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ANDROID BASED EXPERT SYSTEM AS A LEARNING MEDIA TO RECOGNIZE CHEMICALS

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ABSTRACT

Expert system applications for recognizing chemical elements function as a learning medium, hoping to help users identify each chemical element. Expert systems can be an option or a reference source for users' knowledge, where this knowledge is obtained from chemists. In this study, an expert system application was developed using the forward chaining method. The system consists of two types of applications, namely web-based applications for admins and android applications, for users to conduct consultation sessions with the system. Knowledge contains a chemical element's characteristics in the form of a substance, metalness, types of elements, electrical properties, element groups, and period of elements. This knowledge is represented using inference rules. In this expert system, users can consult chemical elements by answering the system's six questions. The user's answer will determine the solution in the form of a hypothesis, namely the chemical element's name, and its explanation according to the characteristics given. The results of system testing using the black box testing method show that the expert system application is valid and under expectations to be used as a learning medium to recognize chemical elements.

KEYWORDS: Chemical Elements, Expert System, Forward Chaining, Android, Learning Media.

INTRODUCTION

The universe is rich in chemical elements. Until now, there are 118 chemical elements which are divided into two groups, namely natural and artificial elements. Based on their similarity, the elements are grouped into several groups, namely group A (leading group) and group B (transition group) (Sujana et al., 2008). Some groups are given specific names, for example, the alkaline, alkaline earth, or transition groups. The number of groups is eight and is marked with Roman numerals. The chemical elements can be grouped into metal, non-metal, semi-metal, and noble gas elements. Of the many chemical formulas and aspects of chemical substances, it isn't easy to memorize the formulas and names of the chemical elements that exist. A method is needed to study many elements, namely the periodic system of elements (Sudarmo, 2013). This system will help explore the trends in the elements' properties and some of their other properties.

Moseley composed the periodic system of chemical elements as an extension of Mendeleev's known modern periodic system. The number of periods in the modern periodic system is seven and is indicated with a number, namely: 1) period one is called a brief period and contains two elements; 2) period two and period three are called short periods, and each includes eight elements; 3) period four and period five are called long periods, and each contains 18 elements; 4) period six is called a very long period which includes 32 elements; 5) period seven is called the incomplete period because there may still be an increase in the number of elements that occupy it, which until now contains 24 elements. In period 6, there is a series of elements called the Lanthanide series, namely elements number 58 to number 71 and placed at the bottom. Meanwhile, in period 7, a series of elements called the Actinide series, namely elements numbered 90 to number 103, set at the bottom.

As part of artificial intelligence that inevitably is developed in the Industrial Revolution era, expert systems have proven to have extraordinary abilities in helping humans work in all areas of life (Syafaati, 2019). An expert system is a computer program that simulates humans' assessment and behavior who have expert knowledge and experience in specific fields (Budiharto & Suhartono, 2014). Typically, a system like this contains a knowledge base that includes the accumulated expertise and rules for applying fundamental knowledge to any given situation. Based on his abilities, problems that should only be solved by experts can be solved by ordinary people. Conversely, expert systems help the experts activities as assistants who seem to have a lot of experience. We have developed several expert system applications

such as (Mustafidah & Suwarsito, 2010), (S. Suwarsito & Mustafidah, 2011), (Mustafidah et al., 2018), (S. Suwarsito & Mustafidah, 2014), and (Suwarsito Suwarsito & Mustafidah, 2018).

Expert systems have various advantages over conventional methods. Expert systems are pioneers in their development caused of their obedience and inference ability (Giarattano & Riley, 1998). The inference is a process for producing information from known or assumed facts and a logical conclusion or implication based on the information available. The inference process is carried out in a module called the Inference Engine. There are two essential inference methods in expert systems, namely: forward and backward. Forward chaining means using a set or condition-action or reasoning starting from the conditions leading to the goal (data-driven reasoning). In contrast, backward reasoning begins with the goal then traces back to the path that leads to that goal (goal-driven reasoning).

Before being implemented, the development of an expert system was carried out in 4 stages (Budiharto & Suhartono, 2014), namely: 1) analysis; 2) specifications; 3) development; and 4) deployment. The analysis stage aims to identify the needs and suitability of knowledge with the engineering technology used, while at the specification stage, the expert system's ability is defined. Developers must also work with experts to study and plan system development. Experts are identified as experts in a particular field domain, such as psychologists, doctors, and scientists. The development stage is how experts perform tasks (knowledge acquisition) in various cases. Three cases must be met, namely "current," "historical," and "hypothesis." Current issues are obtained by observing an expert while performing an assignment, whereas previous (historical) cases are brought by discussing the task performed in the past with an expert. Meanwhile, a hypothetical case can be obtained with a hypothetical situation. The last stage, namely dissemination, is distributing the system to the community to be widely used.

The development of information technology is increasingly rapid, making the current generation more interested in finding information using gadgets, a learning tool. Most devices are based on the Android operating system, with various tools and APIs developed into an attractive and comfortable application (Safaat, 2014). This function and the difficulty in studying chemical elements make it necessary to create an application that easily memorizes and knows each substance's elements quickly and with more interactive and exciting learning

using gadgets. With the support of expert system technology, learning media will be more useful because the learning process seems to be accompanied by an expert in chemistry.

Several studies had been carried out related to application development in the field of chemistry. They are dictionary application for the formulation of chemical compounds and electrolytes based on android (Wibowo, 2013), desktop-based expert systems (Rubianto & Mustafidah, 2015), web-based applications for determining chemical elements group A (Zakaria & Rohman, 2011), an expert system to identify specific minerals (Folorunso et al., 2012), and the development of Augmented Reality to recognize the names of chemical elements in the periodic table (Sudana et al., 2016). The expert system application being developed is a development from previous research based on android, which is expected to have more benefits because it has flexibility in its use.

MATERIALS AND METHODS

- **Data collecting**

Research data obtained through documentation and interviews. The documentation method is used to obtain data on chemical elements from book sources. In contrast, the interview method is carried out by conducting questions and answers to chemists about determining elements based on the characteristics and groups possessed by chemical elements based on the elements' periodic system table.

- **Research Variables**

The variables used in this research are element characteristics, which consist of 6 general types: the form of the substance, the metallic nature, the kind of element, the electrical properties, the element group, and the period.

- **System Development**

The system was developed using the Waterfall model (Sommerville, 2011), as in Figure 1.
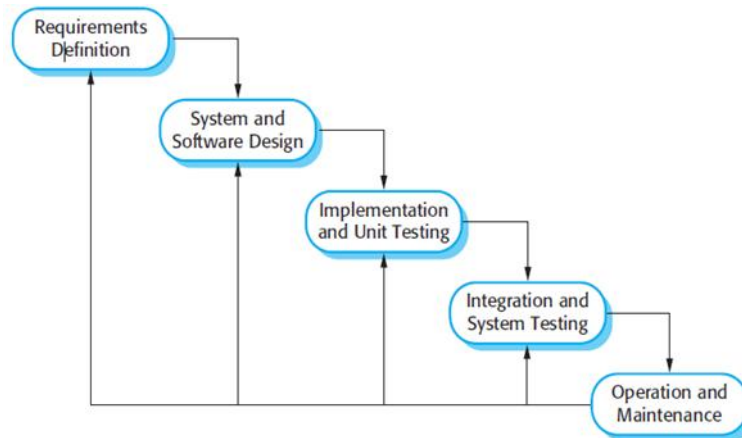
Figure 1: Waterfall Development Model.

The requirements definition stage analyzes system requirements, namely hardware and software requirements and data requirements, including element data and characteristics. Furthermore, a development environment and consultation or runtime environment is designed at the system and software design stage. The ES builder uses the design development environment to build components and feed knowledge into the knowledge base. In contrast, non-expert users use the consulting environment to gain expert knowledge and advice. The inference method used is also determined at this stage, namely using forward chaining. The system performance design is represented using a flow chart as in Figure 2. Expert system knowledge is stored in a database schema with the relationship design shown in Figure 3.
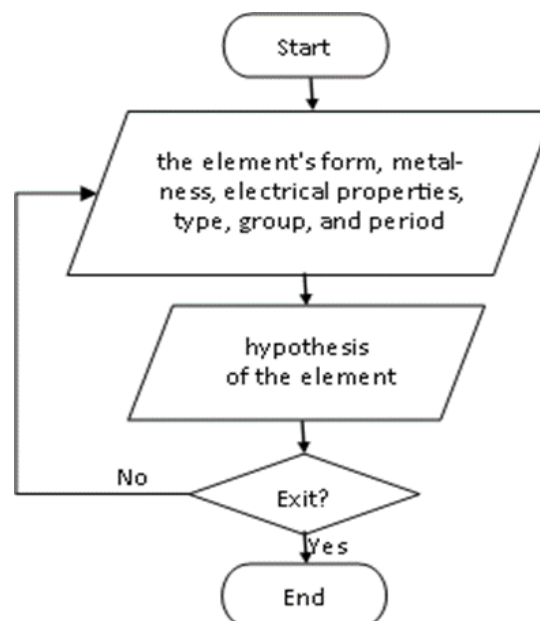
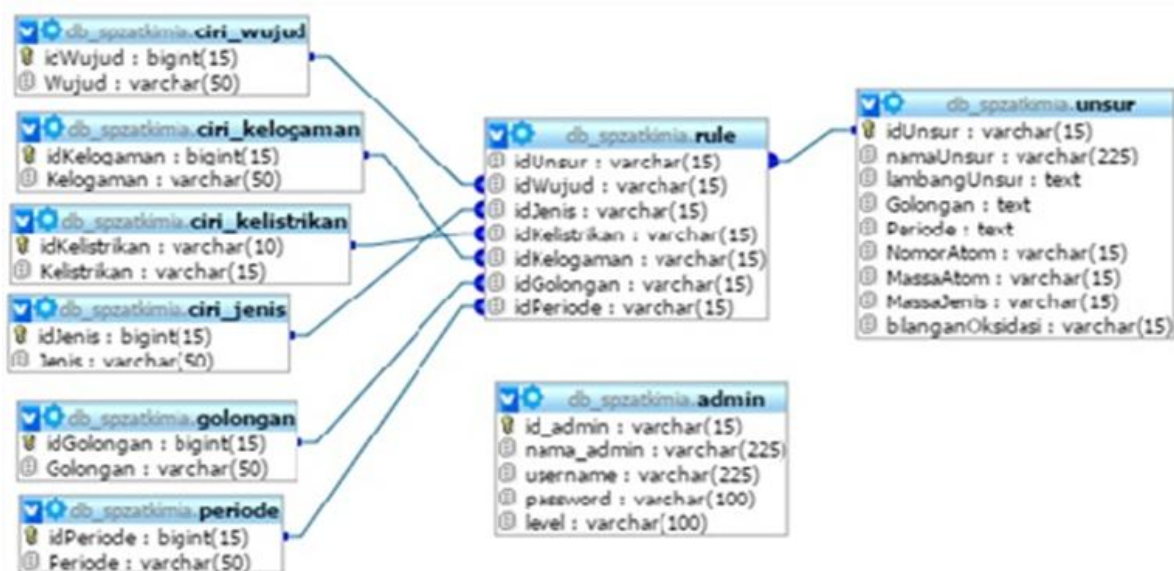**Figure 2: An outline of the system flow chart.**

Figure 3: Relation tables in an expert system database.

The next stage, implementation, and unit testing are to realize the design into several program sets or program units to verify each unit's function. The formation of an expert system application to recognize these chemical substances' elements begins with building a web-based system for the admin. Then an Android-based application is developed for the client. Implementation activities use several PHP software, MySQL for databases (Mufti, 2015), JavaScript Object Notation (JSON), Android Studio 1.4, Android Software Development Kit (SDK), Corel Draw X-7, Java Development Kit (JDK), Windows 7 Ultimate 64-bit operating system, Sublime Text 3, SQL Manager 2010 for MySql, XAMPP 1.7.3, and one unit of Android Smartphone at least version 5.0 Jelly Bean. Furthermore, the integration and system testing stage is carried out to test all system elements according to the objectives. The last step is operation and maintenance as a repair stage when the system runs to improve system quality.

RESULTS AND DISCUSSIONS

- **Knowledge representation**

Data requirements that have been analyzed must be represented in a software application based on a knowledge base. The knowledge base in this expert system contains the characteristics of the chemical elements that have been grouped. The chemical elements in the periodic system table have 118 Elements. These elements have specific characteristics so that they need to be grouped based on six criteria to make it easier to implement the system.

The criteria are the name of the element, the type of element, the element's metalness, the element's electrical properties, the element group, and the period of the element.

Knowledge representation is a method used to encode knowledge in a knowledge-based expert system. Based on the knowledge base that has been compiled, then the task of a programmer is to represent existing knowledge into a programming language. Knowledge in this expert system is defined using rules by first gathering a decision table to make it easier to determine the premise and hypothesis (Mustafidah & Fatimah, 2018). The knowledge base is represented using the "IF ... AND ... THEN ..." rule as presented in Table 1. The number of rules is 118 according to the number of elements in nature.

Table 1: Expert System Rules for recognizing chemical elements.

Element Code	Rule	Element Description
U1	IF Gas AND Isolator AND Natural AND Non - Logam AND Group 1 AND Period 1 THEN HYDROGEN	Group 1 (I A) Period 1 Atomic Number 1 Atomic Mass 1,008 Density 0,071 g/ml Oxidation Numbers 1 Symbol H
U2	IF Gas AND Isolator AND Natural AND Non - Logam AND Group 18 AND Period 1 THEN HELIUM	Group 18 (VIII-A) Period 1 Atomic Number 2 Atomic Mass 4,002602 Density 0,126 g/ml Oxidation Numbers - Symbol He
U3	IF Wujud Zat padat AND Bersifat Konduktor AND Natural AND Logam AND Group 1 AND Period 2 THEN LITIUM	Group 1 (I A) Period 2 Atomic Number 3 Atomic Mass 6,94 Density 0,53 g/ml Oxidation Numbers 1 Symbol Li
U118	IF Gas AND Isolator AND Jenis Unsur Buatan AND Non - Logam AND Group 18 AND Period 7 THEN UNUNOKTIUM	Group 18 (VIII-A) Period 7 Atomic Number 118 Atomic Mass 294 Density – Oxidation Numbers - Symbol Uuo

- **System Implementation**

This expert system is developed in Bahasa. The development of an expert system application to recognize this chemical element consists of two applications: the website and Android applications. The admin uses the application based on the website to manage elemental data and rule data (Figure 4). The data can be accessed by the android application used by the user. In exchanging data between the website application and the Android application, data from the website application database is changed using the JavaScript Object Notation (JSON) format. After the data is changed, the android application can access the URL from the JSON.
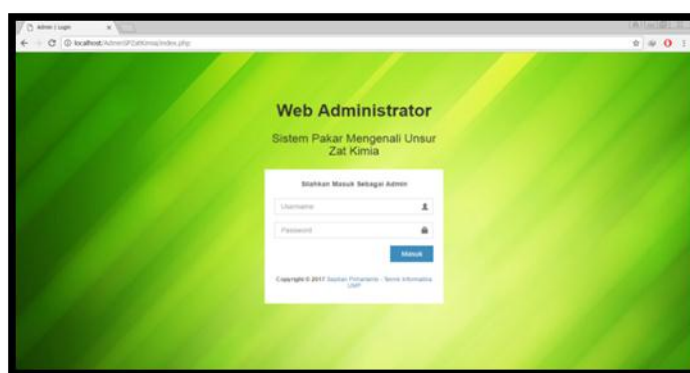
Figure 4: Admin page using the website application.

In this website application, the admin can edit the elemental data that has been previously validated by an expert. Besides, admins can also update rules. As already explained that the user uses the android application. The display of the expert system application icon is as shown in Figure 5.

The application's initial display is a splash screen containing the application logo and progress bar (Figure 6). The application will then display the existing menu, namely data elements, consultation, about the application, and exit (Figure 7). The element data menu contains a list of chemical element data taken from the website application using the JSON data exchange format. Meanwhile, as the most crucial menu in an expert system, the consultation menu contains consultation sessions between the user and the system. In contrast, the menu "about" contains application developers' information, namely Informatics Engineering – Universitas Muhammadiyah Purwokerto. The last menu, "exit," contains a confirmation of whether the user will end and close the system.

Figure 5: Application icon on a smartphone.

Figure 6: Splash screen display.

Figure 7: Application main menu.

As previously explained, the consultation menu is a dialogue facility between the user and the system as the main activity in an expert system. This consultation session contains six questions, which are the variables of this research. The six questions are the characteristics of the element's existence, the characteristics of the element's metalness, the features of the type of elements, the electrical characteristic of the elements, the element groups, and the period of the elements. An example of an expert system consultation session is presented in Figure 8.

Figure 8 shows the six questions that must be answered by the user to get a solution in the form of a hypothesis. The six questions are given in sequence, starting from number 1 to the last. After answering each question by selecting the element characteristics, the system will bring up the rule base and the element's name as a solution (Figure 9). This tracing method is known as forward-chaining. The system requests data from the user in the form of facts, and then, based on these facts, the system will look for a suitable or appropriate hypothesis as a solution given to the user (Mustafidah & Fatimah, 2018).

Figure 8: Questions during the consultation session.

Figure 9: Results of the consultation session.

- **System Testing**

The expert system application as a learning media for chemical elements was tested using the black box testing method. This test method focuses on system functions. This method is used to find out if the software is functioning correctly. Application testing is divided into two parts, namely the website application for admin and android application for users. Testing of website applications is emphasized on the process of updating data (Table 2) and updating rules (Table 3), while testing of Android applications is focused on elemental data (Table 4).

Table 2: Testing of data updates by admin.

Cases and Test Results (Correct Data)			
Input Data	**Expected**	**Observation**	**Conclusion**
Add Data Element name: Hydrogen Symbol of the elements: H Group: IA Period: 1 Atomic Number: 1 Atomic mass: 1.008 Density: 0.071 g / ml	Data entered into the database server	Data entered into the database server	[x] accepted [　] rejected
Update Data Element name: Hydrogen Symbol of the elements: H Group: IA Period: 2 Atomic Number: 2 Atomic mass: 1.008 Density: 0.071 g / ml	Data can be changed on the edited database server	There was a data change in the database server	[x] accepted [　] rejected

Clear Data Element name: Hydrogen	Display data on form data elements, and the database server is deleted	Display data on form data elements, and the database server is deleted	[x] accepted [ ] rejected
Cases and Test Results (Incorrect Data)			
Input Data	**Expected**	**Observation**	**Conclusion**
The data entered is incomplete	There is a message that data filling is incomplete	Complete data notification message does not appear	[x] accepted [ ] rejected

Table 3: Testing rule update by admin.

Cases and Test Results (Correct Data)			
Input Data	**Expected**	**Observation**	**Conclusion**
Add Data Element name: Hydrogen Characteristics of the form: Gas Element type: Natural Electrical properties: Isolator Metallic properties: Non-metal Group: IA Period: 1	Data entered into the database server	Data entered into the database server	[x] accepted [ ] rejected
Change Data Element name: Hydrogen Physical characteristics: Solid Element type: Natural Electrical properties: Isolator Metallic properties: Non-metal Group: IA Period: 1	Data can be changed on the edited database server	There was a data change in the database server	[x] accepted [ ] rejected
Clear Data Element name: Hydrogen	Display data on the form data rule and database server is deleted	Display data on the form data rule and database server is deleted	[x] accepted [ ] rejected
Cases and Test Results (Incorrect Data)			
Input Data	**Expected**	**Observation**	**Conclusion**
The data entered is incomplete	There is a message that data filling is incomplete	An incomplete data warning message appears	[x] accepted [ ] rejected

Table 4: Testing Consultation Menu.

Cases and Test Results (Correct Data)			
Input Data	**Expected**	**Observation**	**Conclusion**
Click the consultation menu. Question 1: Gas Question 2: Non-Metals Question 3: Natural Elements Question 4: Isolators Question: IA	The resulting element name appears: Hydrogen	The resulting element name appears: Hydrogen	[x] accepted [ ] rejected

Period: 1			
Cases and Test Results (Incorrect Data)			
Input Data	**Expected**	**Observation**	**Conclusion**
Question 1: Gas Question 2: Semi-Metal Question 3: Question 4: Question5: Period:	The element possibility does not exist	The message 'Possible element name does not exist' appears	[x] accepted [ ] rejected

It can be seen in Tables 2, 3, and 4 that the test was carried out for true and false data. The test results show that the system is valid and meets the expectations.

CONCLUSIONS

The development of an expert system and its testing shows that this expert system application can be used as a tool to learn and recognize chemical elements. Users can learn about the characteristics of an element as if an expert accompanied them. This expert system still needs to be developed again by completing questions or quizzes complete with scoring to determine their level of understanding after learning chemical elements. The system can also be developed with the knowledge and rules to combine elements into compounds or break down compounds into smaller parts.

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