Development of an Interest- and Skill-Based Expert System for Student Career Decisions

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Abstract
This study examines an expert system for assessing student career paths based on interests and competencies. This approach is intended to assist Informatics Engineering students in identifying a career trajectory that aligns with their profile. This system is anticipated to be an effective solution, given the growing demand for students to receive pertinent career guidance, as numerous students encounter difficulty in selecting a career path that aligns with their competencies. This expert system is developed by aggregating data concerning students' interests and skills, thereafter processed through the forward chaining approach to align facts and rules inside the knowledge base. Furthermore, the certainty factor approach is employed to assess the degree of certainty for each career recommendation provided. The algorithm can generate pertinent career recommendations depending on the student profile and the degree of certainty of the results. The system is evaluated against expert suggestions to verify the accuracy and relevance of the outcomes. The testing of several datasets indicates that the algorithm can deliver career suggestions aligned with expert outcomes. The findings indicate that 100% of the test outcomes align with the validation results provided by experts. So, this system can be a useful tool that helps students choose a job path and can also help with career counseling at schools.

1. Introduction

Research from the Indonesia Career Center Network (ICCN) indicates that 87% of students in Indonesia acknowledge a misalignment between their chosen majors and their interests (Rahmasari et al., 2023). Selecting an appropriate career is a crucial decision that significantly influences students' future success and personal fulfillment, impacting financial stability and sustained motivation in the workplace, particularly within the increasingly intricate labor market and the evolution of diverse industrial sectors (Pratama et al., 2021). Consequently, it is essential for pupils to possess a thorough comprehension of their interests and abilities.

However, a primary problem encountered by students is the planning and identification of an appropriate career trajectory (Potensi et al., 2024). Students frequently struggle to identify the traits and requirements of the diverse job alternatives available. This deficiency in comprehension may result in errors while selecting a professional trajectory that aligns with your interests and competencies (Potential et al., 2024). Consequently, it is essential for students to recognize their potential, select a conducive educational trajectory, and cultivate pertinent skills to attain their aspired career (Kumala et al., 2024).

Despite receiving formal education in technology, not all Informatics Engineering students comprehend the prospective career paths that align with their abilities. Many students remain uncertain about their desired job paths, even being in the concluding phases of their education. This issue underscores the necessity for a career advice system that assists students in making more focused and educated job choices (Nurmasari, 2024). Interest plays a crucial part in shaping one's professional trajectory, as it influences an individual's motivation, performance, and skill development throughout their educational journey (Alfazani & A, 2021). Nonetheless, numerous students remain without access to resources or systems that facilitate their comprehension of the alignment between their occupations and their interests and skills (Zulfahmi, 2021). The lack of sufficient career guidance may lead students to select career pathways misaligned with their interests and abilities (Sari & Khairuddin, 2024). This may adversely affect job satisfaction and productivity in the future.

The expert system may serve as a solution to assist students in identifying suitable careers (Sapriadi et al., 2023). The expert system intends to deliver career recommendations through the examination of students' interests and competencies. The Knowledge Bases System-based technique can emulate the counselor's thought process to deliver suitable career suggestions (Sapriadi et al., 2023). The primary distinction between this study and prior studies is the incorporation of the Forward Chaining approach alongside the Certainty Factor to deliver career suggestions to students. Forward Chaining enables the system to directly query student data according to specific rules, yielding more deterministic and conclusive outcomes than fuzzy-based systems.

Simultaneously, the Certainty Factor is employed to address ambiguity in the formulation of career recommendations by quantifying the degree of confidence in the correlation between student input data (interests and talents) and suggested jobs (Yulianti et al., 2019). The amalgamation of these two methodologies aims to enhance result accuracy by synthesizing the strengths of deterministic logic and probabilistic measurement, hence yielding clearer and more dependable outcomes. This project seeks to create an Expert System for Career Determination of Informatics Engineering Students, utilizing interests and skills through the integration of Forward Chaining and Certainty Factor methodologies. This method is anticipated to deliver pertinent and precise career recommendations by mitigating ambiguities frequently encountered in the profession selection process. This approach enables students to acquire career information tailored to their interests and skills, thereby enhancing future work satisfaction and student productivity.

1.1 Literature Review

Previous research on student career determination has been conducted, as evidenced by the study by (Toibin S. and Purnomo, 2018). This study employs the Fuzzy Tsukamoto approach to examine student career interest data across multiple dimensions, including realistic, investigative, creative, social, enterprise, and conventional categories. The test findings indicated a system accuracy of 67%, with 33% of the data failing to align with the expert validation outcomes. This is affected by students' uncertainty on the ambiguous scale, and the accuracy remains comparatively low.

A study utilizing the Profile Matching approach within a computer-based psychological assessment system to align student occupations with interests (RIASEC) and personality traits (DISC) was undertaken by (Zulaika and Purnomo, 2023). The system evaluates the alignment of an individual's profile with career criteria via the GAP methodology. The test findings indicated a 90% validity of career recommendations relative to expert outcomes, demonstrating the system's correctness. This method facilitates fast career mapping and has the potential to enhance academic data integration for more comprehensive outcomes.

Research by (Simanjorang et al., 2024) established an expert system based on genetic algorithms to assist students in identifying careers that align with their personalities. The system employs optimization techniques like fitness evaluation, selection, crossover, and mutation to produce precise career suggestions. Case studies demonstrate that the system effectively assists students in selecting jobs efficiently, yielding optimal outcomes in the field of Administrative Staff (fitness score: 3205.1). This solution facilitates the consultation of careers and the management of guidance data efficiently.

2. Research Methods

This research develops an expert system as an alternative counseling medium for students who are uncertain about choosing the right career path based on their interests and skills. The data used in this research comprises the interests and skills of Information Technology students from the Institute of Technology and Business Asia Malang. The output of this system is career recommendations tailored to the students' profiles, obtained by gathering data on their interests and skills. The system employs the forward chaining method to draw conclusions from the gathered facts. The general system design is depicted in Figure 1.

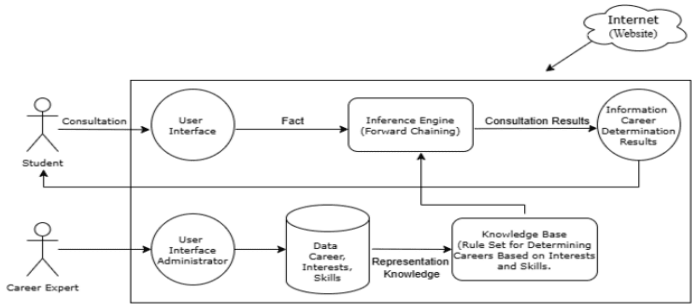

Fig. 1 System Design

2.1 Dataset

The dataset used in this research includes students' interests and skills, which are collected through questionnaires and relevant literature. Data from the questionnaires are validated by experts to ensure relevance and accuracy. The collected data is analyzed to determine the variables that influence students' career choices. These variables include interests and skills, which are processed into values for the expert system. The details of interests, skills, and careers are presented in Table 1.

Table 1. Variable for interests, Skills, and Career

No	Skill		Interest		Career	
	Code	Description	Code	Description	Code	Description
1	KEA01	HTML	MIN01	Pengembangan Web	KAR01	Frontend Web Developer
2	KEA02	CSS	MIN02	Pengembangan Mobile	KAR02	Backend Web Developer
3	KEA03	Javascript	MIN03	Data Science	KAR03	Fullstack Web Developer
4	KEA04	MySQL	MIN04	Analisis Basis Data	KAR04	Mobile App Developer
5	KEA05	MongoDB	MIN05	Pengolahan Big Data	KAR05	Data Science
6	KEA06	Flutter	MIN06	Digital Design	KAR06	Database Administrator
7	KEA07	Java	MIN07	Pengembangan Machine Learning	KAR07	Big Data Engineer
8	KEA08	Phyton	MIN08	Pengembangan Augmented Reality	KAR08	UI/UX Designer
9	KEA09	C++	MIN09	Pengembangan Augmented Reality	KAR09	Game Developer
10	KEA10	Unity	MIN10	Pengembangan Jaringan	KAR10	AR/VR Developer
11	KEA11	Corel Draw	MIN11	Cyber Security Jaringan	KAR11	Network Engineer
12	KEA12	Nodejs	MIN12	Pengembangan Game	KAR12	Machine Learning Engineer
13	KEA13	Konfigurasi Perangkat Jaringan	MIN13	UI/UX Design	KAR13	DevOps Engineer

No	Skill		Interest		Career	
	Code	Description	Code	Description	Code	Description
14	KEA14	Figma	MIN14	Pengembangan Kecerdasan Buatan	KAR14	Desain Grafis
15	KEA15	AWS	MIN15	Desain Perangkat Lunak	KAR15	Cloud Engineer
16	KEA16	Azure	MIN16	Administrasi Jaringan	KAR16	Analisis Help Desk
17	KEA17	Protokol Jaringan	MIN17	Pengembangan Cloud Computing		
18	KEA18	Hadoop				

2.2 System Design

Career consultation system design is shown in Figure 2, illustrating the workflow followed by students when using the application. The process begins with login or registration, followed by access to various menus such as Career Information, Consultation, Consultation History, and Profile. Students select their interests and skills to receive appropriate career recommendations.

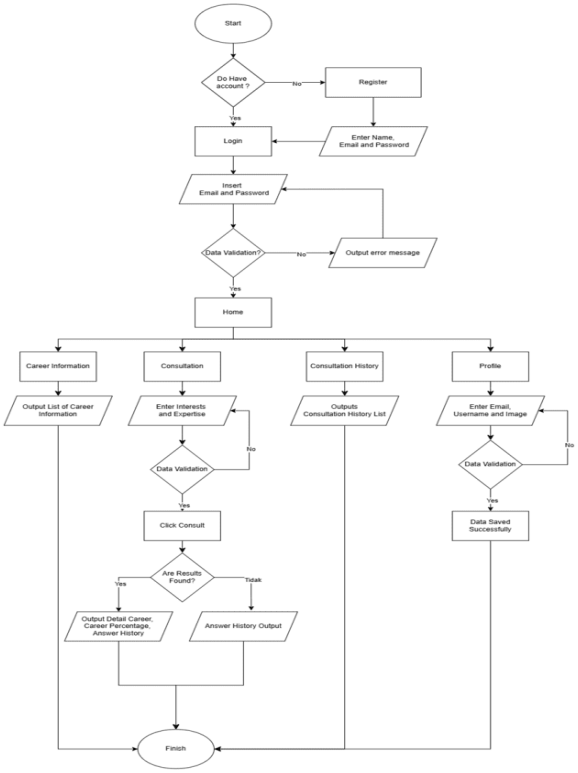

Fig. 2 Flowchart of Student Consultant System

2.3 Knowledge Based System (KBS) Design for Career Determination

Expert system is developed using a Knowledge-Based System (KBS) to store and manage information related to interests, skills, and careers. The KBS processes rules (rule set) to determine suitable careers using the forward chaining method for inference. The career determination problem is described in Figure 3.

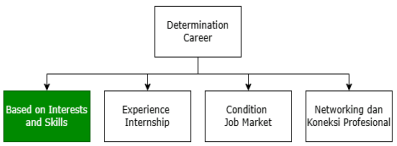

Fig. 3 Career Determination Problem Description

Figure 3 outlines the scope of career determination, encompassing four factors: interests and skills, internship experience, labor market conditions, and professional networking. However, this study limits the scope to interests and skills. Career determination is based on aligning interests and skills. This process involves analyzing and identifying areas suitable for both, resulting in the most appropriate career recommendations.

2.3.1 Decision Target for Career Determination

Decision target for determining student careers involves eight decision factors influenced by students' interests and skills. The decision target diagram visualizes the relationships between interests, skills, and career decisions based on student-provided data. The decision target diagram is shown in Figure 5.

Fig. 5 Decision Target Diagram

2.3.2 Dependency Diagram for Career Determination

Dependency diagram visualizes the overall logical flow in the expert system, starting from student data input to generating career recommendations based on their interests and skills. This diagram illustrates the structured interconnections between system components, simplifying understanding of how data is processed and decisions are made. The dependency diagram is shown in Figure 6

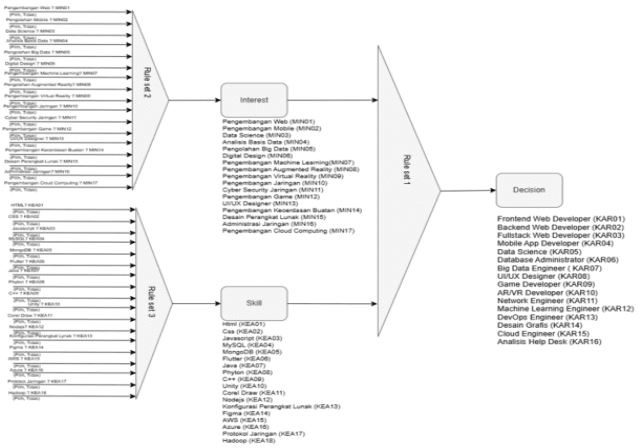

Fig. 6 Dependency Diagram

2.3.3 Decision Table and Rule (IF-THEN) Development for Career Determination

At this stage, decision tables and IF-THEN rules are formulated to define combinations of interests and skills that guide students toward specific career choices. Each rule is designed to generate decisions based on input data provided by students, enabling the system to systematically match student profiles with the most relevant career recommendations. The decision table is shown in Table 2.

Table 2. Table IF-THEN Rule

No	Rule Base	
	Rule	***Code***
1	IF MIN01 AND KEA01 THEN KAR01	BAS01
2	IF MIN01 AND KEA02 THEN KAR01	BAS02
…	….	….
53	IF MIN 10 AND KEA04 THEN KAR16	BAS32

This table organizes the rules used in the expert system to determine careers based on combinations of interests and skills. For example, if a student selects an interest in web development (MIN01) and a skill in HTML (KEA01), the consultation system will recommend a career as a frontend web developer (KAR01).

2.4 Implementation of Forward Chaining Method

Forward chaining method manages the inference process step-by-step from student data to generating suitable career recommendations. In this method, the system begins with facts provided by students, such as interests and skills, and proceeds based on predetermined rules until a conclusion is reached. The forward chaining steps are shown in Figure 7.

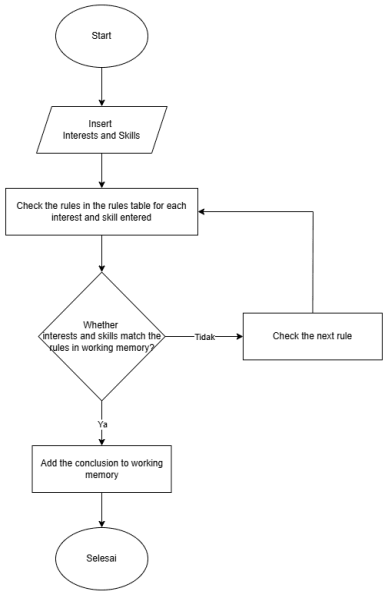

Fig. 7 Forward Chaining Flowchart

Based on Figure 7, the process begins by checking the compatibility of students' interests and skills with existing rules. If a match is found, the rule is applied, and the working memory is updated with relevant conclusions. If not, the system checks other rules until all relevant rules are processed. This iterative process continues until appropriate career recommendations are generated. Forward chaining enables the system to provide dynamic, accurate, and relevant recommendations based on updated data

2.5 Implementation of Certainty Factor Method

After implementing forward chaining to determine career recommendations based on students' interests and skills, the next step involves using the Certainty Factor (CF) method to assess the confidence level of the given recommendations. The CF method measures the degree to which the system is confident that the recommendations match the student's profile. By calculating CF values based on the alignment between interests, skills, and desired careers, the system provides more accurate and relevant recommendations. The CF implementation strengthens forward chaining results by adding a clear and realistic certainty level. The CF results are shown in Table 3.

Table 3. Certainty Factor Values

No	CF Assessment		No	CF Assessment	
	Career	***CF Expert***		***Career***	***CF Expert***
1	Frontend Web Developer	1.0	9	Game Developer	0.8
2	Backend Web Developer	0.8	10	AR/VR Developer	0.8
3	Fullstack Web Developer	0.8	11	Network Engineer	1.0
4	Mobile App Developer	0.6	12	Machine Learning Engineer	0.8
5	Data Science	1.0	13	DevOps Engineer	0.8
6	Database Administrator	0.8	14	Desain Grafis	1.0
7	Big Data Engineer	0.8	15	Cloud Engineer	0.8
8	UI/UX Designer	1.0	16	Analisis Help Desk	0.8

3.Result and Discussion

3..1 Implementation of the Career Determination Expert System Consultation Process for Student

Implementation of the web-based career determination expert system involves designing several main pages to support the consultation process. This system is designed to allow students to easily access it anytime and anywhere online. Below are the details of the implementation of the main pages:

1. Register Page

Students start the process by registering through the registration page, which is designed to be simple, requiring basic information such as name, email, and password. Input validation is implemented to ensure the email format is correct and the password meets security standards.

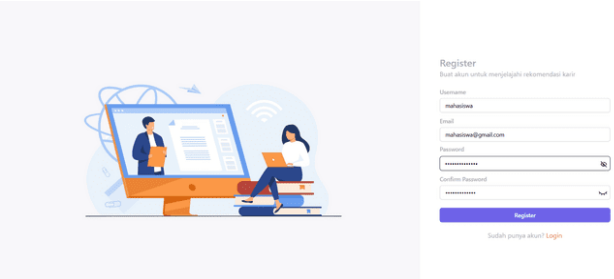

Fig. 8 Register Page

2. Login Page

After successful registration, students can access the system through the login page by entering their registered email and password. Validation is performed to ensure the security of user data. In case of an error, the system provides informative error messages such as "incorrect email or password

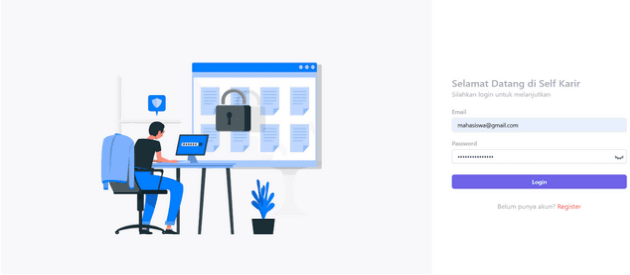

Fig. 9 Login Page

3. Website Homepage

The website homepage serves as an introduction for students, providing general information about the purpose and functionality of the system. This page also explains how the expert system works, including the use of the Forward Chaining method.

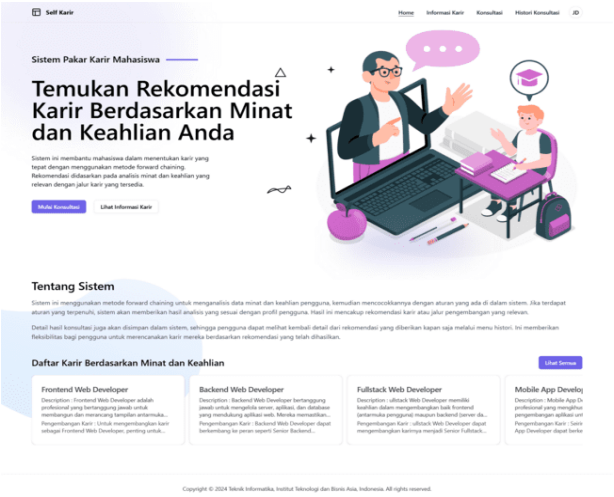

Fig. 10 Homepage

4. Career Information Page

This page provides information on career paths in Informatics Engineering, including job descriptions, required skills, and future opportunities.

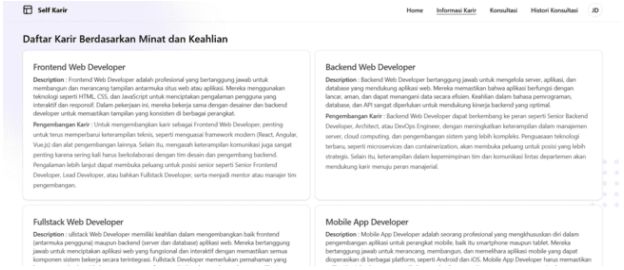

Fig. 11 Career Information Page

5. Consultation Page

On this page, students select interests and skills according to their preferences. The system analyzes the choices using Forward Chaining and provides career recommendations based on matching rules in the knowledge base.

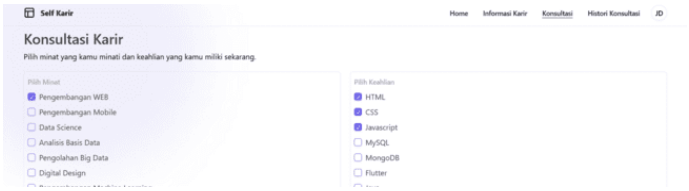

Fig. 12 Consultation Page

6. Consultation Results Page

After consultation, this page displays the recommendation results, including career descriptions and a percentage of compatibility based on the Certainty Factor method. If there are multiple matches, more than one career may be recommended.

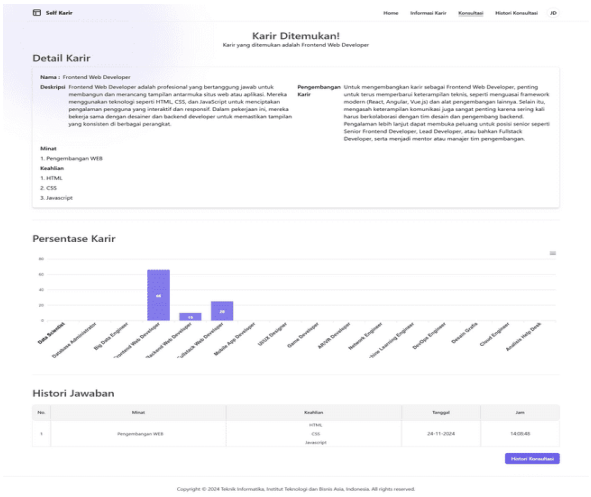

Fig. 13 Consultation Result and Compatibility Percentage Page

7. Consultation History Page

This page stores the consultation history of students, including recommendations, compatibility percentages, consultation dates, and selected interests and skills, enabling students to track changes in their career preferences over time.

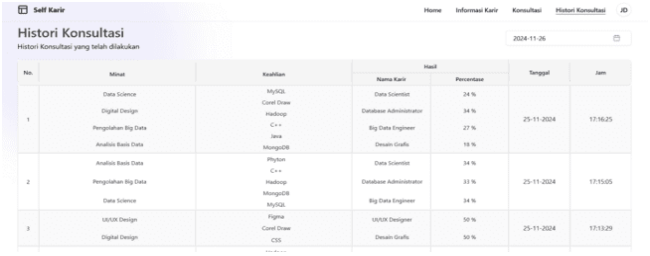

Fig. 14 Consultation History Page

3.2 Implementation of the Knowledge Base in the Career Determination Expert System for Students

After logging in with special credentials, the admin is directed to the main dashboard, which facilitates system management. This web-based system uses a knowledge base as its core, storing rules and data related to careers, interests, and students' skills. The input provided by students during consultation is processed through the rules in the knowledge base to generate suitable career recommendations. Below is the implementation of each component related to the knowledge base:

1. Dashboard Homepage
   This page displays a summary of monthly consultations in graphical form, visualizing the number of consultations and the most frequently recommended careers, along with notifications of the latest activities.

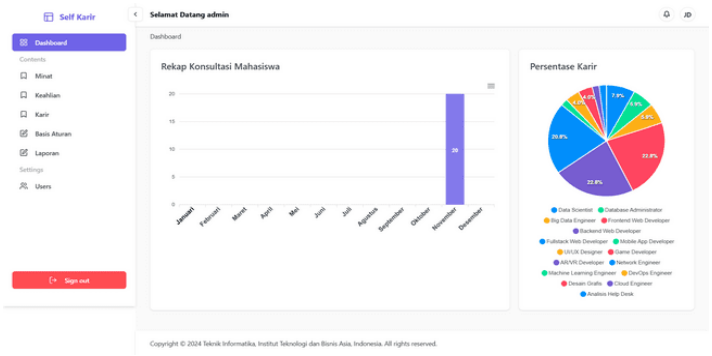

Fig. 16 Dashboard Homepage

2. Knowledge Base Page
   This page is the central management hub for rules in the expert system, where admins can add, edit, or delete rules connecting careers, interests, and skills of students. Each rule is equipped with a Certainty Factor (CF) value, representing the degree of confidence in the relevance of the relationship between interests, skills, and careers. CF values are input by the admin through a form when creating a new rule. CF is used by the system to calculate priority and recommendation accuracy, supporting the inference process through the Forward Chaining method to validate data and avoid rule duplication. Thus, the system can provide accurate career recommendations based on student input data.

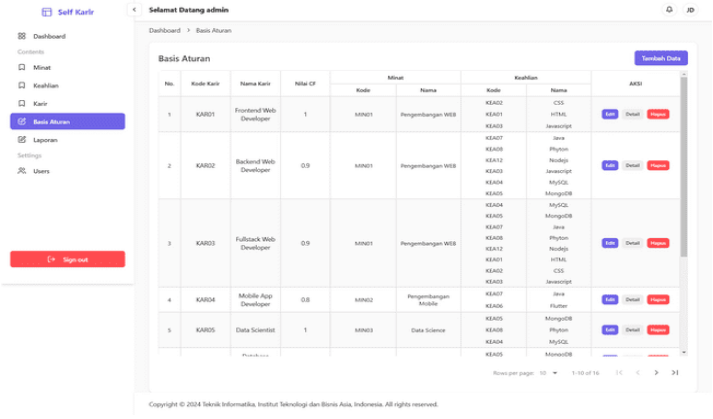

Fig. 20 Knowledge Base Page

3. Report Page
   Report page presents a history of student consultations, including career recommendations, dates, and consultation times. Filter features allow the admin to sort reports based on specific periods, facilitating data analysis and system evaluation.

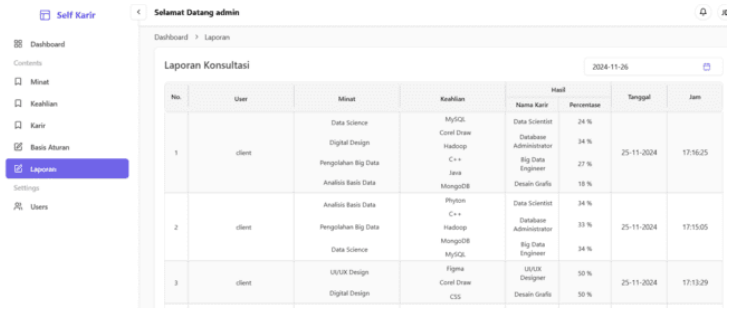

Fig. 21 Report Page

3.3 System Validation Testing and Expert Analysis

Testing aims to determine the accuracy level of consultation results provided by the developed system. The testing process involves conducting consultations with 5 students and comparing the results with expert diagnoses. The students' personal data is confidential and not disclosed; however, their gender is indicated during the testing. The testing results are presented in Tables 4.

Table 4. Test Results

No	Interest	Skill	System Diagnosis	Expert Diagnosis	Validation
1	UI/UX Design	Figma	UI/UX Designer	UI/UX Designer	Valid
		CSS			
2	Pengembangan Web	Javascript	Backend Web Developer	Backend Web Developer	Valid
		MySQL			
		MongoDB			
		Java			
		Phyton			
		Nodejs			
3	Pengembangan Mobile	Java	Mobile App Developer	Mobile App Developer	Valid
	Desain Perangkat Lunak	Flutter			
	Pengembangan Game				
4	Pengembangan Jaringan	MySQL	Cloud Engineer	Cloud Engineer	Valid
	Administrasi Jaringan	Phyton			
	Pengembangan Cloud Computing	Nodejs			
		Phyton			
		AWS			
		Azure			
5	Data Science	MySQL			Valid

No	Interest	Skill	System Diagnosis	Expert Diagnosis	Validation
	Analisis Basis Data	MongoDB	Database Administrator	Database Administrator	
	Pengolahan Big Data	Java			
	Digital Design	Hadoop			
		C++			
		Corel Draw			

The first test was conducted with a female student. The consultation results showed consistency between the system and expert diagnoses, both recommending UI/UX Designer. The second test was conducted with a male student. The consultation results showed consistency between the system and expert diagnoses, both recommending Backend Web Developer. The third test was conducted with a male student. The consultation results showed consistency between the system and expert diagnoses, both recommending Mobile App Developer. The fourth test was conducted with a male student. The consultation results showed consistency between the system and expert diagnoses, both recommending Cloud Engineer. The fifth test was conducted with a female student. The consultation results showed consistency between the system and expert diagnoses, both recommending Database Administrator. The test results show that 100% of the system is in accordance with the validation results from experts.

4. Conclusions

This study has developed an expert system using Forward Chaining and Certainty Factor methodologies to aid Informatics Engineering students in identifying a job aligned with their interests and skills. The findings indicate that employing both methodologies enables the system to deliver more precise and pertinent job recommendations, mitigating the uncertainty frequently encountered in the career decision-making process. The approach has demonstrated efficacy in assisting students in comprehending the correlation between their interests and skills with many career opportunities, consequently enhancing future job happiness and productivity.

Advanced researchers may enhance this method by incorporating more external criteria, such as internship experience and job market conditions, to yield more comprehensive and dynamic career recommendations. Furthermore, incorporating elements that provide direct engagement with counselors or career specialists might enhance the quality of consultations offered. This project aims to serve as a foundational step in developing a technology-driven career counseling system for students, facilitating a more targeted career path aligned with their potential.

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