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Design and Development of Industrial Practice Monitoring and Assessment Systems using Tsukamoto Fuzzy Logic

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ABSTRACT

Vocational high schools are given flexibility for their students to carry out direct learning in the industry as part of the practical education activities of implementing student skills. The implementation of industrial practice requires a special way to find out and monitor each student's activities so that the achievements of the implementation of industrial practice can be carried out properly. The implementation of industrial work practice assessment has several assessment criteria. These criteria include attendance, neatness, attitude, skills, and knowledge. The problems found in the assessment system are still done manually so that the effectiveness is minimal. This study aims to create a system that can monitor and assess the implementation of industrial practices. The system developed will be tested as a medium for monitoring and assessing industrial practices. This research uses *Fuzzy Tsukamoto's* logic approach as a scoring logic model and uses the waterfall method as a development model consisting of analysis, design, coding, and testing. The results of the research conducted resulted in a system that can monitor and assess the implementation of industry practices. The test was carried out by 24 people consisting of guidance teachers and students. Testing is done by testing aspects of functionality and aspects of usability. Based on the test results, the functionality aspect scored 100% (very feasible) and the usage aspect got a score of 84.8% (very feasible)

Keywords: Industry Practice, Monitoring, Assessment, Fuzzy Tsukamoto.

INTRODUCTION

Presidential Regulation Number 68 of 2022 which regulates the Revality of vocational education and vocational training in order to improve the quality of Indonesian human resources which is the leading direction of vocational education. The Presidential Regulation explains several things, namely 1) increasing access, quality, and relevance of the implementation of Vocational Education and Vocational Training in accordance with the needs of the job market; 2) encourage the development of specific excellence in each vocational education and vocational training institution according to regional potential and job market needs; 3) strengthening synergy between the Central Government, Regional Governments, the business world, the industrial world, the world of work, and other stakeholders in improving the quality and competitiveness of Indonesia's human resources/workforce; 4) equipping human resources/manpower with competencies to work and/or entrepreneurship; and 5) encourage the participation of the business world, the industrial world, and the world of work in the context of implementing Vocational Education and Vocational Training [1].

One of the important parts of the Presidential Regulation relating to the Ministry of Education and Culture is to strengthen synergy between the Central Government, Regional Governments, the business world, the industrial world, the world of work, and other stakeholders in improving the quality and competitiveness of Indonesian human resources/workers. Based on the Presidential Regulation of 2022, vocational education includes vocational education[1]. Vocational high schools that provide education by producing superior human resources in a field, are certainly very closely related to the Presidential Regulation. Strengthening synergy or cooperation is implemented in the Industrial Practice program which provides direct education for students in the industrial world, in this program students can take advantage of the industrial world not only a place of practice, but also a place to add insight into the real world of work.

One of the government policies has imposed *dual system* education for vocational high schools. This system aims to integrate the world of education and the world of industry. At school students conduct simple theoretical and practical learning, then at other times students are given the opportunity to carry out practice areas of expertise directly in the industrial world. The aim is to[2]improve the quality of vocational education graduates, both knowledge, skills, discipline and work ethic that are relevant to the demands of employment.

Characteristics of Education in SMK is vocational education that prepares learners to work in a particular field [3]. So that the curriculum in Vocational High Schools is designed and the testing system is tailored to the needs of DUDI. To adjust the competencies needed in the world of work with the skills of alumni from schools, it is necessary to synchronize the curriculum [4]. Through curriculum synchronization with the integration of learning in the classroom and industry can be carried out optimally. Another thing that can be done is flexibility in student learning while still carrying out industrial practice [3]. One of the curriculum alignments is focused on implementing industrial practices.

The implementation of industrial practices is carried out when students are still pursuing vocational high school education. This activity provides an opportunity for students to gain competencies that are not obtained in school and provides experience and knowledge of DUDI development. Improving learning can be pursued by SMK by applying industrial practices in companies [5]. With the implementation of industrial practice, it provides benefits for students to become skilled workers and ready to work in accordance with the competencies learned.

The implementation of industrial practice is carried out in several stages of expansion, the stage involves several people who are responsible for the implementation of pre-employment ranging from the principal, vice principal, head of technical competence, to teachers in the field of expertise as supervisors for the implementation of industrial practice. If a structural part has been formed that is responsible for the implementation of industrial practice, then proceed with preparing an administrative file for industrial practice. Mapping students to debriefing industrial practices is also an important priority before industrial practice is implemented. The duration of the process of implementing industrial practices is mostly carried out for three months. The guidance teacher becomes someone responsible for monitoring the group of industrial practice students. The actions of vocational teachers should be able to negotiate what is and is not included in their role as teachers [6]. So that teachers as supervisors of industrial practice can negotiate and can always maintain good communication with DUDI. Monitoring activities are carried out once a month, to find out the implementation of pre-employment activities in accordance with the expectations of the school and DUDI.

Management Problems Existing industrial work practices in terms of monitoring Industrial work practices have not been maximized and met the desired standards [7]. This is in line with what has happened, the monitoring process should be carried out in a not too long-time span. With the implementation of monitoring, which is carried out once a month, the daily activities carried out by students are not well monitored. One of the goals of monitoring this industry practice is to find out the complaints of students and find out the shortcomings of students who are carrying out industrial practices through DUDI supervisors [8]. With one of these objectives, the supervising teacher should be able to monitor in real time, so that the assessment process based on passing standards for industrial practice implementation can be carried out properly.

Assessment by industry advisers and School advisors [9]. The assessment process for the implementation of industrial practices is carried out by DUDI supervisors and evaluation by supervisory teachers. The competencies that are assessed are approximately five elements, 1) the social needs of the community, 2) the needs of the world of work, 3) professional needs, 4) the needs of future generations, 5) the needs of science [10]. These five elements should be able to be used as a reference in the process of assessing the implementation of industrial practices. With these five elements, in order for the assessment process to be appropriate, of course, you must know the activities that students carry out every day. In its implementation, many vocational high schools are found in the process of assessing industrial practices manually, so that there is minimal effectiveness and compatibility between the values obtained and what students actually do in the industrial practice process.

This study aims to develop a quality system so that it can provide convenience in the process of monitoring and evaluating the implementation of industrial practices which were previously carried out using a manual system so that it is vulnerable to incompatibility and minimal effectiveness. Efforts to be made are developing a web-based system using Tsukamoto's Fuzzy logic. The Tsukamoto Fuzzy method can handle the complexity of the data in performance appraisal. In the implementation of industrial practices, there are several factors that are difficult to measure precisely because of the variety of assessment criteria, such as attendance, neatness, attitude, skills and knowledge.

Tsukamoto's Fuzzy Logic enables realistic judgments by calculating and modeling data based on the results of integration of expert (teacher or instructor) knowledge into the system. The contribution in this research is the development of a web-based system using the Fuzzy Tsukamoto method and the integration of expert knowledge to provide a more adaptive monitoring and assessment system for implementing industrial practices in monitoring and measuring student performance in an industrial environment. Tsukamoto's Fuzzy Technique which may not have been widely explored in the context of education and training so that it can provide a knowledge base as part of a technological solution that supports the improvement of the quality of Vocational High School education.

METHODS

System development is carried out using a waterfall model or *Software Life Cycle*[11]. The waterfall approach is a linear and sequential software development process in which progress flows towards conclusion through separate phases in which activities are executed one by one [12]. The main stages of the waterfall model are analysis, design, coding, and testing [13]. Feasibility testing is carried out by testing a specificity spec and usability aspects. Functionality aspects tested with test case checklist model [14]. The usability aspect was validated using instruments that were tested on 2 teachers and 22 students at SMK Muhammadiyah 1 Yogyakarta. Figure 1 is a waterfall model image; the focus of this research is on designing and creating an industrial practice assessment system with *Fuzzy Tsukamoto* logic.

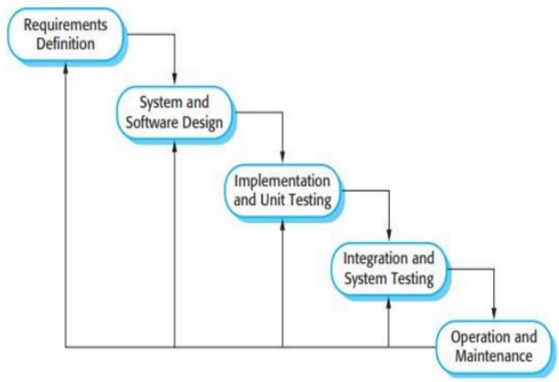

Figure 1. *Waterfall Model* [15]

Based on the model used in system development, the first stage of *Requirements Definition*, this step aims to find out the problems, objectives, and needs of the system through observation. *System and Software Design*, In the second stage, design the system design according to your needs. Implementation and unit testing, at the implementation stage begins to create a system program code, the *unit testing* stage is the system test stage for functionality and usability aspects. *Integration and System Testing* completed programs will be integrated and tested. Testing is done by testing aspects of functionality and usability. *Operation and Maintenance*, start using and repairing the system in case of deficiencies or *errors*.

The process of designing and creating an industrial practice assessment system uses *Tsukamoto's fuzzy logic*. *Fuzzy Tsukamoto* is one of several types of *Fuzzy Inference System* [16]. Where in the Tsukamoto method, each consequence of the *if-then* rule must be represented by a *fuzzy* set with a monotonous membership function [17]. Fuzzy consists of four main components: fuzzification, fuzzy rule base (knowledge base), inference engine and defuzzification [18]. The following are the stages of the industry practice assessment process using *Fuzzy Tsukamoto*.

A. Fuzzyfication

Fuzzification is the process of transforming an assertive value into a fuzzy variable in the form of a linguistic variable, which is then grouped into fuzzy sets [19]. There are two aspects that must be considered during the fuzzification process, namely input and output values. Then a member function is created which is used to determine the fuzzy value of the input and output values [16]. Tsukamoto's fuzzy logic goes through three fundamental stages, namely fuzzification, rule formation, inference engine and defuzzification [20]. There are five inputs and one output of the developed system, the inputs of this system include presence, neatness, attitude, skills and knowledge. Number of functions of presence, neatness, attitude, skills and knowledge.

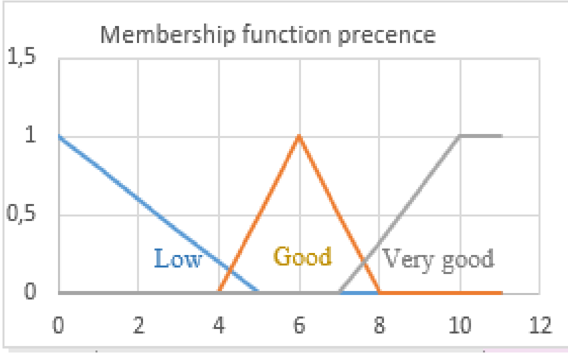

Figure 2. Function member presence

Presence variables consist of three types of value input/input categories: 1) Low presence variable (0-5); 2) Good presence variables (4-8); and 3) Excellent presence variables (7-10).

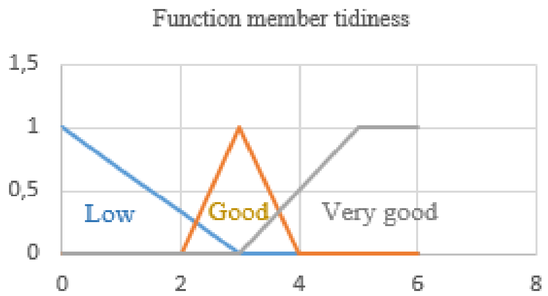

Figure 3. Function member tidiness

The neatness variable consists of three types of input categories / input values: 1) Low neatness variable (0-3); 2) Good neatness variables (2-4); and 3) Variable neatness is excellent (3-6).

Figure 4. Function member attitude

Attitude variables consist of three types of value input/input categories: 1) Low attitude variables (0-3); 2) Good attitude variables (2-4); and 3) Excellent attitude variables (3-6).

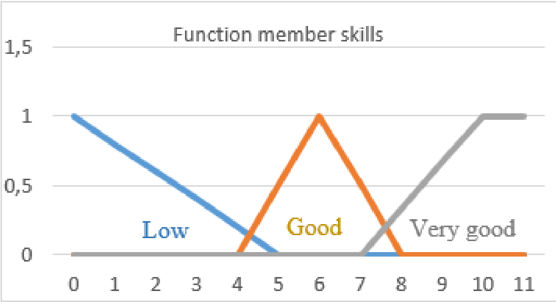

Figure 5. Function member neatness

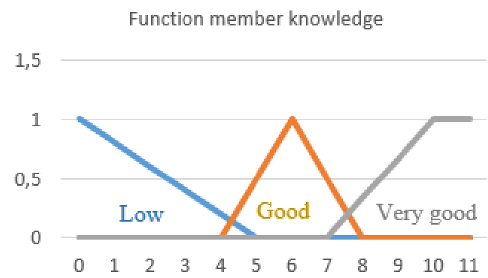

Figure 6. Function member knowledge

Skill and knowledge variables also consist of three types of value input/input categories:
1) Low skill variable (0-5)
2) Good skill variables (4-8)
3) Excellent skill variables (7-10)

B. Rule Base

The stage that is carried out after establishing the *member function* is to develop a rule base. The development of the rule base refers to the fuzzy logic rule base. A fuzzy rule base is a set of rules based on IF-THEN combined with and/or operators representing expertise [21]. Here's an explanation of the fuzzy rule base of industry practice assessment.

Table 1. Rule base

No.	Presence	Neatness	Attitude	Skills	Knowledge	Output
1	Very good	Very good	Very good	Very good	Very good	Very good
2	Good	Very good	Good	Low	Good	Good
3	Low	Very good	Low	Good	Low	Good
4	Very good	Good	Good	Low	Good	Good
5	Good	Good	Very good	Good	Very good	Very good
6	Low	Good	Very good	Very good	Low	Good
7	Very good	Low	Low	Good	Good	Good
8	Good	Low	Good	Low	Very good	Good
9	Low	Low	Low	Very good	Low	Good
10	Very good	Very good	Good	Low	Good	Very good
11	Good	Very good	Very good	Very good	Very good	Very good
12	Low	Good	Low	Good	Low	Good
13	Very good	Good	Very good	Very good	Good	Very good
14	Good	Low	Good	Good	Very good	Good
15	Low	Low	Low	Low	Low	Low

Note :
The output will be low if all inputs are low.

C. Defuzzyfication

In the last stage that will be done in *fuzzy* logic, namely *defuzzification*, this stage looks at the value of the input that has been used as *a crisp value.* The defuzzification method used in the Tsukamoto method is the *Center Average Defuzzifier* [22]. Here is the formula for the defuzzification of the Tsukamoto method.

$$Z = \frac{\sum \alpha i \; zi}{\sum \alpha i} \quad (1)$$

Note:
Z = Output variable
Ai = α-value predicate
zi = output variable value

Provided that the output results will be displayed in the following table:

Table 2. Fuzzy result range

No	Output results	Range
1	Very Good	11 ≥ N ≤ 15
2	Good	6 ≥ N ≤ 10
3	Low	0 ≥ N ≤ 5

The data analysis techniques tested are functionality aspect and usability aspect. The functionality aspect refers to the matrix of completeness of system features. Testing aspects of functionality using Guttman scale instruments. This Gustman scale is used to get an unequivocal answer of "successful" or "no".

The usability aspect tested uses a Likert scale with a scale of 4 points from strongly agreeing to disagreeing as the answer choice of all question items. The scores for alternative answers for each item are as follows: (1) A score of 5 for a strongly agreeing answer, (2) A score of 4 for an affirmative answer, (3) A score of 3 for an answer of disapproval, and (4) a score of 2 for a strongly disagreeing answer. The score is then analyzed by calculating the average of the answers from the respondents.

The results of the percentage scores are then compared with the Likert scale interpretation criteria table. The interplay criteria can be seen in Table 3.

Table 3. Interpretation criteria

Percentage	Description
0% - 24%	Bad
25% - 49%	Not good
50% - 74%	Good
75% - 100%	Very good

RESULT AND DISCUSSION

The monitoring and assessment system for the implementation of industrial practices goes through several stages, including analysis, design, implementation, and testing. At the stage of analysis is carried out using the technique of study of literature from various sources. Literature studies include National and International scientific articles. At this stage includes data preparation, problems, and system development needs.

In the design stage, starting with creating a design entity relationship diagram (ERD), this includes the design of database logic and physical databases. Entity Relationship Diagram describes data as entities, relationships, and attributes [23]. Entity Relationship Diagram on this system is shown in Figure 7. Database logic is implemented in an entity table. Each table contains an associated column based on a MySQL database [24]. Architectural design performed using UML diagrams with *Microsoft Visio* 2013.

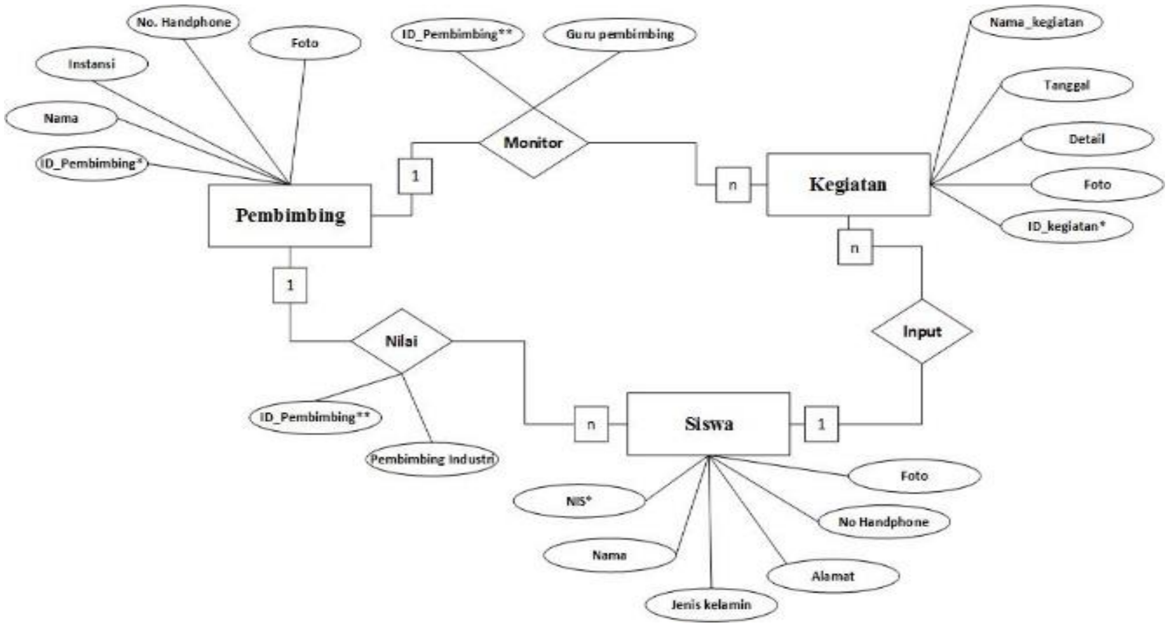

Figure 7. ER Diagram

UML diagrams consist of class diagrams, use case diagrams, activity diagrams and sequence diagrams. The use case diagram illustrates the user's activities and processes as a system user. The activity diagram illustrates the analysis process of a use case diagram. Sequence diagram describes the interaction between objects in the system based on the sequence of time in the field of software engineering.

The implementation stage makes in accordance with the design carried out in the previous ta h ap. Implementation is carried out by starting to create a programming language assessment system and monitoring the implementation of industrial practices. Program writing is created using the *Visual Studio Codes* application as software used for system development, with the PHP programming language and using the Laravel framework. Laravel makes the development process standardized, processing multiple logical relationships automatically [25]. Here are some views of the scoring and monitoring system using *Fuzzy Tsukamoto* logic.

On the first page displayed after accessing the PM PLI site is the login page as shown in figure 8. The login page is used to verify the data of the user who will use the system. This system consists of several users, namely admins, students, guidance teachers and industry supervisors. for the login process the user is directed to enter the email and password or account that has been obtained from the admin to use the PM PLI system.

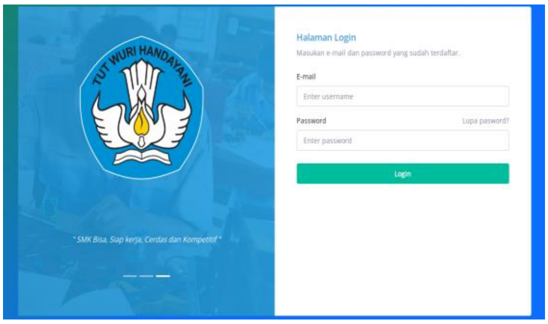

Figure 8. Login page

On the student user page, there are several features, one of which is a feature for the attendance process. On this page, students input attendance every day every time they carry out industrial practice activities. The attendance page consists of two arrival time forms and uniform completeness. Each form has a value that is then processed by the system as a determination of the final value of implementing industrial practices.

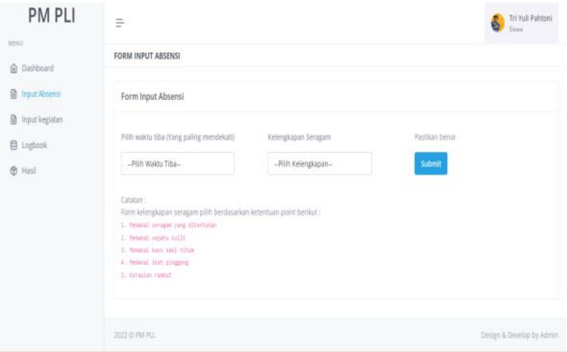

Figure 9. Attendance page

The system provides a value input feature on the industry advisory page. Industry Advisors can provide attitude value, ability and knowledge. These values are given by industry advisors at the final session of implementing industry practice. The calculation of these values uses the logic principle of Fuzzy Tsukamoto based on the rules that have been created.

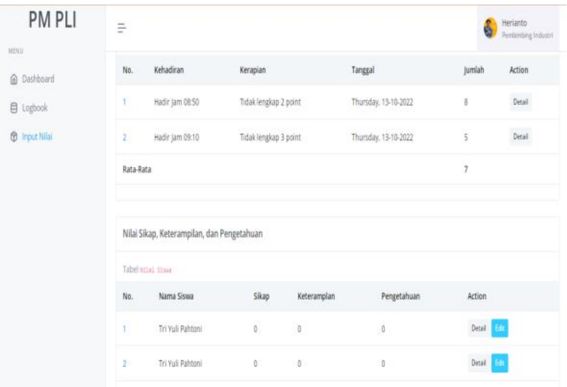

Figure 10. Value input page

On the guidance teacher's page, there is a feature to monitor student activities while carrying out industrial practice.

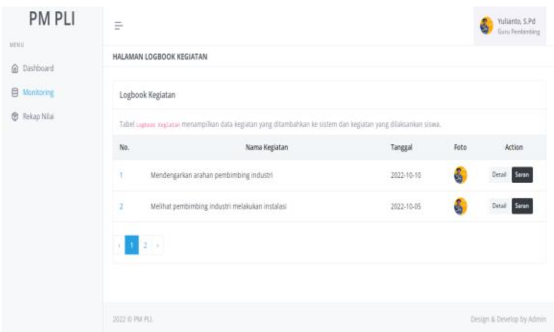

Figure 11. Monitoring page

On the page, information on the data of activities carried out by students is given, the guidance teacher can provide suggestions for students on each activity carried out.

The final score of the implementation of industrial practice can be seen in the value menu on the student's page user. On this page, information is given on the results of the implementation of industrial practices that have been implemented. Value takes the form of information; information refers to the basis of rules that have been created.

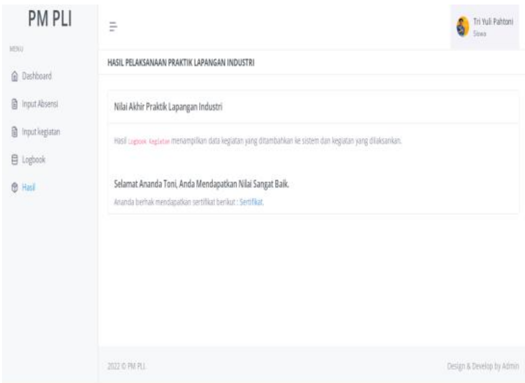

Figure 12. Values page

Tahapan pengujian bertujuan untuk menguji kelayakan sistem monitoring dan penilaian pelaksanaan praktik industri menggunakan metode blackbox pada aspek fungsionalitas dan kegunaan.

A. Fungsionality Aspects

The feasibility validation test of the functionality aspect serves to test the feasibility of each feature in the system that has been developed. The results of this test are then used as material for media repair in the system. The results of the recapitulation of functionality aspect testing can be seen in Table 4.

Table 4. Functionality test results

Page	Answers	
	Success	No
Login page	1	
Dashboard	1	
Attendace	1	
Value Input	1	
Monitoring	1	
Student Grades	1	
Certificate	1	
Response monitoring	1	
Student data	1	
Mentor data	1	
Partner industriy data	1	

Based on the results of the recapitulation of the validation of the functionality test, it can be known the average percentage of assessment:

(total score / question item) * 100
= (11/11)*100
= 100%

Based on the calculation of the results of testing aspects of functionality, a percentage of 100% is obtained. From these results it can be concluded that the functionality aspect of the system is acceptable,

B. Usability Aspects

Usability Test by conducting a system overhaul directly with 24 respondents consisting of 2 teachers and 22 students.

$$\text{Percentage Usability} = \frac{Scores\ obtained}{Maximum\ score}\ x100$$

$$\text{Percentage Usability} = \frac{2037}{2400}\ x\ 100 = 84{,}8\ \%$$

Based on the final calculation analysis carried out, a percentage of 84.8% was carried out in the *usability* test carried out. The score shows that the quality of software usability in the usability aspect is appropriate and if interpreted on the Likert scale this result is included in the excellent category. Analysis of the results of the assessment of responses from respondents can be seen in Table 5.

Table 5. Analysis of the results of the assessment responses

No.	Score	Score Max	(%)
1	82	100	82
2	77	100	77
3	82	100	82
4	84	100	84
5	80	100	80
6	86	100	86
7	84	100	84
8	84	100	84
9	88	100	88
10	87	100	87
11	86	100	86
12	87	100	87
13	86	100	86
14	85	100	85
15	87	100	87
16	86	100	86
17	86	100	86
18	88	100	88
19	88	100	88
20	86	100	86
21	81	100	81
22	83	100	83
23	87	100	87
24	87	100	87
Average	2037	2400	84,8

CONCLUSION

The system that has been developed uses Fuzzy Tsukamoto logic. The final score results are obtained from five predetermined variables, namely presence, neatness, attitude, skills, and knowledge. Each variable gets value input from students and industry supervisors which is then processed by the system using *Fuzzy Tsukamoto* logic. The system has gone through the functionality test and usability test stages. The functionality test scored 100% which means it was very feasible and the usability test got a score of 84.8% which means it is very feasible.

The development of a monitoring and monitoring system for the implementation of industrial practices still needs development for improvement. The system still does not have some features such as the continuation of student status at these companies that have high scores. This can be added to secure students after graduating from school if the company matches the students who have implemented industrial practices in their company.

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