENT INFORMATION SYSTEM EVALUATION (SIMNAG) USING PIECES AND UAT METHODS,” *Journal of Applied Engineering and Technological Science*, vol. 4, no. 1, pp. 512–521, Aug. 2022, doi: 10.37385/jaets.v4i1.1326.
- [36] K. Lord and S. Brown-Schmidt, “Temporary ambiguity and memory for the context of spoken language,” *Psychon Bull Rev*, vol. 29, no. 4, pp. 1440–1450, Aug. 2022, doi: 10.3758/s13423-022-02088-y.
- [37] J. Schreiter *et al.*, “A multimodal user interface for touchless control of robotic ultrasound,” *Int J Comput Assist Radiol Surg*, vol. 18, no. 8, pp. 1429–1436, Aug. 2023, doi: 10.1007/s11548-022-02810-0.