Published online on the page : https://ejournal.uinbukittinggi.ac.id/index.php/ijokid/

Knowbase : International Journal of Knowledge in Database

| ISSN (Print) 2798-0758 | ISSN (Online) 2797-7501 |

Design of an Expert System for Determining Learning Styles (SIPATUGABEL) for Students at The Madrasah Tarbiyah Islamiyah (MTI) in Canduang

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Article Information

Article History:

Submitted: March 13, 2026
Revision: April 30, 2026
Accepted: May 3, 2026
Published: June 24, 2026

Keywords

Expert System
Learning Style
Certainty Factor
SDLC
Waterfall

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A B S T R A C T

Humans possess diverse potentials that are inherent from birth and must be nurtured to develop fully. These potentials can be developed in various ways, one of which is through learning. The learning process can help individuals develop their potential in accordance with their unique characteristics. Since every individual has different characteristics, students have diverse learning styles. It is crucial to consider learning styles in the learning process to ensure meaningful learning. The Merdeka Curriculum also includes several assessments, one of which is diagnostic assessment, which serves as the initial step a teacher takes to determine students' baseline conditions both cognitive and non-cognitive. However, in implementing this diagnostic assessment at MTI Canduang, a challenge arises: the difficulty in accurately and quickly identifying students' learning styles. Based on this problem, the researcher aims to design a web-based expert system for determining students' learning styles using the Certainty Factor method, which can identify students' learning styles in a valid, practical, and effective manner. The researcher employed the Research and Development (R&D) methodology to produce an expert system product, utilizing the Systems Development Life Cycle (SDLC) model with the Waterfall method, to develop an expert system for determining the learning styles of students at Madrasah Tarbiyah Islamiyah (MTI) Canduang. After the system was successfully designed, product testing was conducted. The results of the product testing, such as the system validity test, indicated that the system was valid, with an average score of 0.96 from the validator. The designed system was then deemed practical, achieving an average score of 0.93 from the practicality evaluator, and the designed system was deemed effective, achieving an average score of 0.56 from all respondents the fourth grade students of the MTI Canduang special class. Based on these test results, the designed expert system for determining learning styles was deemed valid, practical, and effective in determining learning styles quickly and accurately.

1. Introduction

Humans possess diverse potentials that are inherent within them from birth. Every potential inherent within a person must be explored more deeply in order to develop properly. These potentials consist of academic and non-academic potentials.

Potential is an innate ability that humans possess and that has the possibility of being developed. The factors influencing the development of these potentials do not originate solely from within the individual;

rather, the development of potential is also influenced by the environment [1]. The development and actualization of these potentials are also influenced by the environment, which determines a person's character [2]. A child's potential development is also influenced by their parents (the environment) [3]. One aspect of the environment is education. Education significantly influences the development of every individual. Parents have a responsibility to ensure their children develop in accordance with their innate nature and are accountable for their children's education. It is through this education that a person's internal potential is utilized to explore and develop a variety of other potentials.

It is understood that to develop human potential, one must use their five senses to acquire knowledge. This can be achieved through learning. Learning is an activity deeply ingrained in human nature and is frequently practiced throughout one's entire life. Learning is a process undertaken by humans to bring about behavioral changes whether in the form of knowledge, skills, attitudes, or positive values as a result of experiences gained from various subjects studied [4]. Through learning, it is hoped that the diversity of potential within every individual can be enhanced.

The diversity of potential within every human being means that people must go through a learning process to develop their potential. The learning process is crucial for developing the potential of each individual. The learning process is a series of stages that lead to positive (progress oriented) changes in the cognitive, affective, and psychomotor behaviors of the learner [5]. From this, it can be understood that the learning process can enhance human abilities or potential. To conduct the learning process effectively, appropriate methods, media, approaches, and strategies are essential for implementation [6]. Moreover, to create an effective learning process, it must be tailored to the characteristics of the learners.

Learners possess diverse potentials and, consequently, diverse characteristics. Understanding learners' initial characteristics before the learning process begins is essential to facilitate the management of all aspects related to learning including the selection of management strategies, the organization of instruction, and the learning styles they possess so that instructional components align with students' characteristics, ultimately making the learning experience more meaningful [7].

Learning styles are one way to achieve meaningful learning. A learning style refers to the unique way each individual uses to understand and process information, especially when encountering complex and new material. Everyone has their own method for concentrating and absorbing knowledge, in accordance with their individual mindset and perceptions [8][9]. Each individual has their own learning style depending on the situation they face, allowing each student to have multiple learning styles, generally consisting of visual, auditory, and kinesthetic [10]. This also impacts the educator. Here, teachers must understand effective teaching methods for each student, so they must know and understand each student's individual characteristics. For this reason, it is important for teachers to know their students' learning styles [11].

The Merdeka Curriculum takes into account each student's learning style. This curriculum is flexible. Additionally, it focuses on essential content, character development, and student competencies [12]. One characteristic of the Merdeka Curriculum is the application of more interactive and collaborative learning methods. The Merdeka Curriculum is also considered more flexible than previous curricula. This means that teachers, students, and schools have greater autonomy in conducting learning activities at school [13]. The Merdeka Curriculum also allows teachers to use a wide variety of teaching tools, ranging from assessments, literacy materials, teaching modules, textbooks, and others, tailored to students' learning styles, learning environments, and other factors [10].

The Merdeka Curriculum aims to create differentiated instruction. Differentiated instruction is a teaching approach that adapts the teaching learning process to meet the unique needs, interests, and potential of each student. The goal is to maximize individual potential by providing learning experiences tailored to each student's characteristics [14]. To implement differentiated learning within the Merdeka Curriculum, an initial assessment or diagnostic assessment is required to align students' conditions with differentiated learning.

This initial or diagnostic assessment is conducted to measure students' prior knowledge levels. A diagnostic assessment identifies students' weaknesses and the factors suspected to be causing them, and is conducted to inform the provision of academic guidance [15]. Diagnostic assessment is divided into two types: cognitive diagnostic assessment, used to determine students' initial proficiency regarding learning materials, and non-cognitive diagnostic assessment, which explores students' social context, background, learning styles, and learning interests [16]. Diagnostic assessments can be conducted in various ways, such as through observation, interviews, and testing [17]. All of these methods can also leverage technological advancements for implementation, such as the use of expert systems. Expert systems can be used to solve problems by incorporating experts' knowledge, which is converted into computer programs that can then be used for problem solving [18]. An expert system is an interactive and reliable computer based decision making system that uses facts and heuristics to solve complex decision making problems involving knowledge in a specific field, based on the expertise of specialists or experts [19].

The implementation of diagnostic assessment has been carried out in schools, one of which is Madrasah Tarbiyah Islamiyah Canduang, also known as MTI Canduang. At MTI Canduang, the implementation of diagnostic assessment is conducted by teachers in each class. According to the results of an interview conducted with one of the teachers at MTI Canduang, the implementation of diagnostic assessment is carried out through direct observation in the classroom, conducted gradually during each session. This implementation faces significant challenges. Each teacher struggles to determine learning styles during the diagnostic assessment because the gradual direct observations in the classroom take a long time and yield inaccurate results, given the large number of students and the teachers' heavy workload.

Based on the problems described, the design of an expert system at MTI Canduang is crucial as it can assist teachers in conducting diagnostic assessments particularly in determining students' learning styles in an effective and efficient manner. Therefore, the author is interested in addressing this issue in this study, titled "Design of an Expert System for Determining the Learning Styles (SIPATUGABEL) of Students at Madrasah Tarbiyah Islamiyah (MTI) Canduang."

2. Method

The research conducted is of the Research and Development (R&D) type. This method aims to produce a specific product while testing its effectiveness. Research and Development (R&D) is a research approach designed to develop or validate various products, particularly those related to needs in the field of education and learning [20].

The system development model used by the researcher is the SDLC (Systems Development Life Cycle) model with the Waterfall method. Its stages consist of communication, planning, modeling, construction, and deployment [21], as shown in the figure below:

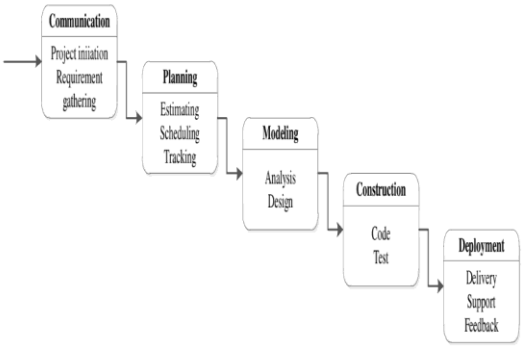

Figure 1. Stages of the Waterfall Model

Communication Phase: This phase involves gathering requirements to specify the software needs in a way that is easily understood by users. During this phase, we will analyze the issues encountered in determining the learning styles of students in grades 1 and 4, as well as the special MTI Canduang class.

Planning Phase: Following the requirements identification phase, the next step is to develop a work plan for software development. This includes defining technical tasks, identifying potential risks, allocating necessary resources, setting expected deliverables, and scheduling project implementation[22].

Modeling Phase: This phase involves developing the design, including data structures, software architecture, interface representations, and coding steps that will be integrated into a program in the next phase. Process design using UML, database design using Class Diagrams, table design, and user interface design required for the development of the expert system to determine the learning styles of MTI Canduang students.

Construction Phase: This phase is carried out after the modeling phase and involves translating the design into software code. The output of this phase is a computer program that aligns with the design established in the design phase. Upon completion, testing is conducted on the developed software. The objective is to evaluate the system and identify potential errors within it.

This testing aims to ensure that the system's primary functions operate properly as expected, comprising content validity testing, construct validity testing, linguistic validity testing, effectiveness testing, and practicality testing. Testing is conducted using test instruments containing specific inputs to verify whether the generated outputs comply with predetermined rules. This testing is performed by experts and respondents to evaluate the expert system under development.

Test results indicate that the system is capable of producing outputs consistent with the provided inputs, signifying that the system functions correctly as designed. The testing instruments used were first subjected to instrument validity testing using a previously prepared instrument validation sheet. The formulas used for each test are as follows:

Validity testing was performed using Aiken's V statistical formula as follows [23]:

$$V = \sum s / [n(c-1)] \quad (1)$$

Descriptions:

s = r – lo

lo = Lowest rating

c = Highest rating

r = Rating given by a rater

n = Number of raters

According to Aiken's validity criteria, a test is considered valid if the V value falls within the range of 0.60 to 1.00. Conversely, if the obtained V value falls below this threshold, the instrument is categorized as invalid.

The practicality test is then conducted using the following formula [24]:

$$k = \frac{P-Pe}{1-Pe} \quad (2)$$

Description:

k : Product practicality score.

P : The ratio of the total score given by the evaluator to the maximum possible score.

P*e* : The total score given by the evaluator minus the maximum score, divided by the maximum score.

With the following criteria intervals:

Table 1. Practicality Criteria

Interval	Criteria
0,81 – 1,00	"Very High"
0,61 – 0,79	"High"
0,41 – 0,60	"Moderate"
0,21 – 0,40	"Low"
0,01 – 0,20	"Very Low"
< 0,00	"Not Practical"

And the effectiveness was tested using the G-Score, this effectiveness test using the G-Score is used to measure how effective the system is in determining the extent to which students are aware of their dominant learning style. Thus, this effectiveness test can determine how effective the system is in identifying learning styles. formula as follows [25]:

$$G = \frac{Sf - Si}{Skro\ Maksimal - Si} \quad (3)$$

Description:

G : G-Score

Sf : Final score

Si : Initial score

The results of the calculation are classified into the following categories:

Table 2. Effectiveness Criteria

Interval	Criteria
G > 0,7	"High Effectiveness"
0.7 < G > 0,3	"Medium Effectiveness"
G < 0,3	"Low Effectiveness"

The final stage is Deployment. This stage involves the implementation or use of the expert system developed by the users—namely, teachers and administrators at MTI Canduang. Maintenance is also performed to ensure that the system continues to function as intended.

3. Results and Discussion

Based on the research stages outlined above, the results and discussion of the study are as follows:

3.1. Results

The result of this study is an expert system for determining the learning styles of students at Madrasah Tarbiyah Islamiyah (MTI) Canduang. This expert system facilitates the determination of students' learning styles without requiring direct assistance from experts. Furthermore, this expert system not only determines students' learning styles but also provides further explanations, solutions, and conclusions regarding the results of the learning style diagnosis. Following the research, the results of each stage of the Waterfall process are as follows:

Communication Phase: In this phase, the project was initiated to identify the requirements needed to address the challenge teachers face in determining students' learning styles during diagnostic assessments under the Merdeka Curriculum. Consequently, an expert system was deemed necessary to determine valid, practical, and effective learning styles for students. Thus, this expert system requires specific learning style categories and their indicators to identify each student's learning style. Then, the Certainty Factor method is used, determined based on the highest CF value; therefore, the system is designed for students, teachers, and administrators who will use this system. Each CF value was obtained from an expert, Dr. Hidayani Syams, M.Pd., using a questionnaire that included criteria for determining the extent of the indicator's influence on the learning style [26]. The criteria used for each question containing indicators of the respective learning styles are: "Strongly Agree" with a user CF value of 0.9, "Agree" with a CF value of 0.7, "Don't Know" with

a user CF value of 0.5, "Somewhat Agree" with a user CF value of 0.3, and "Disagree" with a user CF value of 0.1. These values were selected based on expert determinations and are also taken from the textbook [27]

The learning styles to be studied are Visual, Auditory, and Kinesthetic. Then, the indicators for each learning style will be assigned a CF value by experts, and rule mapping will be performed.

Table 3. Learning Style Criteria

Number	Code	Learning Styles
1	G001	Auditory
2	G002	Visual
3	G003	Kinesthetic

Table 4. Indicators of Visual Learning Styles

Code	Visual Learning Style Indicator	CF Score
V001	"Tends to watch the teacher's posture, movements, and lips while they are teaching."	1
V002	"Speaks somewhat quickly."	0.8
V003	"Pays attention to appearance in terms of clothing and presentation."	1
V004	"Is not easily distracted by noise."	1
V005	"Remembers what is seen rather than what is heard."	1
V006	"Prefers to read rather than have something read to them."	1
V007	"A fast and diligent reader."	0.8
V008	"Often knows what to say but struggles to choose the right words."	1
V009	"Prefers demonstrations over speeches."	1
V010	"Prefers music over art."	0.8
V011	"Has trouble remembering verbal instructions unless they are written down, and often asks others to repeat them."	0.8

Table 5. Indicators of Auditory Learning Styles

Code	Visual Learning Style Indicator	CF Score
A001	"Tends to talk to themselves while working."	0.8
A002	"Neat appearance."	1
A003	"Easily distracted by noise."	1
A004	"Learns by listening and remembering what is discussed rather than what is seen."	1
A005	"Enjoys reading aloud and listening."	1
A006	"Moves their lips and says the words in the book aloud while reading."	1
A007	"Is usually an articulate speaker."	0.8
A008	"Better at spelling aloud than writing it down."	0.8
A009	"Prefers verbal jokes to reading comics."	1
A010	"Has trouble with tasks involving visuals."	0.8
A011	"Speaks in a rhythmic pattern."	1
A012	"Can repeat and imitate tone, rhythm, and voice quality."	1

Table 6. Indicators of Kinesthetic Learning Styles

Code	Visual Learning Style Indicator	CF Score
K001	"Speaks slowly."	1
K002	"Has difficulty remembering maps unless they've been to the place before."	1
K003	"Memorizes by walking and looking around."	1
K004	"Uses a finger as a guide when reading."	0.8
K005	"Cannot sit still for long periods of time."	1
K006	"Handwriting may be poor."	0.8
K007	"Always physically oriented and very active"	1
K008	"Wants to do everything."	1
K009	"Often touches people, stands close, and moves around when interacting with others."	1
K010	"Learns by doing."	0.8

Based on the rules in the table above, each rule will be selected based on the highest combined CF value, which will determine the learning style diagnosis. Based on the table above, the following decision tree is generated:

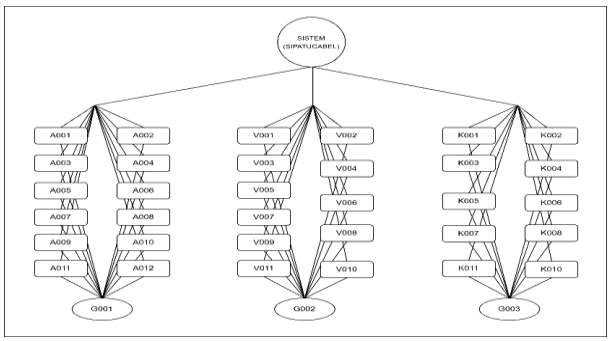

Figure 2. Decision Tree

The next phase is the planning phase, during which project estimates and scheduling are carried out. Following that, we move on to the modeling phase, which involves using UML comprising use case diagrams, activity diagrams, sequence diagrams, and class diagrams to provide an overview of the activities that may occur within the system, the interactions between actors and the system, and other processes that may take place within the expert system being designed. The overview of the modeling phase is as follows:

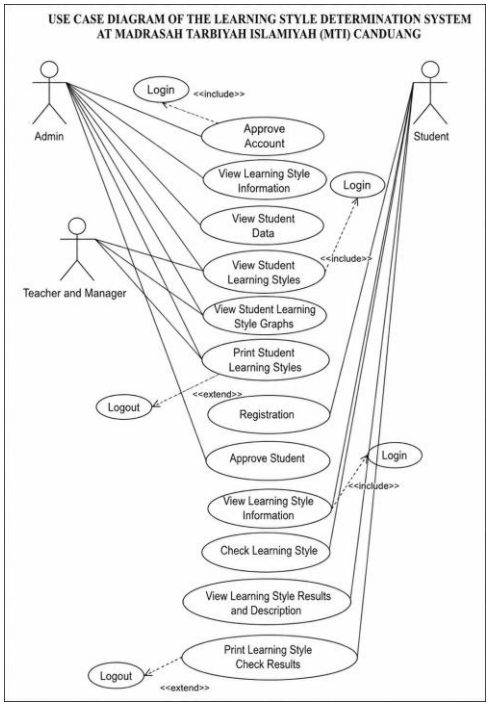

Figure 3. Use Case Diagram

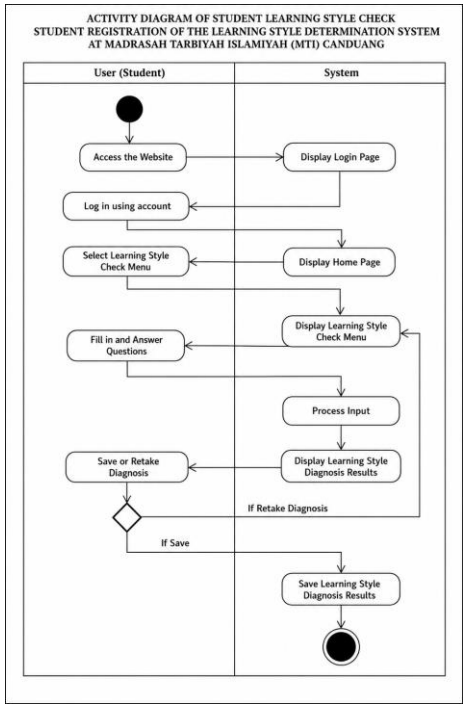

Figure 4. Activity Diagram Check Learning Styles

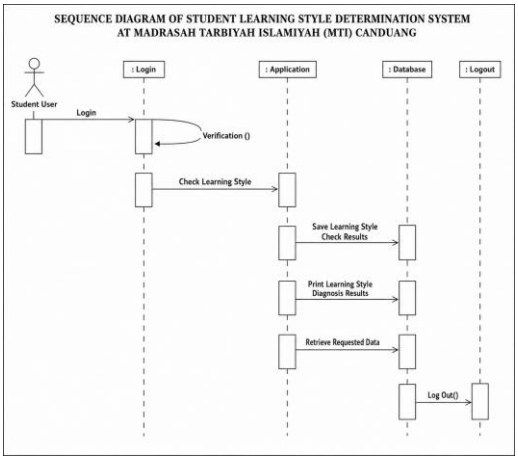

Figure 5. Student Sequence Diagram

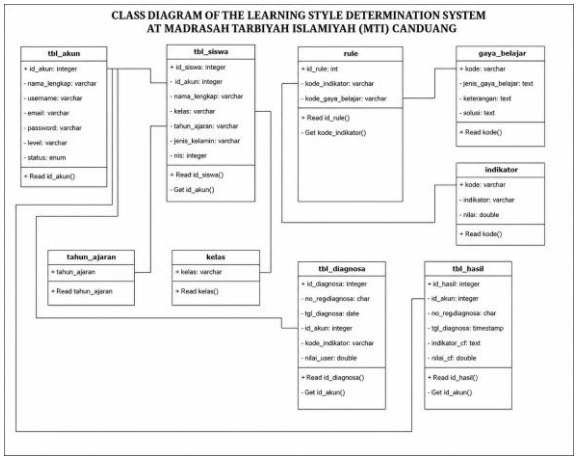

Figure 6. Class Diagram

Once the modeling phase is complete, the next step is the construction phase. During this phase, the coding and implementation of the previously created model or design will be carried out. The expert system being developed is a web-based system using the PHP programming language with a MySQL database.

Based on the information obtained in the previous stage for each learning style, the indicators and rules for determining the learning style diagnosis results use the Certainty Factor method with the following CF Combine formula [28]:

IF both CF > 0, then

$$CF[H, E] = CF[old] + CF[new] (1 - CF[old]) \quad (4)$$

IF both CFs are < 0, then:

$$CF[H, E] = CF[old] + CF[new] (1 + CF[old]) \quad (5)$$

IF either CF is < 0, then:

$$CF[H, E] = CF[old] + CF[new] / (1 - \min(CF[old] \mid CF[old]) \quad (6)$$

Where:

CF[H, E] : CF of the hypothesis influenced by evidence

CF[old] : First CF or CF from the previous calculation

CF[new] : Second CF or subsequent CF

Based on the formula above, the rule mapping from the knowledge base obtained in the previous stage will be mapped based on code into the programming language as follows:

Table 7. Knowledge Base Rule Encoding

Number	Rules
1	**IF** A001 **THEN G001**
2	**IF** A002 **THEN G001**
3	**IF** A003 **THEN G001**
4	**IF** A004 **THEN G001**
5	**IF** A005 **THEN G001**
6	**IF** A006 **THEN G001**
7	**IF** A007 **THEN G001**
8	**IF** A008 **THEN G001**
9	**IF** A009 **THEN G001**
10	**IF** A010 **THEN G001**
11	**IF** A011 **THEN G001**
12	**IF** A012 **THEN G001**
13	**IF** V001 **THEN G002**
14	**IF** V002 **THEN G002**
15	**IF** V003 **THEN G002**
16	**IF** V004 **THEN G002**
17	**IF** V005 **THEN G002**
18	**IF** V006 **THEN G002**
19	**IF** V007 **THEN G002**
20	**IF** V008 **THEN G002**
21	**IF** V009 **THEN G002**
22	**IF** V010 **THEN G002**
23	**IF** V011 **THEN G002**
24	**IF** K001 **THEN G003**
25	**IF** K002 **THEN G003**
26	**IF** K003 **THEN G003**
27	**IF** K004 **THEN G003**
28	**IF** K005 **THEN G003**
29	**IF** K006 **THEN G003**
30	**IF** K007 **THEN G003**
31	**IF** K008 **THEN G003**
32	**IF** K009 **THEN G003**
33	**IF** K010 **THEN G003**

After the system was successfully designed, system testing was conducted to ensure that the developed expert system was valid, practical, and effective for use. This was done using a questionnaire containing product testing instruments, which had previously undergone instrument validity testing by a validator a faculty member who reviewed whether the criteria to be used were appropriate for measuring the test results. Therefore, the testing instruments to be used were fully considered valid in terms of content, construct, and language for implementation during the testing phase.

The validators for each testing aspect are experts who are competent in system design in accordance with the aspects to be tested. Each aspect will be tested by three different validators to ensure the accuracy of the expert system to be built so that it can determine learning styles in a valid, practical, and efficient manner.

Based on the results of mapping these rules, the implications of using the Certainty Factor formula—specifically the CF Combine calculated manually by the system are as follows:

CFcombine = 0 + 0.4 × (1 - 0) = 0.4
CFcombine = 0.4 + 0.7 × (1 - 0.4) = 0.82
CFcombine = 0.82 + 0.9 × (1 - 0.82) = 0.982
CFcombine = 0.982 + 0.7 × (1 - 0.982) = 0.9946
CFcombine = 0.9946 + 0.9 × (1 - 0.9946) = 0.99946
CFcombine = 0.99946 + 0.9 × (1 - 0.99946) = 0.999946
CFcombine = 0.999946 + 0.4 × (1 - 0.999946) = 0.9999676
CFcombine = 0.9999676 + 0.24 × (1 - 0.9999676) = 0.999975376
CFcombine = 0.999975376 + 0.7 × (1 - 0.999975376) = 0.9999926128
CFcombine = 0.9999926128 + 0.4 × (1 - 0.9999926128) = 0.99999556768
CFcombine = 0.99999556768 + 0.3 × (1 - 0.99999556768) = 0.999996897376
CFcombine = 0.999996897376 + 0.3 × (1 - 0.999996897376) = 0.999997828163
Combine Score for Learning Style (Auditory): 0.999997828163

CFcombine = 0 + 0.1 × (1 - 0) = 0.1
CFcombine = 0.1 + 0.24 × (1 - 0.1) = 0.316
CFcombine = 0.316 + 0.3 × (1 - 0.316) = 0.5212
CFcombine = 0.5212 + 0.1 × (1 - 0.5212) = 0.56908
CFcombine = 0.56908 + 0.7 × (1 - 0.56908) = 0.870724
CFcombine = 0.870724 + 0.5 × (1 - 0.870724) = 0.935362
CFcombine = 0.935362 + 0.24 × (1 - 0.935362) = 0.95087512
CFcombine = 0.95087512 + 0.7 × (1 - 0.95087512) = 0.985262536
CFcombine = 0.985262536 + 0.3 × (1 - 0.985262536) = 0.9896837752
CFcombine = 0.9896837752 + 0.56 × (1 - 0.9896837752) = 0.995460861088
CFcombine = 0.995460861088 + 0.4 × (1 - 0.995460861088) = 0.997276516653
Combine Score for Learning Style (Visual): 0.997276516653

CFcombine = 0 + 0.5 × (1 - 0) = 0.5
CFcombine = 0.5 + 0.7 × (1 - 0.5) = 0.85
CFcombine = 0.85 + 0.7 × (1 - 0.85) = 0.955
CFcombine = 0.955 + 0.56 × (1 - 0.955) = 0.9802
CFcombine = 0.9802 + 0.7 × (1 - 0.9802) = 0.99406
CFcombine = 0.99406 + 0.4 × (1 - 0.99406) = 0.996436
CFcombine = 0.996436 + 0.3 × (1 - 0.996436) = 0.9975052

CFcombine = 0.9975052 + 0.7 × (1 - 0.9975052) = 0.99925156
CFcombine = 0.99925156 + 0.7 × (1 - 0.99925156) = 0.999775468
CFcombine = 0.999775468 + 0.56 × (1 - 0.999775468) = 0.99990120592
CF Combine Score for Learning Style (Kinesthetic): 0.99990120592

Highest CF Score: 0.999997828163
Learning Style with the Highest CF Score: Auditory

From the manual calculations performed within the system using the CF Combine formula, the results for each learning style present in each individual are obtained. Then, using this CF method, the highest CF Combine value is selected, which becomes the most dominant learning style. Thus, this most dominant learning style serves as the result of the learning style assessment within the expert system that has been designed, providing teachers with ease in conducting diagnostic assessments within the Merdeka Curriculum.

The results of the system validity testing in terms of content, construct, and language were deemed valid, with the following results:

Table 8. Results of the Product Validity Test: Content Aspect

Items	Validator			
	Dr. Hidayani Syam, M.Pd.			
	Score (r)	∑S	$n(c-1)$	1
1	4	3	3	1
2	4	3	3	1
3	4	3	3	1
4	4	3	3	1
5	4	3	3	1
6	4	3	3	1
7	4	3	3	1
8	4	3	3	1
9	4	3	3	1
10	4	3	3	10
Total	40	30	3	1
Average		1		

Table 9. Results of the Product Validity Test: Construct Aspects

Items	Validator			
	Ihdi Syahputra Ritonga, M.Kom			
	Score (r)	∑S	$n(c-1)$	1
1	4	3	3	1
2	4	3	3	1
3	4	3	3	1
4	4	3	3	1
5	4	3	3	1
6	4	3	3	1
7	4	3	3	1
8	4	3	3	1
9	3	2	3	0,66
10	4	3	3	1
Total	39	38	3	9,66
Average		0,966		

Table 10. Results of the Product Validity Test: Language Aspect

Items	Validator			
	Dr. Deswalantri, M.Pd.			
	Score (r)	∑S	$n(c-1)$	1
1	4	3	3	1
2	4	3	3	1
3	4	3	3	1
4	4	3	3	1

5	4	3	3	1
6	3	2	3	0,66
7	4	3	3	1
8	4	3	3	1
9	3	2	3	0,66
10	4	3	3	1
Total	38	37	3	9,33
Average		0,93		

Next, the average of the three validity scores—for content, construct, and linguistic validity—was calculated, resulting in an overall validity score of 0.96, which meets the criteria for "highly valid." The following table shows the overall average results of the product validity test:

Table 11. Product Validity Test Results

Validation Aspects	Validity Scores
Content Aspects	1
Construct Aspects	0,96
Language Aspects	0,93
Average	**0,96**

Next, the practical test was conducted by the guidance counselor, with the following results:

Table 12. Results of the Practicality Test for Guidance Counselors 1

Items	Practicalitator	
	Hidayatul Husni, S.Pd	
	Score	Score Max
1	3	4
2	3	4
3	4	4
4	4	4
5	3	4
6	3	4
7	3	4
8	3	4
9	3	4
10	4	4
Total	33	40
P	0,83	
Pe	0,18	
k	0,79	

Table 13. Results of the Practicality Test for Guidance Counselors 2

Items	Practicalitator	
	Randi Saputra, S. Ag	
	Score	Score Max
1	4	4
2	4	4
3	4	4
4	4	4
5	4	4
6	4	4
7	4	4
8	4	4
9	4	4
10	4	4
Total	40	40
P	1	
Pe	0	
k	1	

Table 14. Results of the Practicality Test for Guidance Counselors 3

Items	Practicalitator	
	Latifah Hanum, S.Pd	
	Score	Score Max

1	4		4
2	4		4
3	4		4
4	4		4
5	4		4
6	4		4
7	4		4
8	4		4
9	4		4
10	4		4
Total	40		40
P		1	
Pe		0	
k		1	

Based on the practicality tests conducted by the three guidance and counseling teachers mentioned above, the designed product was found to have a practicality score of 0.93 (based on the average), indicating that it has very high practicality. An effectiveness test was then conducted by a special fourth-grade class, with the following results:

Table 15. Product Effectiveness Test Table

Number	Respondent's Name	Initial Score (Si)	Final Score (Sf)	G-Score
1.	Abdul Hafiz	30	33	0,30
2.	Frida Yanti Nababan	25	32	0,47
3.	Hidayatul Nazwa	26	37	0,79
4.	Kamila Hayati Hasnah	23	37	0,82
5.	Muhammad Fadli Al Hakim	27	30	0,23
6.	Muhammad Nazlan	27	35	0,62
7.	Muhammad Rafi	24	34	0,63
8.	Nada Murandari	26	38	0,86
9.	Prima Rizki Nuggroho	26	30	0,29
10.	Sultan Al – Banna	29	35	0,55
11.	Wahyu Yudistira	23	34	0,65
Average		0,56		

After conducting an effectiveness test with fourth-grade special education students, an average score of 0.56 was obtained, indicating that the designed expert system is effective at a moderate level for use.

Following the design phase, the next step is deployment, where the designed product will be implemented and continuously maintained to ensure the expert system functions effectively as intended. Below is a screenshot of the learning style determination expert system (SIPATUGABEL) for students at Madrasah Tarbiyah Islamiyah (MTI) Canduang:

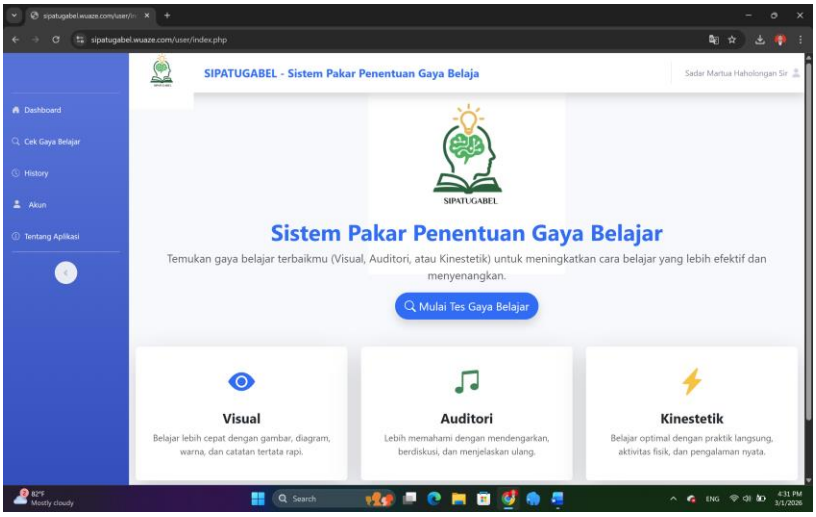

Figure 7. Student Home Page

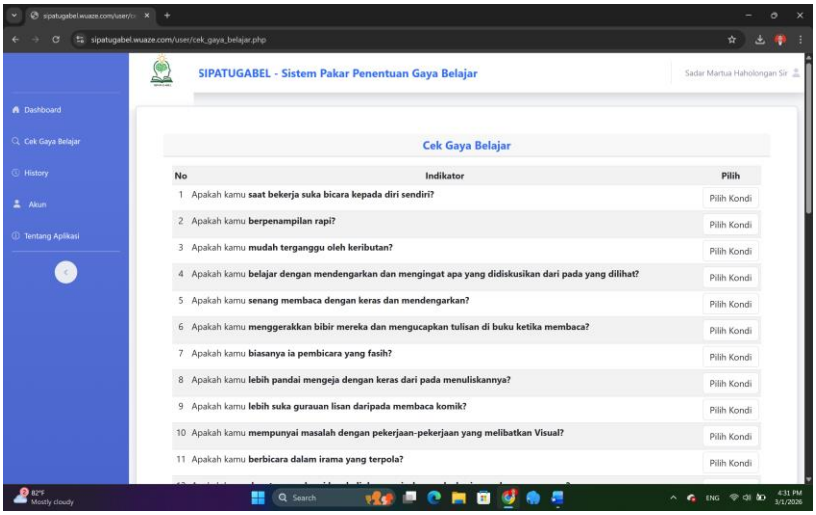

Figure 8. Student Learning Style Assessment Page

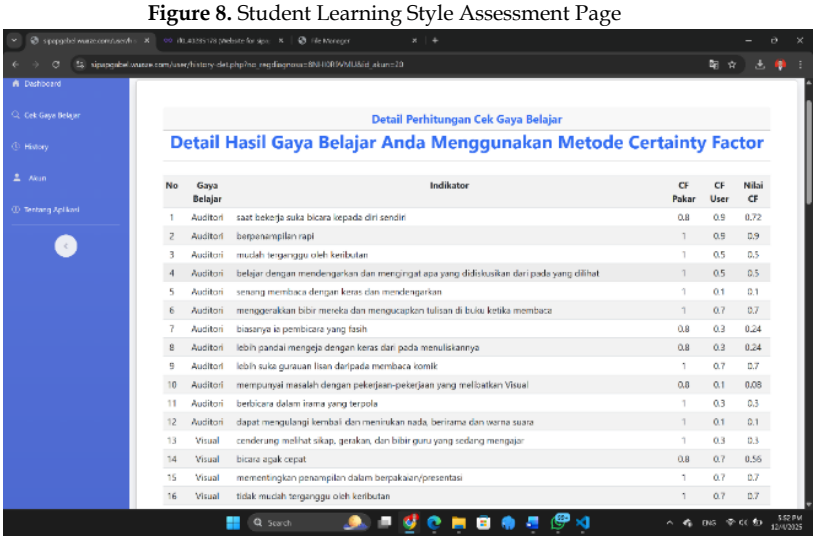

Figure 9. Student Learning Style Diagnosis Results Page

Figure 9 shows the menus available to students, such as the learning style check, banner, account, and logout menus. Clicking on each menu will take the user to its corresponding function, as described in the menu label. Figure 10 shows the learning style check menu. This menu contains questions specifically, indicators for each learning style which students will fill out based on their personal experiences. Once completed, the system will calculate the results based on user input and predefined rules to determine the highest CF score, which will identify the student's learning style.

Figure 10. Report on Student Learning Style Diagnosis Results

Figure 11 above shows the results of the learning style assessment, which includes detailed calculations for each learning style, solutions, and an explanation of the dominant learning style or the highest CF score as determined by the student's learning style. The admin dashboard looks the same as the student dashboard, except that it includes menus that can be used as described in their respective descriptions. From this admin or guidance counselor account, users can view the learning style results of all students who have completed the learning style assessment in their respective accounts. They can also generate reports, such as the one shown in Figure 11, and use the class filter menu to help teachers identify students' learning styles. The interface is as follows:

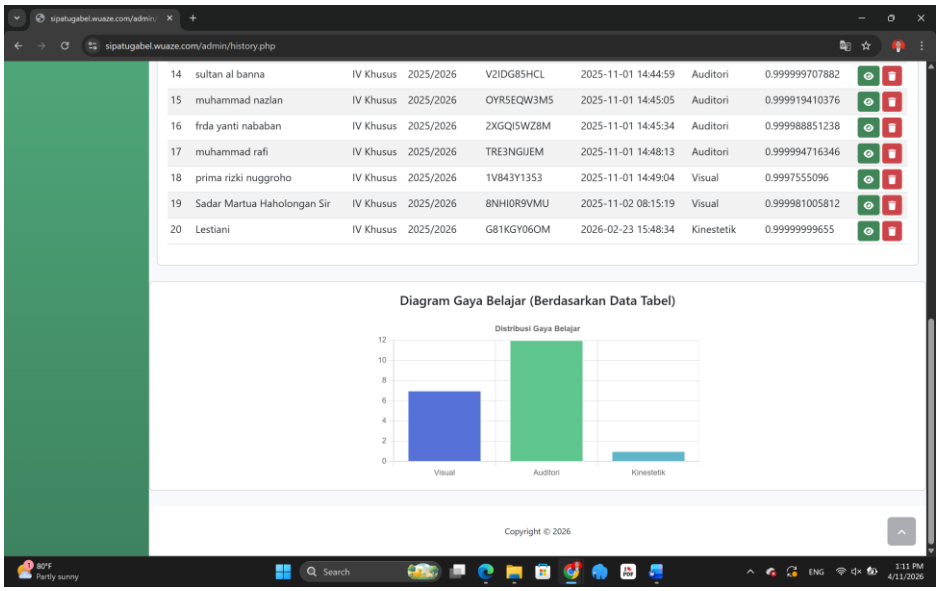

Figure 11. Page Graphical Representation of Students' Learning Styles

3.2. Discussion

Based on the results of the research conducted, the expert system designed to determine learning styles has been found to be valid, practical, and effective for use. The development of rules from the knowledge base has successfully diagnosed the learning styles of students at Madrasah Tarbiyah Islamiyah (MTI) Canduang. This aligns with the research conducted by M. Panji Al – Qodri, Liza Efriyanti, Supratman Zakir, and Gusnita Darmawati in 2025 titled "Design of an Expert System for Early Detection of Drug Abuse Among Students Using the Forward Chaining Method at SMK Negeri 1 Kota Jambi" where the expert system developed to detect early drug abuse among students at SMK Negeri 1 Kota Jambi was proven effective for use. The study utilized the Forward Chaining method, which successfully detected early drug abuse among students at SMK Negeri 1 Kota Jambi. However, this expert system could not generate graphical presentations of detection results and lacked notification of account approval, diagnostic reports, or PDF file formats. The Certainty Factor method can identify the most dominant learning style for each individual. By combining the expertise of an education specialist with the Certainty Factor expert system, the method provides accurate calculations, enabling it to recommend or identify the most dominant learning

style among the styles studied namely, Visual, Auditory, and Kinesthetic. Consequently, the diagnostic assessment process can be conducted quickly, allowing teachers to determine teaching methods, learning media, and instructional tools that align with students' interests and relevant needs, in accordance with the guidelines of the Merdeka Curriculum.

This research aligns with the study conducted by Sutri Serlika, Zulfani Sesmiarni, Wedra Aprison, Supratman Zakir, and Hari Antoni Musril in 2024 titled "Design of an Expert System for Detecting HOTS Questions in the 11th-Grade Computer Science Curriculum at State High School 2 Bukittinggi," in which the researchers designed an expert system to diagnose whether a question falls into the HOTS category or not. The results of the research demonstrated that the designed expert system successfully determined whether a question was a HOTS question or not. However, the expert system that was built did not explain in detail the methods used to construct each rule. Methods and rules are crucial in determining the results of an expert system's diagnosis. In contrast, the expert system developed by the author incorporates both methods and rules: it employs the Certainty Factor method and uses IF-THEN rules to determine the results of evaluating each indicator, thereby generating an effective diagnosis based on the user's input.

This is also consistent with research conducted by Husin Sufi, Danang Wahyu Utomo, and Gusnita Darmawati, who developed an expert system titled "Expert System for Healthy Menu Recommendations for Patients with Diseases Using the Forward Chaining Method" in 2023. This research, which was used to determine healthy foods for patients with high cholesterol, proved successful and valid in providing healthy food recommendations and helping patients manage their cholesterol levels. The previously developed expert system used the forward chaining method, whereas this newly developed expert system employs a different method the Certainty Factor to determine learning styles using the basic CF Combine formula, which generates decisions based on a combination of diverse user responses to identify their learning style.

Then, the research conducted by Isti Nurhafiyah and Hendra Marcos in 2023, titled "Expert System for Mental Health Diagnosis Among Students at Amikom University Purwokerto," designed an expert system to diagnose mental health conditions specifically depression, stress, and mental disorders among students at Amikom Purwokerto University, which proved successful in diagnosing mental health, aligning with the research previously conducted. However, the expert system that was designed did not provide further details regarding the diagnosis results; it only displayed the percentage of the results and a brief solution, without providing a conclusion of the diagnosis. Meanwhile, the expert system designed by the author provides a complete explanation of the diagnosis results, offers a comprehensive solution based on the diagnosis results, and includes a conclusion of the diagnosis.

Furthermore, this aligns with the research conducted by Jefdy Kurniawan, Sarjon Defit, and Yuhandri Yunus in 2021 titled "Expert System for Identifying Vocational Interests Using the Certainty Factor and Forward Chaining Methods," in which the study designed an expert system to determine the types of vocational interests namely Tangible, Thinking, Flexible, and Entrepreneurial, which proved successful in determining these types of vocational interests. However, the expert system that was designed did not provide further details regarding the diagnostic results; it only displayed the percentage of the results and a brief solution, and did not provide conclusions regarding the diagnostic results. Meanwhile, the expert system designed by the author provides a complete explanation of the diagnostic results, offers a comprehensive solution based on the diagnostic results, and presents conclusions regarding the diagnostic results.

Related research conducted by previous researchers has shown that expert systems are essential for effectively solving various problems. Every expert system designed uses the Certainty Factor method to generate valid statements. However, the expert system designed in this study offers a unique feature by providing clear explanations based on calculation formulas using the CF Combine method with a knowledge base employing IF-THEN rules to determine the evaluation results of each indicator, thereby generating effective diagnoses based on user input, providing comprehensive solutions, and conclusions for

each diagnostic result. Furthermore, the expert system developed by the author presents students' learning styles accurately, effectively, and efficiently. Consequently, it assists teachers in conducting diagnostic assessments easily, enabling them to tailor the learning process including the selection of teaching methods, instructional materials, learning media, and other requirements—to align with students' learning styles, or what is termed "flexible" learning, as outlined in the Merdeka Curriculum, which promotes flexible learning approaches. Therefore, the results of the research conducted by the author indicate that the expert system can also be used to determine learning styles; by employing the Certainty Factor method, this system can provide accurate diagnostic results consistent with the experiences of the users namely, students at MTI Canduang and the product testing results confirm that the designed expert system is valid, practical, and effective. Therefore, the results of the research conducted by the author indicate that the expert system can also be used to determine learning styles; by using the Certainty Factor method, it can provide accurate diagnostic results consistent with the experiences of the users the students at MTI Canduang and the product testing results confirm that the designed expert system is valid, practical, and effective.

4. Conclusion

Based on the results of the research conducted, the author has successfully designed an expert system to determine the learning styles of students at Madrasah Tarbiyah Islamiyah (MTI) Canduang. This expert system is designed to help teachers identify students' learning styles during diagnostic assessments. Challenges such as the time required to identify students' learning styles which previously relied on direct classroom observation during the teaching learning process and the inaccuracies in observation results regarding students' learning styles can be addressed by the designed expert system. With this expert system, teachers can quickly and accurately determine students' learning styles. This is because an expert system mimics the ability of an expert to solve a problem. After the system was successfully designed, the expert system product testing consisted of validity tests, which included content validity, construct validity, and linguistic validity tests. There were also practicality and effectiveness tests. Based on the results of the validity tests (content validity, construct validity, and linguistic validity) conducted by three validators, each validator stated that the designed system achieved an average score of 0.96, indicating that the system is valid for use. The practicality test, conducted by three guidance counselors at MTI Canduang, yielded an average score of 0.93, indicating that the designed expert system is practical for use. The effectiveness test conducted by all students in Special Class 4 yielded a score of 0.56, indicating that the designed expert system fell into the "Medium Effectiveness" category, meaning that this system can be used to determine students' learning styles.

Recommendations include adding rules to the knowledge base to cover a wider variety of issues related to each learning style indicator. Integrating or using other inference methods besides the Certainty Factor method to reinforce that the expert system can be used to determine learning styles. Developing the expert system on other platforms, such as mobile-based platforms, to make the expert system easier to use. This expert system for determining learning styles also requires updates or the addition of rules to strengthen each indicator so that the variety of problems experienced by students can be addressed more effectively. Integration with other inference methods is necessary to improve the accuracy of the expert system in determining learning styles. Development on other platforms, such as mobile applications, can provide users with greater convenience in using the expert system to determine learning styles in the future.

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