Development of Nursing Process Expert System for Android-based Nursing Student Learning

Aristoteles[1]*, Abie Perdana Kusuma[2], Anie Rose Irawati[3],
Dwi Sakethi[4], Lisa Suarni[5], Dedy Miswar[6], Rika Ningtias Azhari[7]
Department of Computer Science - Faculty of Mathematics and Natural Sciences, Lampung University, Indonesia[1, 2, 3, 4]
Department of Nursing, Polytechnic of Tanjung Karang, Bandar Lampung, Indonesia[5]
Department of Geography Education - Faculty of Teacher Training and Education, Lampung University, Indonesia[6]
Master's Program in Computer Science - Faculty of Mathematics and Natural Sciences, Lampung University, Indonesia[7]

***Abstract*—Nurses are professionals who provide health services using a scientific process called nursing. In nursing, problem-solving uses the nursing process which is a critical thinking method, nurses must analyze the data found in patients to diagnose and determine the results and appropriate intervention plans. Prospective nursing students are required to be able to apply the nursing process in carrying out nursing care according to existing nursing standards, of course, with supervision by nursing experts to improve the quality of medical services. This study aims to develop an android application with the help of an expert system as a nursing diagnosis tool, which helps nursing students learn the nursing process and helps lecturers monitor the nursing process carried out by nursing students. This research uses 116 symptom data, 22 diagnosis data, 60 intervention data, 8 type data, and 864 description data. The results of this research are in the form of an expert system with an android-based forward chaining method that has been tested using the black box testing method.**

***Keywords*—Classification; expert system; forward chaining; blackbox testing; android; flutter; nursing process**

I. INTRODUCTION

Nursing service is a way for nurses to provide professional services, both emotional and otherwise, to individuals, families, groups, and communities, for the healthy and the sick. [1]. Nursing services are part of health services, and the quality of nursing services in general determines the quality of health services [2]. Nurses are professionals who provide medical services using a scientific process called nursing, problem-solving using the nursing process. The nursing process is used as a tool for nurses to practice nursing systematically in solving nursing problems [3]. Nurses provide care according to established standards. This standard was developed by the Indonesian National Nurses Association (PPNI). RI Law No. 36 of 2009 concerning Health has mandated that health workers are obliged to meet professional standards and respect patient rights [4]. The relationship between quality and standards are two things that are very closely related, because through these standards it can be measured that service is improving or even getting worse [5].

The standards ensure that nurses make appropriate and rational decisions and perform interventions that are safe and legally responsible [6]. Nursing students are prospective nurses according to their expertise, they must be able to apply the nursing process in the performance of nursing care, therefore vocational nurses (D3) and nurses are equipped with knowledge of the nursing process in education. Students can utilize expert system applications to support the learning process of nursing diagnoses and appropriate interventions by the Indonesian Nursing Diagnosis Standards (SDKI). In the diagnostic process, experienced experts are needed to provide the correct conclusions [7].

An expert system is a computer-based system that uses knowledge, facts, and reasoning techniques to solve a particular problem which normally can only be solved by experts in their field [8]. The nursing process Expert System is designed to be able to assist nurses in analyzing patient data so that interventions and outputs can be determined according to the conditions and circumstances of the patient.

There are several studies on diagnostic expert systems but for expert systems that produce nursing diagnoses to help nursing students there is still no. Research in [9] discusses the creation of an expert system to diagnose eye disease with the android-based certainty factor method. This Android-based expert system has 75% accuracy results with details of 15 diseases and 52 symptoms of eye disease.

In the study [10] built an android-based expert system to detect dental and oral diseases. The data used is 13 diseases and 44 symptoms. This dental and oral disease detection expert system has an accuracy of 100% if tested with black box testing, while the test results of the User Acceptance test have an accuracy of 93.03%.

Then in the study [11] built an android-based expert system to detect liver disease. This study used 64 test data. The method used in this study is Fuzzy Tsukamoto to diagnose liver disease. The test data was then tested and has an accuracy of 96.87%.

Furthermore, the study [12] built an expert system to diagnose diseases in chili plants. The data used is in the form of 37 symptom data, 10 chili disease data, and 10 rules. The method used is forward chaining, testing carried out using black box testing gives the expected results from each test class. As for the test results from the User Acceptance Test obtained an average of 84%.

In research [13], the researcher developed an expert system that can identify stroke symptoms using the naive

*Corresponding Author

bayes method. In this study using data from patient consultation results at Dr. M Hatta Bukittinggi Brain Hospital for seven months in 2021. Drs. M Hatta Bukittinggi for seven months in 2021. The research has an accuracy of 100% in identifying the type of stroke disease from 10 data samples used.

Based on previous related research, the expert system to improve the quality of nursing quality still does not exist. Meanwhile, in the era of the Industrial Revolution like now, nursing students must be able to adapt to existing technological advances. In research [14], it is said that technological developments really need further development to get better results, in order to get accurate results. Therefore, this research aims to develop an information system for information system for monitoring the nursing process with the addition of an expert system that uses the forward chaining method as a nursing diagnosis tool based on android application, to help nursing students in learning and improving the ability of the nursing process as well as assisting lecturers in monitoring the process carried out by prospective students. Students will enter input first by analyzing the symptoms that have occurred, and the expert system that will be developed will save the results of the student's work. Furthermore, lecturers will be able to monitor and see whether students have correctly analyzed or not.

II. Materials and Methods

The workflow of this research is divided into two stages, namely the 1st stage of building an expert system for nursing diagnoses, and the 2nd stage of implementing the android application using the waterfall system development method. This research workflow can be seen in Fig. 1.

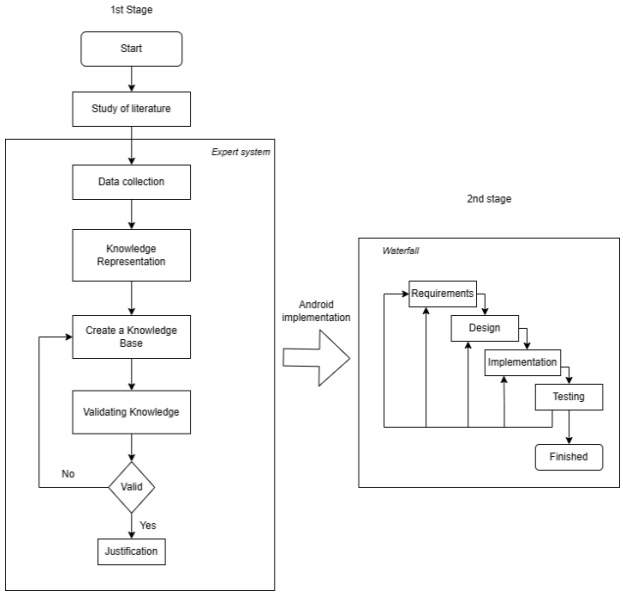

Fig. 1. Research workflow.

A. Building an Expert System

At the expert system development stage, several steps are carried out as follows.

1) Data collection: It was carried out by conducting literature studies and interviewing experts in the field of nursing. The results of the collection are in the form of data needed by expert systems such as symptom data, results of nursing diagnoses, interventions, and descriptions of interventions. In addition, an overview of the system requirements to be built is also obtained.

2) Representing knowledge: The goal at this stage is to represent the knowledge that has been collected to build a knowledge base. Examples of knowledge in this study are symptoms. Each of these symptoms has a different code and has its score as well. Scores on symptoms ranging from a score of 1 to 5 are obtained from interview data with nursing experts, which will later be used in the diagnosis process, where the diagnosis will only be made if the total number of selected overall scores is more than 4 scores. The symptom data can be seen in Table I.

Table I is part of the symptom data collection needed in this study. Symptom data is denoted by the letter "G", and this symptom data has 116 data. After collecting symptom data, then the next step is to collect diagnosis data to enter the next stage. The following are some of the diagnosis data used in this study.

Table II is some data from the results of diagnosis data collection. Diagnosis data has a total of 22 data. Diagnosis data is symbolized by "D" to simplify the running of the system. From the diagnosis data above, researchers also need intervention data. Here is some intervention data used in this study.

TABLE I. Symptom Data

Code	Symptoms	Score
G1	Cough is not effective	5
G2	Can't cough	4
G3	Excess sputum	3
G4	Wheezing, and or dry rhonchi	2
G5	Meconium in the airway (in neonates)	1
G6	Use of accessory muscles of respiration	5
G7	Abnormal breathing pattern	4
G8	The expiratory phase is prolonged	3
G9	Pursed lip breathing	2
G10	Vital capacity decreases	1
G11	Complain of nausea	5
G12	Feeling like vomiting	4
G13	Not interested in eating	3
G14	Sour taste in the mouth	2
G15	Increased saliva	1
G16	Complain of pain	5
G17	Looked grimaced	4
G18	Being protective (positioning to avoid pain)	3
G19	Nervous	2
G20	Focus on yourself	1

TABLE III. DIAGNOSIS DATA

Code	Diagnosis
D1	Ineffective airway clearance
D2	Ineffective breathing pattern
D3	Nausea
D4	Acute pain
D5	Childbirth pain

TABLE IV. INTERVENTION DATA

Code	Intervention
A1	Effective coughing exercises (A)
A2	Airway management (B)
A3	Respiration monitoring
A4	Airway management
A5	Respiration monitoring

Table III above is some data from the intervention in this study. Intervention data has a total of 80 data. The diagnosis data will be coded with the letter "A" to facilitate the running of the system.

3) Creating a knowledge base: The knowledge representation from an expert that the system needs to solve certain problems. The knowledge that has been obtained is made into rules; these rules consist of relationships between existing data such as symptoms, diagnosis results, type interventions, and intervention descriptions.

4) Validate the knowledge: Validate the knowledge base by experts so that there is no mission of interpretation between an expert's knowledge and the knowledge base created.

5) Justification: The final stage, namely justification, the system can already provide the results of nursing diagnoses based on existing symptoms and descriptions of interventions that are suitable for the results of these diagnoses.

B. Implementation of Android Applications

The development of an Android application is carried out using the Flutter framework. The method used in the manufacture of the system is the "waterfall" method, which takes a systematic approach starting from the stage: Requirement, Design, Implementation, until Testing. The following describes each stage.

1) Requirement: The requirement is the stage of identifying the needs of the system to be built and being a reference in determining what functions need to be developed. Here are the system requirements in research that can be seen in Fig. 2.

In the use case diagram, it has been shown that there are two levels of users, namely students, and lecturers. In the use case diagram, limitations have also been given on what each type of user can do on the system. Students can perform the nursing process on patients and lecturers can monitor the results of the nursing process carried out by their students.

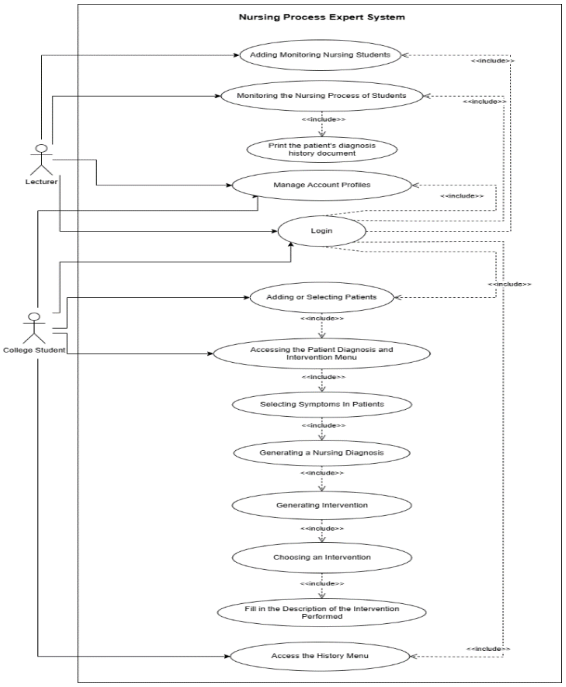

Fig. 2. Use case diagram.

2) Design: The next stage is to make a system development plan into design forms such as ERD designs and activity diagram designs. The following is the ERD system which will be shown in Fig. 3.

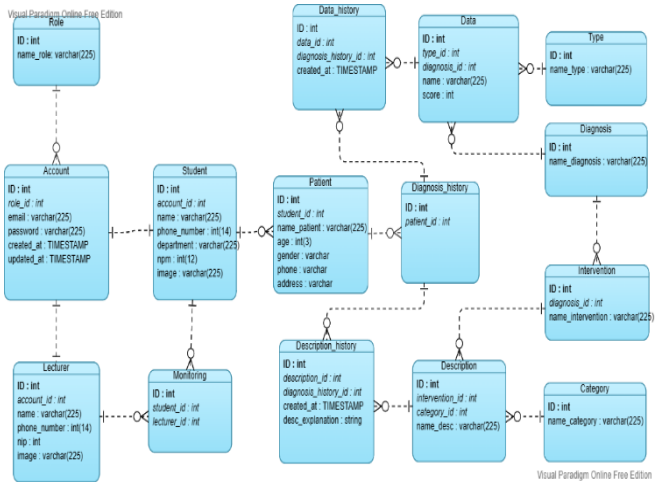

Fig. 3. Entity relationship diagram.

Entity Relation Diagram explains the relationship between tables in the database that the system uses. In the tables, some data is used in expert systems. These data consist of 116 symptom data, 22 diagnosis data, 60 intervention data, 8 type data, and 864 description data. The activity design for students explains how the system flows if the logged-in user is a student, students can carry out the patient nursing process from determining the type of diagnosis, selecting symptoms, generating diagnoses, selecting interventions, and filling out appropriate intervention descriptions for patients. The following activity design for nursing students can be seen in Fig. 4.

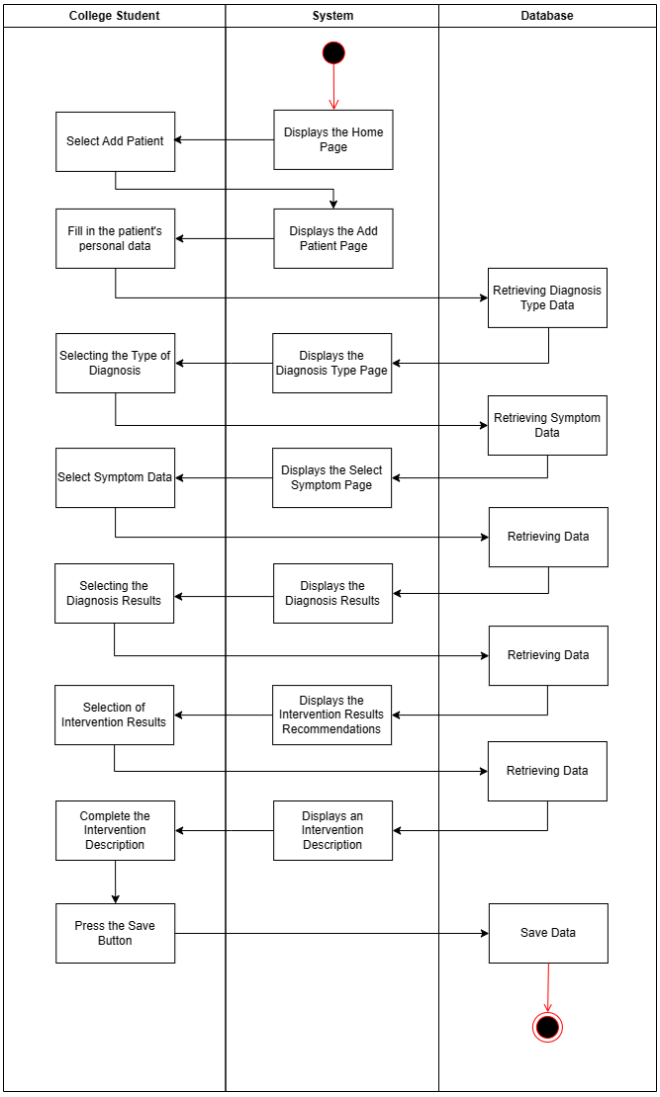

Fig. 4. Nursing process activity by nursing students.

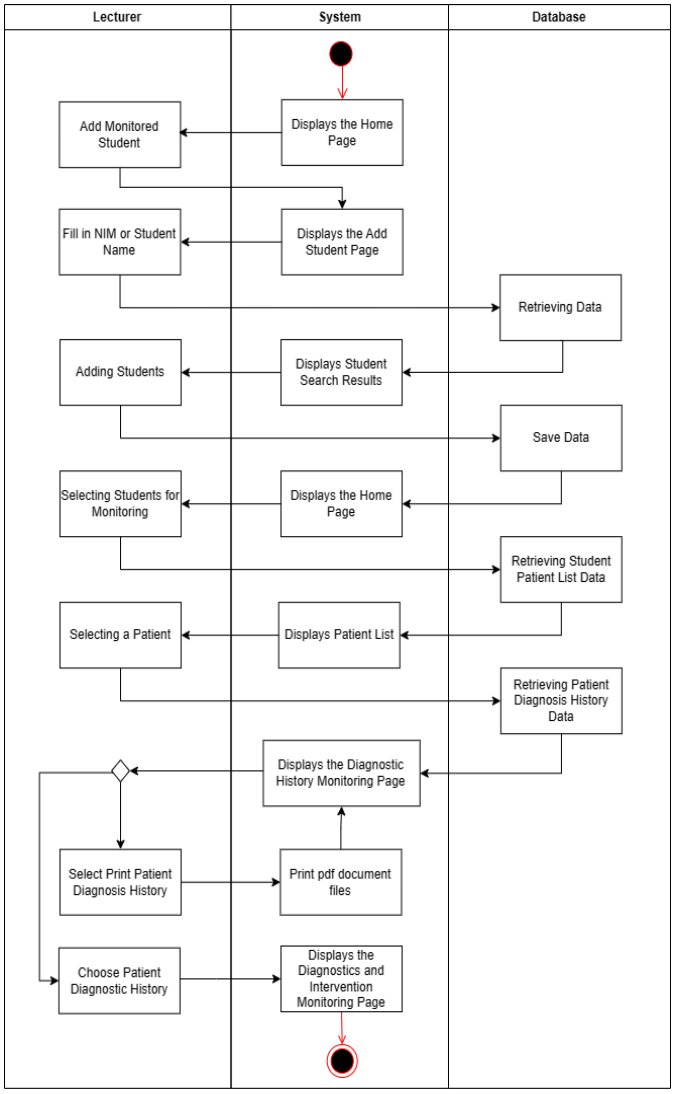

Fig. 5. Activity monitoring nursing process.

Fig. 4 explains the flow of how students diagnose patients, starting from students adding patients first by filling in the data of the patient to be diagnosed, followed by students starting to diagnose from symptoms to the end until the system saves patient data that has been diagnosed by students. The activity plan for the lecturer explains the flow of how the system runs if the user who login is a lecturer, lecturers can monitor the results of the nursing process carried out by their students, starting from a nursing process carried out by their students starting from adding a student to being monitored. Students, who are monitored, view all patient lists who have been treated by students, to see all the history of the nursing process that has been carried out. The following activity plan for lecturers can be seen in Fig. 5.

Fig. 5 explained the flow of how lecturers monitor the results of their student nursing process, starting from lecturers adding students to the system of displaying the history of the patient's nursing process by students.

3) Implementing: All system designs that have been created including expert system functions to help students learn in the nursing process into the form of program code built using dart language, with the help of Flutter frameworks to build android applications and Laravel8 frameworks to build system database APIs.

4) Testing: After implementation, the next stage is testing. Testing will be done using the Black-Box Testing method. In addition to testing the system using black-box, user acceptance testing of the built system is also carried out, the target of system users, namely students and nursing science lecturers.

IV. Result and Discussion

A. Knowledge Base

The knowledge base is the core of the expert system, which is a representation of knowledge from experts. The knowledge base shown in Table IV is a description of the relationship between symptom data and other data contained in the database. Here is the knowledge base that can be seen in Table IV.

TABLE V. Expert System Knowledge Base

Type	Symptom	Diagnosis Results	Intervention	Description
T1	G1 G2 G3 G4 G5	D1	A1	U1, U2, U3, U4, U6, U10, U5, U7, U8, U9
			A2	U12, U13, U14, U 15, U16, U17, U18, U19, U20, U21, U22, U23, U24, U25
			A3	U26, U27, U28, U29, U30, U31, U32, U33, U34, U35, U36, U37, U38, U39, U40
	G6 G7 G8 G9 G10	D2	A4	U41, U42, U43, U44, U45, U46, U47, U48, U49, U50, U51, U52, U53, U54
T2	G11 G12 G13 G14 G15	D3	A6	U55, U56, U57, U58, U59, U60, U61, U62, U63, U64, U65, U66, U67, U68, U69, U70
			A7	U71, U72, U73, U74, U75, U76, U77, U78, U79, U80, U81, U82, U83, U84, U85, U86, U87, U88, U89
	G16 G17 G18 G19 G20	D4	A8	U90, U91, U91, U93, U94, U95, U96, U97, U98, U99, U100, U101, U102, U103, U104, U105, U106, U107, U108
			A9	U109, U110, U111, U112, U113, U114, U115, U116, U117, U118, U119

Table IV above is part of the expert system knowledge base consisting of the data used, for symptoms coded with the letter "G", for diagnoses coded "D", interventions coded "A", types coded "T" and descriptions coded "U". The results of the system diagnosis will appear if the main requirements are met, namely if the total score of the selected symptoms is more than equal to 5 scores (∑Symptom Score ≥ 5). After the results of the system diagnosis appear and are selected, the results of the intervention and description of the intervention will appear following the options.

1) User interface: The user interface is part of an information system that requires user interaction to create input and output for the system [15]. The User Interface is used to provide an overview of the appearance of the application that will be used by the user.

B. System Testing Results

System testing is carried out by testing the system functionally using the black-box testing method and non-functionally, the system aims to determine the response and assessment of users of the system created.

1) Black-box testing: Black-box testing is a software testing technique that focuses on the functional specifications of software [16]. This test is carried out by examiners as well as application users consisting of lecturers and nursing students. All test results obtained from the examiner are successful for each test case carried out.

2) User acceptance testing: This test is carried out with a focus on the non-functional attributes of the system. The main goal is to develop software that can meet user requirements. Not only meets system specifications and can be used but also to find out whether the system is acceptable to users or not [17]. Technical testing was carried out by the way respondents downloaded and ran the application, after using the application respondents were directed to fill out the questionnaire. Here are the results of the questionnaire in this test.

TABLE VI. User Acceptance Test Results

No.	Question	Index (%)
1	The application is easy to understand how to use it	**87,83%**
2	The application interface display is good and easy to understand	**85,22%**
3	The images and icons used in the application display are easy to understand	**86,96%**
4	The instructions in the application are clear and easy to understand	**86,1%**
5	I feel comfortable while using the app	**81,74%**
6	The application helps nursing students in making nursing diagnoses	**86,96%**
7	The diagnostic results given are by the facts	**81,74%**
8	The application helps nursing students in nursing learning	**86,96%**
9	This application can assist lecturers in monitoring the nursing process of students	**73,33%**
Average Index		**84%**

Table V is a summary of the test results conducted by each user. Testing was carried out by students and lecturers, 22 students and three lecturers. Testing is done with nine questions that must be filled in by each user whether the features in the system are running properly; the functionality of each feature will be tested by students and lecturers. The results of the test show that this research has an average index value of 84% which means that the system built has a "Very Good" value.

V. Conclusion

In this study, the expert system for the learning process of nursing students is considered capable of helping nursing students to properly analyze the diagnosed patients and can assist lecturers in monitoring every nursing process carried out by students. The expert system application that was successfully built using the Flutter framework has a test value of "Very Good" with an average value obtained of 84%.

Recommendations for future researchers are that future researchers can add and complete data that is in accordance with SDKI (Indonesian Nursing Diagnosis Standards) and SIKI (Indonesian Nursing Intervention Standards), add assessment features, corrections and notes for lecturers on each treatment result carried out by students, add features to replace lecturers for students, add features to remove students from the monitoring list for lecturers, add features for students to be able to add patient progress notes and add features for lecturers to evaluate the patient care process carried out by students.

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