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Accurately Determining Labor Test Results Using the Rough Set Method

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Abstract: An exam is something that must be done to test a person's ability or intelligence. The laboratory exam in the Computer Systems study program at Putra Indonesia University "YPTK" Padang consists of a digital systems exam, a fuzzy logic control exam, and a tool presentation. The Labor Exam must be passed by students who will take the comprehensive exam. In this study, laboratory exam data was taken for 20 students. So far, processing of student laboratory exam results has been done manually so it takes a long time to make decisions. To overcome this problem, a Rough Set method is used to determine laboratory test results. The Rough Set method is part of machine learning. This research produces 29 rules as knowledge, namely {Digital System} Or {A} = 3 rules, {Fuzzy Logic} Or {B} = 3 rules, {Tool Presentation} Or {C} = 3 rules, {Fuzzy Logic, Tool Percentage} Or {BC} = 6 rules, {Digital System, Fuzzy Logic} Or {AB} = 6 rules and {Digital System, Tool Percentage} Or {AC} = 8 rules. The Rough Set method can determine student laboratory exam results (pass or fail) accurately.

Keywords: Knowledge; Lab exams; Machine learning; Rough set method; Rules

Introduction

Machine learning is one method used to solve problems in the environment. In machine learning (Alkinani et al., 2020; Gao & Wu, 2020), there is a more detailed part in decision-making, namely data mining. In data mining, there is a rough set method that can be used to assist decision-making (Chinnaswamy & Srinivasan, 2017; Kurniawan et al., 2018). An exam is something that is used to test a person's abilities or learning results, A laboratory test must be carried out by students before taking the Comprehensive exam (Pelton, 2017). The laboratory exam in the Computer Systems study program consists of 3 parts, namely the Digital Systems Exam, Fuzzy Logic Control, and Tool Presentation. So far, the process of determining student laboratory exam results has been carried out manually (González-Calatayud et al., 2021; Swiecki et al., 2022; Abdulrahman et al., 2020). This process results in decision-making taking a long time. In this research, the rough set method was used to help make laboratory exam decisions for students who had registered to take the laboratory exam (Attaullah et al., 2023; Chen et al., 2023; Hariri et al., 2019). Wang et al. (2023) and Puška et al. (2023) stated Rough Set is a method for dealing with ambiguity and uncertainty introduced in the processing of imprecise information.

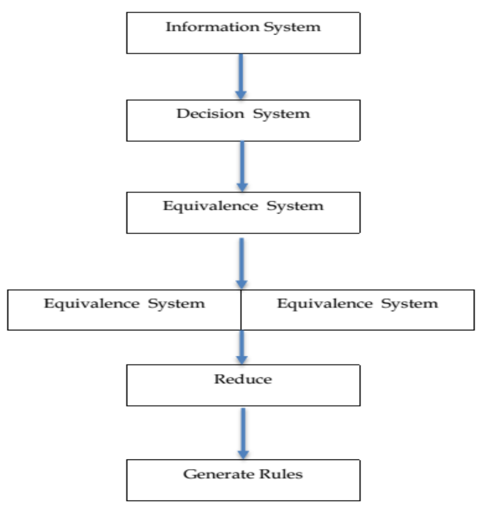

Figure 1. Solution algorithm using the rough method set

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The settlement scheme using the Rough Set method consists of several stages, namely the Decision System, Equivalence Class, Dicernibility Matrix, Dicernibility Matrix Modulo D, Reduction, and Knowledge (Zuhdi, 2022). This research aims to accurately determine the results of the digital system laboratory exam, fuzzy logic, and the percentage of tools that students pass or fail.

Method

The method used in this research is the Rough Set method (Raharjo & Windarto, 2021; Halder et al., 2019) and to simplify the methodology and system design process, an analysis and design flow chart can be created as shown in the image below:

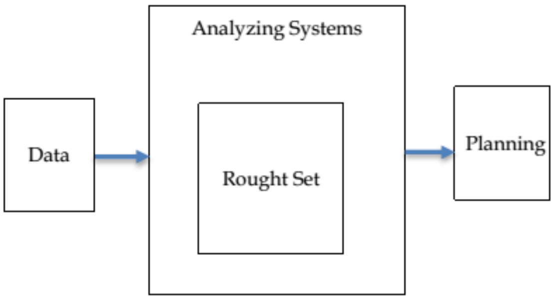

Figure 2. Analysis flow chart

In this research, 20 students took laboratory exams, namely the Digital Systems, Fuzzy Logic Control, and Tool Percentage exams.

Result and Discussion

Rough set theory is a tool mathematics to deal with disadvantages clarity and uncertainty introduced to process the absence uncertainty and inaccurate information (Qu et al., 2020; Pendrill, 2014; Demin, 2020). Rough the set has been widely applied in many ways real problems in medicine, pharmacology, engineering, banking, finance, market analysis, environmental management and etc (Kocornik-Mina et al., 2021; Khairunnessa et al., 2021). According to Dagdia et al. (2020), Swiniarski et al. (2003), and Manurung et al. (2018), that, stages in use The Rough Set algorithm is as follows: Data selection (Selection of data will be used); Establishment of a Decision System contains condition and attribute attributes decision; Establishment of Equivalence Class, namely by eliminating data which is repetitive; Formation of the Discernibility Matrix; Modulo D, namely the matrix contains comparisons between data different condition attributes and attributes decision; Produce reduct with using boolean algebra; Produce rules (knowledge) (Sianturi et al., 2021; Nurhidayat et al., 2020).

Rough Set was created by Zdzislaw Pawlak in the early 1980s, in order to mathematically reveal the concept of vagueness, its main goal is to be an automated process of transforming data into knowledge (Pięta et al., 2019; Pięta & Szmuc, 2021). Rough sets are a mathematical approach to knowledge that is not perfect, this is important in fuzzy logic (Slim & Nadeau, 2020; Bobillo & Straccia, 2012). Rough set lies in the fact that, based on a set of objects, a set attributes and decision values, one can create a rule to find upper and lower estimates, and the boundary region of the set object (Herbert & Yao, 2009; Del Giudice et al., 2017). After the rule is created, new objects can be created easily classified into one of the regions (region) (Sarker, 2021). The concept of rough sets in general can be defined by 2 topologies, namely interior and closure (Ali et al., 2013; AL-Khafaji & Hussan, 2018).

The basic idea of Rough Set (RS) is a mathematical technique used to handle problems of uncertainty, imprecision and ambiguity in Artificial applications Intelligence (AI) (Liu et al., 2022; Kristanto et al., 2021). RS is related to the classification from the table. Even in theory RS is related to discrete data, RS is usually used in conjunction with engineering another to perform discreetization on the dataset (Ali et al., 2023; Zhang et al., 2020; Ayub et al., 2022). The main features of RS data analysis are non-invasive, and the ability to handle qualitative data. The results of the RS analysis can be obtained used in the Data Mining and Knowledge Discover processes. In this research, several stages were carried out to obtain the desired results.

Decision Systems

Data is prepared in table form containing Condition Attributes and Decision Attributes. Condition attributes are placed in the left column, while decision attributes are in the right column. Condition attributes consist of 1 or more attributes while decision attributes only consist of 1 attribute. The decision system table can be seen in the table below.

Table 1. Decision System

Digital Systems	Fuzzy logic Controls	Tool Presentation	Results
Very good	Very good	Very worthy	Passed
Enough	Good	Very worthy	Passed
Good	Good	Worthy	Passed
Very good	Very good	Very worthy	Passed
Enough	Not enough	No worthy	Fail
Good	Good	Very worthy	Passed
Enough	Not enough	No worthy	Fail
Very good	Very good	Very worthy	Passed
Enough	Good	Very worthy	Passed
Good	Good	Worthy	Passed
Very good	Good	Worthy	Passed
Very good	Very good	Very worthy	Passed

Digital Systems	Fuzzy logic Controls	Tool Presentation	Results
Enough	Good	No worthy	Fail
Good	Good	Worthy	Passed
Very good	Good	Worthy	Passed
Good	Not enough	No worthy	Fail
Very good	Very good	Very worthy	Passed
Very good	Very good	Very worthy	Passed
Very good	Very good	Very worthy	Passed
Enough	Good	No worthy	Failed
Enough	Not enough	Worthy	Fail

Equivalence Class

Equivalence Class is a grouping of objects that have the same Condition Attribute values, which can be seen in the table below.

Table 2. Equivalence Class is a Grouping of Objects that Have the Same Condition Attribute Values

Equivalence Class (EC)	Digital Systems (A)	Fuzzy Logic (B)	Tool Presentation (C)	Results
EC1	Very good	Very good	Very Worth It	Passed
EC2	Very good	Good	Worthy	Passed
EC3	Good	Good	Very Worth It	Passed
EC4	Good	Good	Worthy	Passed
EC5	Good	Not enough	Not feasible	Fail
EC6	Enough	Good	Very Worth It	Passed
EC7	Enough	Not enough	Not feasible	Fail
EC8	Enough	Good	Not feasible	Fail
EC9	Enough	Not enough	Worthy	Fail

Discernibility Matrix

The columns in the Matrix are filled with a set of Condition Attributes that have different Condition values, which can be seen in the figure below.

	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9
EC1	X	BC	AB	ABC	ABC	AB	ABC	ABC	ABC
EC2	BC	X	AC	A	ABC	AC	ABC	AC	AB
EC3	AB	AC	X	C	BC	A	ABC	AC	ABC
EC4	ABC	A	C	X	BC	AC	ABC	AC	AB
EC5	ABC	ABC	BC	BC	X	ABC	A	AB	AC
EC6	AB	AC	A	AC	ABC	X	BC	C	BC
EC7	ABC	ABC	ABC	ABC	A	BC	X	B	C
EC8	ABC	AC	AC	AC	AB	C	B	X	BC
EC9	ABC	AB	ABC	AB	AC	BC	C	BC	X

Figure 3. Distinction Matrix

Dicernibility Matrix Modulo D

The columns in the Matrix are filled with a set of Condition Attributes that have different Condition values and also different decision values, which can be seen in the figure 4.

	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9
EC1	X	X	X	X	ABC	X	ABC	ABC	ABC
EC2	X	X	X	X	ABC	X	ABC	AC	AB
EC3	X	X	X	X	BC	X	ABC	AC	ABC
EC4	X	X	X	X	BC	X	ABC	AC	AB
EC5	ABC	ABC	BC	BC	X	ABC	X	X	X
EC6	X	X	X	X	ABC	X	BC	C	BC
EC7	ABC	ABC	ABC	ABC	X	BC	X	X	X
EC8	ABC	AC	AC	AC	X	C	X	X	X
EC9	ABC	AB	ABC	AB	X	BC	X	X	X

Figure 4. Dicernibility matrix modulo D

Reduction

The Reduction process is used to select Condition Attributes that will be used to produce Knowledge by creating Boolean Algebra equations based on the Discernibility Matrix or Discernibility Matrix Modulo D. The results are used as REDUCT. Manual explanation of the Reduct formed using Boolean Algebra.

$EC1 = (A \vee B \vee C)$
$= A + B + C$

$EC2 = (A \vee B \vee C) \wedge (A \vee C) \wedge (A \vee B)$
$= (A + B + C)\ (A + C).\ (A + B)$
$= A + BC$

$EC3 = (B \vee C) \wedge (A \vee B \vee C) \wedge (A \vee C)$
$= (B + C).\ (A + B + C).\ (A + C)$
$= C + AB$

$EC4 = (B \vee C) \wedge (A \vee B \vee C) \wedge (A \vee C) \wedge (A \vee B)$
$= (B + C).\ (A + B + C).\ (A + C).\ (A + B)$
$= AB + AC + BC$

$EC5 = (A \vee B \vee C) \wedge (B \vee C)$
$= (A + B + C).\ (B + C)$
$= B + C$

$EC6 = (A \vee B \vee C) \wedge (B \vee C) \wedge C$
$= (A + B + C).\ (B + C).\ C$
$= C$

$EC7 = (A \vee B \vee C) \wedge (B \vee C)$
$= (A + B + C).\ (B + C)$
$= B + C$

$EC8 = (A \vee B \vee C) \wedge (A \vee C) \wedge C$
$= (A + B + C).\ (A + C) + C$
$= C$

$EC9 = (A \vee B \vee C) \wedge (A \vee B) \wedge (B \vee C)$
$= (A + B + C).\ (A + B).\ (B + C)$
$= B + AC$

Class	Aljabar Boolean	Hasil	Reduct
EC1	(A∨B∨C)	A+B+C	{A},{B},{C}
EC2	(A∨B∨C) ∧(A∨C) ∧(A∨B)	A+BC	{A},{BC}
EC3	(B∨C)∧(A∨B∨C) ∧(A∨C)	C+AB	{C},{AB}
EC4	(B∨C)∧(A∨B∨C) ∧(A∨C) ∧(A∨B)	AB+AC+BC	{AB},{AC},{BC}
EC5	(A∨B∨C) ∧(B∨C)	B+C	{B},{C}
EC6	(A∨B∨C)∧(B∨C) ∧ C	C	[C]
EC7	(A∨B∨C)∧(B∨C)	B+C	{B},{C}
EC8	(A∨B∨C)∧(A∨C) ∧ C	C	{C}
EC9	(A∨B∨C)∧(A∨B) ∧(B∨C)	B+AC	{B},{AC}

Figure 5. Reduce results from labor exam

Knowledge

Reduce results obtained used for generating Knowledge with referring to the Decision System table on research This produced 29 rules as knowledge from results reduct, can see the explanation below this:

{Digital System} or {A}

If Digital System = Very Good Then Result = Pass
If Digital System = Sufficient Then Result = Passed or Result = Failed
If Digital System = Good Then Result = Passed or Result = Failed

{Fuzzy Logic} Or {B}

If Fuzzy Logic = Very Good Then the Result = Pass
If Fuzzy Logic = Good Then Result = Passed or Result = Failed
If Fuzzy Logic = Less Then Result = Failed

{Tool Percentage} Or {C}

If Tool Percentage = Very Eligible Then Result = Pass
If Tool Percentage = Eligible Then Result = Passed or Result = Failed
If Tool Percentage = No Eligible Then Result = Failed

{Fuzzy Logic, Tool Percentage} Or {BC}

If Fuzzy Logic = Very Good and Tool Percentage = Very Eligible) Then Result = Pass
If Fuzzy Logic = Good and Tool Percentage = Very Eligible Then Results = Pass
If Fuzzy Logic = Good and Tool Percentage = Eligible Then Result = Pass
If Fuzzy Logic = Less and Tool Percentage = No Eligible Then Result = Failed
If Fuzzy Logic = Good and Tool Percentage = No Eligible Then Result = Failed
If Fuzzy Logic = Less and Tool Percentage = Feasible Then Result = Failed

{Digital System, Fuzzy Logic} or {AB}

If Digital System = Very Good and Fuzzy Logic = Very Good Then Result = Pass
If Digital System = Sufficient and Fuzzy Logic = Good Then Result = Passed or Result = Failed
If Digital System = OK And Fuzzy Logic = Good Then Pass Results
If Digital System = Sufficient and Fuzzy Logic = Less Then Result = Failed
If Digital System = Very Good and Fuzzy Logic = Good Then Result = Pass
If Digital System = OK and Fuzzy Logic = Less Then Result = Failed

{Digital System, Tool Percentage} or {AC}

If Digital System = Very Good and Tool Percentage = Very Eligible Then Results = Pass
If Digital System = Sufficient and Tool Percentage = Very Eligible Then Results = Pass
If Digital System = OK and Tool Percentage = Eligible Then Result = Pass
If Digital System = Sufficient and Tool Percentage = No Eligible Then Result = Failed
If Digital System = OK and Tool Percentage = Very Eligible Then Results = Pass
If Digital System = Very Good and Tool Percentage = Eligible Then Result = Pass
If Digital System = OK and Tool Percentage = No Eligible Then Result = Failed
If Digital System = Sufficient and Tool Percentage = Feasible Then Result = Failed

Test Results Using Software

Software used with the Rough Set method is Rosetta, and the file is imported from Microsoft Excel with the attributes Digital System, Fuzzy Logic, Tool Presentation, and Results.

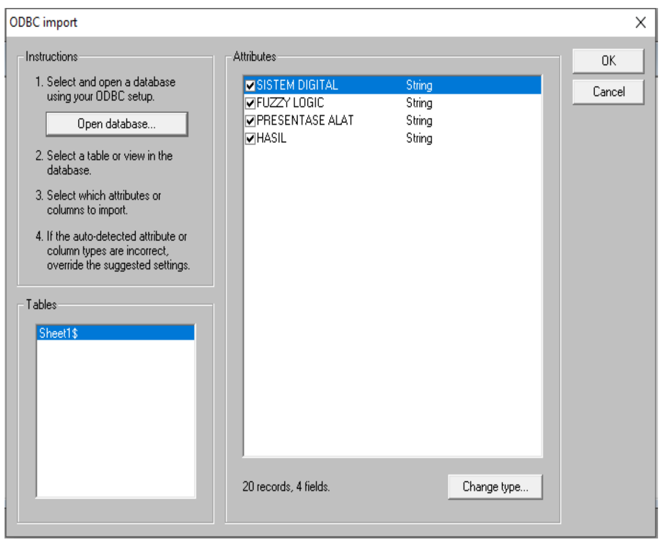

Figure 6. ODBC import

Data for 20 students was imported from Microsoft Excel with the attributes Digital System, Fuzzy Logic, Percentage of Tools, and Results.

SK Labor Exam Data

1	Digital Systems	Fuzzy Logic	Tool Presentation	Results
2	Very good	Very good	Very Worth It	Passed
3	Enough	Good	Very Worth It	Passed
4	Good	Good	Worthy	Passed
5	Very good	Very good	Very Worth It	Passed
6	Enough	Not enough	Not feasible	Fail
7	Good	Good	Very Worth It	Passed
8	Enough	Not enough	Not feasible	Fail
9	Very good	Very good	Very Worth It	Passed
10	Enough	Good	Very Worth It	Passed
11	good	Good	Worthy	Passed
12	Very good	Good	Worthy	Passed
13	Very good	Very good	Very Worth It	Passed
14	Enough	Good	Not feasible	Fail
15	Good	Good	Worthy	Passed
16	Good	Not enough	Not feasible	Fail
17	Very good	Very good	Very good	Passed
18	Very good	Very good	Very good	Passed
19	Very good	Very good	Very good	Passed
20	Enough	Good	Not feasible	Fail
21	Enough	Not enough	Worthy	Fail

Figure 7. Labor exam data in microsoft excel

Dynamic Reduct from research conducted can seen in the figure 8.

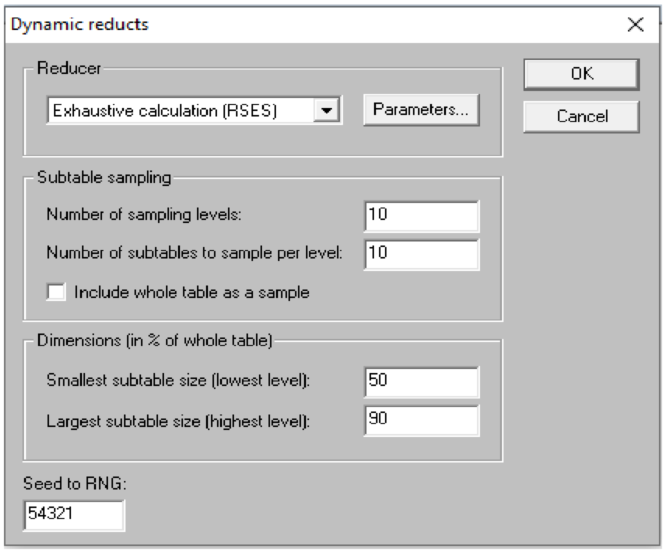

Figure 8. Dynamic reduct

The resulting reduction from the data in the research is shown in Figure 9.

Reduce

	Reduct	Support	Length
1	{SISTEM DIGITAL, PRESENTASE ALAT}	71	2
2	{FUZZY LOGIC, PRESENTASE ALAT}	70	2
3	{PRESENTASE ALAT}	27	1
4	{FUZZY LOGIC}	7	1
5	{SISTEM DIGITAL}	3	1
6	{SISTEM DIGITAL, FUZZY LOGIC}	3	2

Figure 9. Reduce

Table 3. The Rules that are Formed from the Data Provided in a Study this as Many as 29 Rules

Rules	LHS Support	RHS Support	RHS Accuracy	LHS Coverage	RHS Coverage	RHS Stability	LHS Length	RHS Length
Digital System (Very Good) and Tool Percentage (Very Worth It) => Results (Pass)	7	7	1.00	0.35	0.50	1.00	2	1
Digital System (Enough) and Tool Percentage (Very Worth It) => Results (Pass)	2	2	1.00	0.10	0.14	1.00	2	1
Digital System (Good) and Equipment Percentage (Worthy) => Results (Pass)	3	3	1.00	0.15	0.21	1.00	2	1
Digital System (Enough) and Equipment Percentage (Not Value) => Results (Failed)	4	4	1.00	0.20	0.67	1.00	2	1
Digital System (Good) and Tool Percentage (Very Worth It) => Results (Pass)	1	1	1.00	0.05	0.07	1.00	2	1
Digital System (Very Good) and Equipment Percentage (Worth It) => Results (Pass)	1	1	1.00	0.05	0.07	1.00	2	1
Digital System (Good) and Equipment Percentage (Not Value) => Results (Failed)	1	1	1.00	0.05	0.17	1.00	2	1

Rules	LHS Support	RHS Support	RHS Accuracy	LHS Coverage	RHS Coverage	RHS Stability	LHS Length	RHS Length
Digital System (Enough) and Equipment Percentage (Worth It) => Results (Failed)	1	1	1.00	0.05	0.17	1.00	2	1
Fuzzy Logic (Very Good) and Tool Percentage (Very Decent) => Results (Pass)	7	7	1.00	0.35	0.50	1.00	2	1
Fuzzy Logic (Good) and Tool Percentage (Very Worth It) => Results (Pass)	3	3	1.00	0.15	0.21	1.00	2	1
Fuzzy Logic (Good) and Tool Percentage (Worthy) => Results (Pass)	4	4	1.00	0.20	0.28	1.00	2	1
Fuzzy Logic (Less) and Tool Presentage (Not Value) => Results (Failed)	3	3	1.00	0.15	0.50	1.00	2	1
Fuzzy Logic (Good) and Tool Presentage (Not Value) => Result (Failed)	2	2	1.00	0.10	0.33	1.00	2	1
Fuzzy Logic (Less) and Tool Percentage (Worthy) => Results (Failed)	1	1	1.00	0.05	0.17	1.00	2	1
Percentage (Very Decent) => Results (Pass)	10	10	1.00	0.50	0.71	1.00	1	1
Tool Percentage (Worth It) => Result (Pass) or Result (Fail)	5	4. 1	0.80. 0.20	0.25	0.28. 0.17	1.00. 1.00	1	2
Percentage (Not Value) => Result (Failed)	5	5	1.00	0.25	0.83	1.00	1	1
Fuzzy Logic (Very Good) => Result (Pass)	7	7	1.0	0.35	0.5	1.0	1	1
Fuzzy Logic (Good) => Result (Pass) or Result (Fail)	9	7, 2	0.78. 0.22	0.45	0.50. 0.33	1.00. 1.00	1	2
Fuzzy Logic (Less) => Result (Failed)	4	4	1.00	0.20	0.67	1.00	1	1
System (Very Good) => Result (Pass)	8	8	1.00	0.40	0.57	1.00	1	1
Digital System (Enough) => Result (Pass) or Result (Failed)	7	2, 5	0.28. 0.71	0.35	0.14. 0.83	1.00. 1.00	1	2
Digital System (Good) => Result (Pass) or Result (Failed)	5	4. 1	0.80. 0.20	0.25	0.28. 0.17	1.00. 1.00	1	2
System (Very Good) and Fuzzy Logic (Very Good) => Results (Pass)	7	7	1.00	0.35	0.50	1.00	2	1
Digital System (Sufficient) and Fuzzy Logic (Good) => Results (Pass) Or Results (Fail)	4	2. 2	0.50. 0.50	0.20	0.14. 0.33	1.00. 1.00	2	2
Digital System (Good) and Fuzzy Logic (Good) => Results (Pass)	4	4	1.00	0.20	0.28	1.00	2	1
Digital System (Enough) and Fuzzy Logic (Less) => Results (Failed)	3	3	1.00	0.15	0.50	1.00	2	1
System (Very Good) and Fuzzy Logic (Good) => Results (Pass)	1	1	1.00	0.05	0.07	1.00	2	1
Digital System (Good) and Fuzzy Logic (Poor) => Results (Failed)	1	1	1.00	0.05	0.17	1.00	2	1

Conclusion

The Rough Set method can help provide accurate decisions on student laboratory exam results. This research produces 29 rules as knowledge, namely {Digital Systems} or {A} = 3 rules, {Fuzzy Logic} or {B} = 3 rules, {Tool Presentation} or {C} = 3 rules, {Fuzzy Logic, Tool Percentage} Or {BC} = 6 rules, {Digital System, Fuzzy Logic} Or {AB} = 6 rules and {Digital System, Tool Percentage} Or {AC} = 8 rules.

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Author Contributions
Conceptualization, R. D., and S. D., methodology, R. D.; validation, S. D.; formal analysis, R. D.; investigation, S. D.; resources, R. D. and. S. D.; data curation, R. D: writing—original draft preparation, S. D. and R. D.; writing—review and editing, S. D.: visualization, R. D. and J. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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