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Expert System for Detecting Academic Burnout Levels among University Students Using the Certainty Factor Method

Zahrotul Khoiriyah[1], Arif Setiawan[2], Muhammad Arifin[3]
[1,2,3]Information Systems Study Program, Universitas Muria Kudus, Kudus, Central Java, Indonesia, 59327
e-mail: 202153100@std.umk.ac.id[1], arif.setiawan@umk.ac.id[2], arifin.m@umk.ac.id[3]
*Correspondence: 202153100@std.umk.ac.id

Abstract: *Academic burnout is a condition of physical, emotional, and mental exhaustion resulting from prolonged academic demands and may negatively affect students' learning and well-being. This study aimed to develop a web-based expert system to support the preliminary identification of academic burnout among university students using the Certainty Factor method. The system knowledge was constructed through a literature review and a structured knowledge acquisition process involving a psychology expert before being represented in the knowledge base. The system was developed using the Waterfall model with PHP, the CodeIgniter framework, and MySQL. Functional evaluation using Black Box Testing showed that all system features operated as expected. In addition, User Acceptance Testing (UAT) involving 102 students of Universitas Muria Kudus achieved an overall acceptance score of 83.92%, indicating a Very Good level of user acceptance. The developed system was able to classify consultation results into mild, moderate, and severe academic burnout categories based on the implemented Certainty Factor inference process. Therefore, the proposed expert system may serve as a supporting tool for the preliminary identification of academic burnout. Further validation using standardized psychological instruments or professional psychological assessments is recommended in future studies.*

Keywords: *Academic Burnout, Expert System, Certainty Factor, Early Identification, University Students.*

1. Introduction

Academic burnout has become an increasingly important issue among university students due to growing academic demands, excessive workloads, and prolonged learning pressure [1], [2]. It is commonly characterized by emotional exhaustion, cynicism toward academic activities, and a reduced sense of academic efficacy, all of which may negatively affect students' learning motivation, academic performance, and psychological well-being [1]. Recent studies have also reported that academic burnout is associated with psychological factors such as intolerance of uncertainty, self-regulatory fatigue, and low self-compassion, indicating that burnout is influenced by multiple academic and psychological factors rather than academic workload alone [1]. Therefore, identifying students who may be at risk of academic burnout at an early stage is important to support timely academic assistance and preventive efforts.

Academic burnout should be distinguished from other psychological conditions, including academic stress, anxiety, and depression [2], [3]. Academic stress generally reflects an individual's response to academic demands and is often temporary, whereas academic burnout develops after prolonged exposure to unresolved academic stress and is characterized by persistent emotional exhaustion, detachment from academic activities, and reduced academic accomplishment [4]. Likewise, anxiety and depression are broader psychological conditions with different clinical characteristics and should not be regarded as equivalent to academic burnout [1]. Accordingly, this study focuses specifically on academic burnout as a distinct condition requiring an appropriate knowledge representation and reasoning process for preliminary identification, rather than clinical diagnosis.

The advancement of information technology has encouraged the development of knowledge-based systems to support decision-making in educational and healthcare applications [5]. Among these approaches, expert systems have been widely implemented to represent expert knowledge through a collection of rules and perform reasoning based on user input [5], [6]. One of the commonly used inference methods is the Certainty Factor (CF) method, which is designed to represent uncertainty in expert reasoning [7], [8]. Since students may experience burnout symptoms with different levels of confidence, the CF method provides an appropriate mechanism for combining expert certainty values with users' confidence levels during the inference process [7]. Previous studies have applied the Certainty Factor method in expert systems for various mental health-related problems, including depression, stress, and other psychological conditions [9], [10], [11]. In contrast, most studies on academic burnout have focused on measuring burnout levels, identifying associated factors, or evaluating intervention programs [1], [2], [4]. Building upon these studies, this research explores the implementation of a web-based expert system using the Certainty Factor method to support the preliminary identification of academic burnout among university students.

Based on these considerations, this study aims to develop a web-based expert system for the preliminary identification of academic burnout among university students using the Certainty Factor method. The knowledge base was constructed through a literature review and a structured knowledge acquisition process involving a psychology expert. The developed system was implemented using the Waterfall software development model and evaluated through Black Box Testing and User Acceptance Testing (UAT). Accordingly, this study contributes by presenting the implementation of a web-based expert system that integrates expert-derived knowledge with the Certainty Factor method to support the preliminary identification of academic burnout. The proposed system is intended to serve as a supporting tool for preliminary identification and should not be considered a substitute for professional psychological assessment.

2. Research Method

A. Research Flow

This study employed a Research and Development (R&D) approach to develop a web-based expert system for the preliminary identification of academic burnout among university students. The research process consisted of six sequential stages: problem identification, literature review, knowledge acquisition, knowledge base construction, system development, and system evaluation. These stages were designed to ensure that both psychological knowledge and software engineering principles were systematically incorporated into the developed system [5], [9]. The study began with problem identification through a review of previous studies concerning academic burnout among university students [1], [4]. The literature review was conducted to identify burnout characteristics, commonly reported symptoms, previous applications of expert systems in mental health, and the implementation of the Certainty Factor method[7], [11]. The findings from this stage served as the initial reference for constructing the symptom list, inference rules, and knowledge base before expert validation.

Knowledge acquisition was subsequently carried out through a structured consultation with a psychology expert from Universitas Muria Kudus. An initial draft containing burnout symptoms, burnout level classifications, inference rules, and expert certainty values was prepared based on the literature review. The expert then evaluated the relevance of each symptom, verified the relationships between symptoms and burnout levels, and assigned certainty values representing the degree of confidence for each rule. The validated knowledge was subsequently used to construct the knowledge base implemented in the expert system. After the knowledge base had been established, the expert system was developed using the Waterfall software development model, consisting of requirements analysis, system design, implementation, testing, and maintenance [9], [12]. Finally, the completed system was

evaluated through Black Box Testing to verify system functionality and UAT involving 102 university students to assess usability and user acceptance.

B. Certainty Factor Method

The CF method was employed as the inference mechanism in the proposed expert system because it enables reasoning under conditions of uncertainty. In this study, the knowledge base was constructed from a literature review and a structured knowledge acquisition process involving a psychology expert. The expert assigned certainty values to each inference rule, while users selected their confidence level for every symptom experienced during the consultation process. The Certainty Factor method then combined both values to estimate the certainty level of each burnout category [7], [8].

The certainty factor was calculated using Equation (1).

$$CF(H,E) = MB(H,E) - MD(H,E)$$

where CF(H,E) denotes the certainty value of hypothesis H based on evidence E, MB(H,E) represents the measure of belief, and MD(H,E) represents the measure of disbelief assigned by the expert.

The expert certainty value was then combined with the user's confidence level using Equation (2).

$$CF_{rule} = CF_{expert} \text{ X } CF_{user}$$

where:
CFrule represents the certainty factor value of a rule.
CFexpert denotes the certainty value assigned by the expert.
CFuser denotes the user's confidence level for the selected symptom.

If multiple symptoms supported the same burnout category, the certainty values were combined using Equation (3).

$$CF_{combine} = CF_1 + CF_2(1 - CF_1)$$

where:
CFcombine represents the combined certainty factor value.
CF1 denotes the previous certainty factor value.
CF2 denotes the certainty factor value to be combined.

The combination process was performed sequentially for all symptoms associated with the same burnout category until a final Certainty Factor value was obtained. The burnout category with the highest final Certainty Factor value was presented by the system as the result of the preliminary identification process. The detailed calculation procedure is presented in the Results and Discussion section.

3. Results and Discussion

A. Knowledge Base Design

The knowledge base of the proposed expert system was developed through a literature review and a structured knowledge acquisition process involving a psychology expert. The expert reviewed the relevance of each academic burnout symptom, verified its relationship with the corresponding burnout category, and assigned certainty values for each inference rule before implementation. The resulting knowledge base consists of burnout symptoms, burnout categories, inference rules, and expert certainty values that are subsequently used during the Certainty Factor inference process [7], [9].

Table 1. Academic Burnout Symptoms

Code	Symptoms
G01	Feeling emotionally exhausted due to university activities
G02	Experiencing prolonged physical fatigue
G03	Losing motivation to participate in academic activities
G04	Having difficulty concentrating while studying or working on assignments
G05	Feeling jaded or bored with university activities
G06	Frequently procrastinating on coursework
G07	Feeling stressed due to academic demands
G08	Experiencing a decline in academic performance
G09	Withdrawing from social circles or friendships
G10	Experiencing sleep disturbances
G11	Easily feeling anxious or restless regarding university studies
G12	Feeling a decline in one's ability to complete assignments

Table 1 presents the twelve academic burnout symptoms used as observable indicators during the consultation process. These symptoms were initially identified through the literature review and subsequently verified by the psychology expert to ensure that they appropriately represent academic burnout among university students before being incorporated into the knowledge base.

Table 2. Academic Burnout Categories

Code	Burnout Categories
B01	Mild Burnout
B02	Moderate Burnout
B03	Severe Burnout

Table 2 presents the three burnout categories used as the possible hypotheses in the inference process. During preliminary identification, the Certainty Factor method evaluates the available symptom evidence to estimate the certainty level of each burnout category before selecting the category with the highest certainty value as the preliminary identification result.

Table 3. Knowledge Base Structure

Symptom Code	Burnout Category	Expert CF
G01	B02	1.0
G02	B02	0.6
G03	B03	1.0
G04	B02	0.6
G05	B01	0.2
G06	B02	0.2
G07	B02	0.6
G08	B03	1.0
G09	B03	0.6
G10	B02	0.2
G11	B02	0.2
G12	B03	1.0

Table 3 illustrates the inference rules forming the knowledge base by linking each symptom to its corresponding burnout category together with the certainty value assigned by the psychology expert. These validated rules constitute the reasoning mechanism of the expert system and provide the basis for Certainty Factor calculations during the consultation process.

Table 4. User Confidence Levels

User Response	CF Value
Very Sure	1.0
Sure	0.8
Fairly Sure	0.6
Slightly Sure	0.4
Less Sure	0.2
Not Sure	0.0

Table 4 presents the confidence levels selected by users during the consultation process. Each response is represented by a numerical Certainty Factor value, which is subsequently combined with the expert-assigned certainty value according to the Certainty Factor algorithm to estimate the final certainty of each burnout category.

B. Certainty Factor Calculation

This section presents an example of the Certainty Factor calculation using one consultation result obtained from the developed expert system. The calculation was performed based on the symptoms selected by the user together with the corresponding confidence levels, which were then combined with the expert-assigned Certainty Factor values to determine the academic burnout level. The selected consultation case produced a preliminary identification of Moderate Burnout with a confidence level of 54.24%.

Table 5. Selected Symptoms and User Confidence Levels

Code	Selected Symptom	User CF
G04	Having difficulty concentrating while studying or working on assignments	0.8
G05	Feeling jaded or bored with university activities	1.0
G10	Experiencing sleep disturbances	0.6

Symptom G07 was excluded from the calculation because the user selected a confidence value of 0 (Not Sure), resulting in no contribution to the inference process. Based on Table 5, the CF Rule values were obtained by multiplying the expert-assigned Certainty Factor values by the corresponding user confidence levels using Equation (2). The calculation results are presented as follows.

Moderate Burnout (B02)

$$G04 = 0.6 \times 0.8 = 0.48$$

$$G10 = 0.2 \times 0.6 = 0.12$$

Mild Burnout (B01)

$$G05 = 0.2 \times 1.0 = 0.20$$

The CF Rule values belonging to the same burnout category were then combined using Equation (3). In this consultation case, the Moderate Burnout category contained two CF Rule values (0.48 and 0.12), resulting in the following calculation.

$$CF_{Combine} = 0.48 + 0.12(1 - 0.48)$$

$$= 0.48 + 0.0624$$

$$= 0.5424$$

Meanwhile, the Mild Burnout category contained only one CF Rule value (0.20), therefore no combination process was required and the final Certainty Factor value remained 0.20. The system then compared the final Certainty Factor values of each burnout category. The highest value was obtained for the Moderate Burnout category with a Certainty Factor of 0.5424. The final Certainty Factor value was then converted into a percentage to facilitate interpretation of the consultation result, as follows.

$$\text{Percentage} = 0.5424 \times 100\% = 54.24\%$$

The manual calculation indicates that the user is classified as experiencing Moderate Burnout with a confidence level of 54.24%. This result is identical to the preliminary identification

generated by the expert system, confirming that the Certainty Factor method has been correctly implemented in the developed system.

C. System Implementation

This section describes the implementation of the developed web-based expert system for detecting academic burnout. The application was developed using PHP with the CodeIgniter framework and MySQL as the database management system. A web-based implementation enables consultation, knowledge base management, and result presentation to be integrated into a single platform, thereby improving system accessibility and usability [13]. The system enables university students to perform self-assessments by selecting academic burnout symptoms together with their confidence levels, after which the Certainty Factor method is applied to determine the academic burnout level. The implementation focuses on the main functionalities supporting the preliminary identification process, namely the login page, consultation page, and consultation result page.

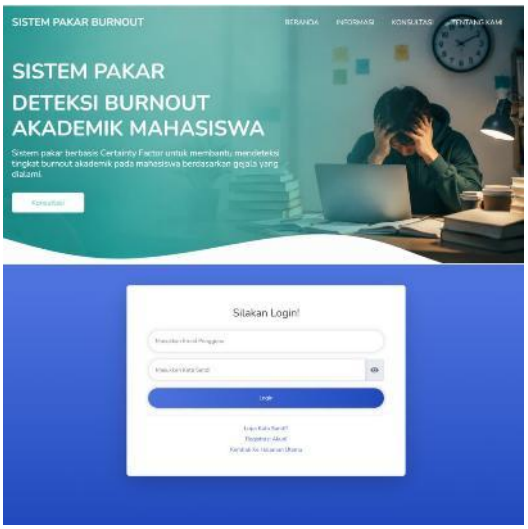

Figure 1. Login Page.

Figure 1 presents the login page used to authenticate users before accessing the expert system. Registered users are required to enter their email address and password, ensuring that only authorized users can perform consultations and access their consultation history.

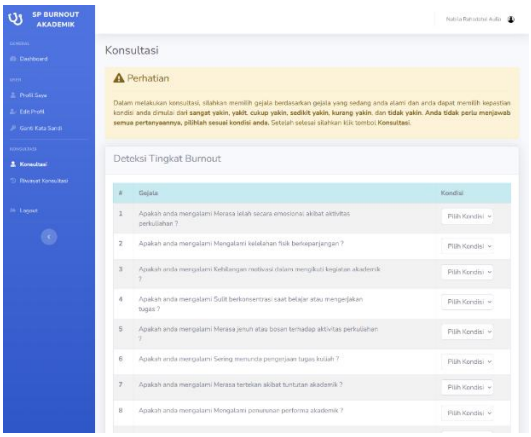

Figure 2. Consultation Page.

Figure 2 illustrates the consultation page where users select academic burnout symptoms together with their confidence levels. The selected confidence levels represent the user's Certainty Factor, which is subsequently combined with the expert-assigned Certainty Factor values during the inference process.

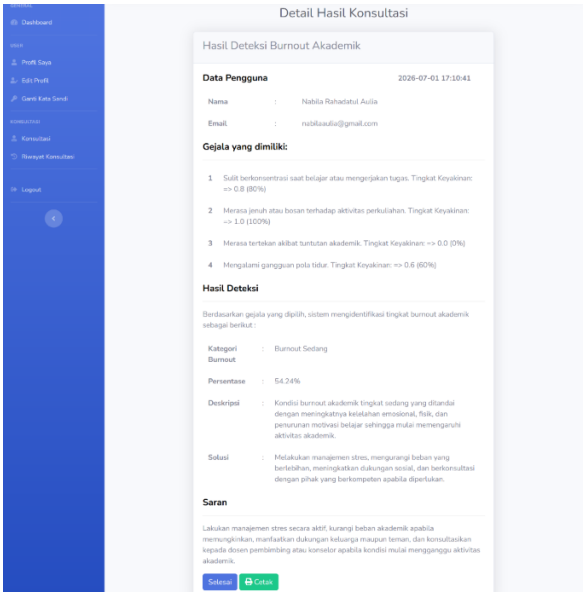

Figure 3. Consultation Result Page.

Figure 3 presents the consultation result page displaying the detected academic burnout category, confidence percentage, condition description, and recommendations generated by the system. These results are obtained through the Certainty Factor calculation process and provide users with preliminary information regarding their academic burnout condition.

D. System Evaluation

System evaluation was conducted to ensure that the developed expert system operates according to the specified functional requirements and is acceptable to its users. In this study, the system was evaluated through three stages, namely Black Box Testing to verify the functionality of the developed application, User Acceptance Testing (UAT) to measure user acceptance, and an analysis of academic burnout identification results obtained from respondent consultations. These evaluation stages were carried out to assess both the functional performance and usability of the developed expert system.

1. Black Box testing

   Black Box Testing was conducted to verify that all major functions of the developed expert system operated according to the specified functional requirements without considering the internal program structure. The evaluation was performed by providing input to each system feature and observing the corresponding outputs. The tested functions included user authentication, consultation process, Certainty Factor calculation, consultation data storage, and preliminary identification result presentation.

Table 6. Black Box Testing Results

No	Test Scenario	Expected result	Test Result	Status
1	Login using a valid email and password	The system successfully displays the user dashboard	As Expected	Passed
2	Login using an invalid email or password	The system displays an authentication error message	As Expected	Passed
3	User selects symptoms and confidence levels	The system accepts consultation data	As Expected	Passed

4	System performs Certainty Factor calculation	The system displays the preliminary identification result correctly	As Expected	Passed
5	System stores consultation results	Consultation data are successfully saved in the consultation history	As Expected	Passed
6	User views consultation details	The system displays the burnout category, confidence percentage, description, and recommendation	As Expected	Passed

Based on the results presented in Table 6, all primary system functions operated successfully according to the predefined test scenarios. Every tested feature produced the expected output, indicating that the developed expert system satisfied the functional requirements and was ready to support academic burnout identification. These findings are consistent with previous research demonstrating that Black Box Testing effectively verifies all system functions before deployment to end users [10].

2. User Acceptance Testing (UAT)

UAT was conducted to evaluate user acceptance of the developed expert system and to ensure that the proposed system not only functioned properly but was also easy to use and well accepted by end users [12]. The evaluation involved 102 Muria Kudus University students who used the system to perform an academic burnout consultation. After completing the consultation process, each respondent completed a questionnaire using a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). The responses were converted into mean scores and percentages, which were subsequently interpreted using five evaluation categories: Very Poor, Poor, Fair, Good, and Very Good. The evaluated aspects included system usability, user interface, consultation process, clarity of information, preliminary identification results, recommendations provided by the system, perceived usefulness, and overall user satisfaction.

Table 7. User Acceptance Testing Results

No	Statement	Mean	Interpretation
P1	The system is easy to understand and use	4.38	Very Good
P2	The user interface is attractive and easy to read	4.23	Very Good
P3	The consultation process is easy to perform	4.24	Very Good
P4	The presented symptom information is easy to understand	4.21	Very Good
P5	The burnout identification results are easy to understand	4.23	Very Good
P6	The recommendations provided by the system are appropriate	4.01	Very Good
P7	The system helps users identify their academic burnout level	4.14	Very Good
P8	Overall, I am satisfied with the developed system	4.15	Very Good
	Overall Mean	4.20	Very Good

Based on the results presented in Table 7, the developed expert system achieved an overall mean score of 4.20 out of 5, equivalent to 83.92%. According to the adopted

interpretation criteria, this result falls into the Very Good category. All evaluated aspects obtained mean scores above 4.00, indicating positive user responses regarding system usability, user interface, consultation process, preliminary identification results, and recommendations generated by the system. These findings indicate that users positively accepted the developed expert system and perceived it as useful for supporting the preliminary identification of academic burnout. However, user acceptance should not be interpreted as evidence of diagnostic validity.

3. Academic Burnout Identification Results
After the developed expert system had successfully passed the Black Box Testing, it was subsequently implemented with 102 students of Universitas Muria Kudus to perform academic burnout identification. Each participant individually completed the consultation process using the researcher's laptop by selecting symptoms, specifying confidence levels, and obtaining the preliminary identification generated by the system. After completing the consultation, the participants were asked to complete the User Acceptance Testing (UAT) questionnaire to evaluate the developed system. The preliminary identification obtained from each consultation was then classified according to the burnout category generated by the Certainty Factor method. The distribution of the identification results is presented in Table 8.

Table 8. Distribution of Academic Burnout Identification Results

Burnout Level	Number of Students	Percentage
Mild Burnout	8	7.84%
Moderate Burnout	69	67.65%
Severe Burnout	25	24.51%
Total	102	100%

Based on the results presented in Table 8, the majority of respondents were classified as experiencing Moderate Burnout, accounting for 69 students (67.65%). In addition, 25 students (24.51%) were identified as experiencing Severe Burnout, while 8 students (7.84%) were classified as Mild Burnout. These findings indicate that the developed expert system successfully classified respondents according to the symptoms selected during the consultation process using the Certainty Factor method. The identification results may serve as preliminary information to help users recognize their academic burnout condition before obtaining further assistance from qualified professionals [14]. It should be noted that these findings represent the distribution of burnout levels among the 102 students of Universitas Muria Kudus who participated in this study and should not be interpreted as representing the prevalence of academic burnout among university students in general.

Overall, the evaluation results indicate that the proposed expert system operated according to the specified functional requirements and achieved a high level of user acceptance among university students. These findings are consistent with previous studies reporting that Certainty Factor-based expert systems are capable of supporting preliminary identification in mental health-related applications through rule-based reasoning under uncertainty [7], [15]. However, unlike standardized psychological instruments, the developed system is intended to support preliminary identification rather than provide a clinical or psychological diagnosis. Compared with previous studies, this research specifically focuses on academic burnout among university students by integrating expert knowledge acquired from a psychology expert with the Certainty Factor method in a web-based environment. The obtained user acceptance results indicate that the proposed system is acceptable from the users' perspective. Nevertheless, user acceptance should not be interpreted as evidence of diagnostic accuracy because the system outputs have not yet been validated against standardized psychological instruments or professional psychological assessments [8], [16].

This study has several limitations. First, the knowledge base was developed with the involvement of one psychology expert. Second, the system has not yet been validated against standardized psychological instruments or independent professional psychological assessments. Therefore, the results generated by the proposed system should be interpreted as preliminary identification outcomes rather than definitive psychological diagnoses. Future research may involve multiple experts, standardized burnout instruments, and diagnostic accuracy evaluation to further improve the reliability of the proposed system.

4. Conclusions

This study developed a web-based expert system for the preliminary identification of academic burnout among university students using the Certainty Factor method. The system knowledge was constructed through a literature review and a structured knowledge acquisition process involving a psychology expert. Functional evaluation demonstrated that all system functions operated as intended, while User Acceptance Testing involving 102 university students indicated a high level of user acceptance (83.92%). The implemented Certainty Factor method successfully generated preliminary identification results based on the knowledge base and users' selected symptoms together with their confidence levels. Accordingly, the developed expert system can be utilized as a supporting tool to facilitate the preliminary identification of academic burnout among university students. Nevertheless, it is not intended to replace standardized psychological instruments or professional psychological assessment. Future studies are recommended to involve multiple psychology experts, standardized burnout instruments, and broader validation procedures to further evaluate the system's performance and reliability.

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