

Designing an Expert System for Evaluating Student Stress Levels: A Novel Instrument Using Backward and Forward Chaining Methods

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ABSTRACT

Academic stress is a problem that students often experience, especially when completing final studies such as writing a thesis. This research aims to develop an instrument for measuring students' academic stress levels based on an expert system using forward chaining and backward chaining methods. The research method used is research and development (R&D) with a Borg and Gall design which includes ten steps. These steps include: (1) Research and information collecting, (2) Planning, (3) Developing a preliminary form of the product, (4) Preliminary field testing, (5) Main product revision, (6) Main field testing, (7) Operational product revision, (8) Operational field testing, (9) Final product revision, and (10) Dissemination and implementation. By following these steps, the research ensures a systematic and thorough development process, leading to a reliable instrument for measuring academic stress. The data collection instrument was the Guttman model academic stress scale (SSA) with 48 valid and reliable items ($r_{xy} = 0.785$). Data was obtained from 319 IAIN Batusangkar student respondents which were processed descriptively. The results showed that 34.8% of respondents experienced high levels of academic stress, 32.6% moderate, and 32.6% low. Furthermore, this research develops a web-based expert system application to detect students' academic stress levels by using forward chaining, which starts from data to reach a conclusion, and backward chaining, which starts from a goal to verify it with available data. These methods ensure accurate stress level assessments. Through this technological approach, the research provides a comprehensive solution for managing and reducing student academic stress effectively and efficiently, with findings showing that the expert system significantly improves early detection and personalized stress management strategies for students.

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1. INTRODUCTION

Stress is a common mental disorder with a prevalence of 10-40% in developing countries, and can have a negative impact both physically and mentally on a person. Stress is characterized by physical symptoms such as difficulty sleeping, fatigue, muscle tension, and decreased body immunity, as well as emotional, intellectual, and interpersonal symptoms. Based on its severity, stress can be divided into mild, moderate and severe stress. Mild stress is usually characterized by feeling tired easily and an inability to relax. Moderate stress can cause body responses such as feeling like you are going to faint, your body feeling like you are going to fall, as well as decreased concentration and memory. Severe stress can cause digestive disorders, an unstable heartbeat, and a shaking body (Andiarna, 2020). Given its broad impact, it is important to understand the signs of stress and take steps to manage and reduce stress in everyday life.

Students are at high risk of experiencing stress, especially when completing studies such as writing theses and research reports, where changes in their emotions and attitudes are very dynamic. Students with a good mentality and fortitude are usually able to complete their final assignments gradually, even though they face various pressures. On the other hand, those who have poor mentality and fortitude tend to retreat and are reluctant to struggle harder in the thesis preparation process. The challenges faced by students in writing their theses are very heavy, including facing supervisors, completing revisions, pressure from family who expect graduation on time, and seeing friends who have completed higher levels of study. This situation makes students very vulnerable to stress, even depression (Najib, 2022). Apart from that, failure to adapt and lack of support from friends, parents and lecturers can significantly affect study completion, especially in writing final assignments (Nur, 2023). Therefore, it is important for the academic environment and family to provide adequate support so that students can overcome pressure and complete their studies well.

An expert system is a computer-based system that uses knowledge, facts, and reasoning techniques to solve problems that can usually only be solved by an expert in a particular field. Expert systems are designed to reason like an expert. Expert systems adopt human knowledge into computers so that they can act like humans to solve a problem. There are 3 main parts to an expert system, namely a knowledge base which functions to store actual information, an inference engine as a reasoning process to find solutions and conclusions, and a user interface which makes it easier for users to communicate with the machine (Apriliyani, 2022).

Expert Systems are a type of artificial intelligence (AI) system designed to mimic human decision-making abilities in a specific domain. Artificial intelligence (AI) has brought major changes in many areas of human life, especially measuring student stress levels with an expert system based on backward and forward chaining methods. Islamic education, as an influence, has also experienced significant changes in teaching and learning methods. This system uses special knowledge in a particular field to provide solutions or recommendations to problems or tasks that are appropriate to that domain. The expert system inference engines that are popularly used are the forward chaining and backward chaining methods, where the forward chaining method is suitable for use by users who are not yet able to estimate the type of diagnosis, while backward chaining is suitable for use by capable users to estimate a diagnosis but are unsure whether the diagnosis is a correct or incorrect hypothesis. Therefore, the expert system for identifying students' academic stress levels in writing their theses applies forward-chaining and backward-chaining methods (Lubis, A. R., Ramadhan, S., & Hasibuan, 2023).

Forward chaining (forward reasoning) is one of the methods used in expert systems to make decisions or conclude information based on existing facts. This method begins by identifying initial facts that are already known, and then uses the rules in the knowledge base to reach a final conclusion or recommendation. The forward chaining process involves several general steps, including: 1) initiation, namely identifying initial facts or information that are already known. 2) application of rules, where these rules contain a correlation between conditions (premises) and actions (conclusions), so that if the conditions in a regulation are fulfilled based on existing facts, then action or conclusions from the regulation are taken. 3) inference, namely drawing conclusions or actions based on the rules applied,

where the results of these conclusions can become new facts that will be used in the next iteration. 4) iteration, namely the process of applying rules and conclusions that continue to repeat until certain conditions are met, such as achieving a goal or no more rules that can be applied. Lastly, output, namely the final result of forward chaining which is the final output or conclusion provided by the system based on initial facts and the rules applied (Ramadhan, 2018). This forward chaining method is effective in situations where the initial facts are already available and a logical process is needed to reach a conclusion, making it very useful in various expert system applications.

Backward chaining is an alternative method in expert systems which is often referred to as "goal-driven reasoning" or "top-down reasoning." In contrast to forward chaining, backward chaining starts from a goal or hypothesis to be achieved then works backwards to look for facts that support that goal. The general steps in backward chaining include several stages: 1) target initialization, namely setting the goal or hypothesis to be achieved, which can be a conclusion or solution to a problem that must be produced by the system. 2) activation rules, where rules of the form "if-then" are used to identify the necessary facts. 3) evaluation of rules and facts, where the rules found with conclusions appropriate to the goal are considered active, and the facts required by the active rules are then identified. 4) question deployment, where the necessary facts are then made into new questions or goals, repeating the process in the second step. 5) conclusion, where the system has collected facts that support the initial goal and can conclude the desired solution or answer (Kuswanto, 2022). This backward chaining method is effective in situations where the final goal is clear, but the supporting facts need to be identified systematically and gradually, providing a structured and logical approach to solving problems in expert systems.

Many previous studies have examined the development of instruments to test students' academic stress levels at the time of completing studies based on expert systems using forward chaining and backward chaining methods. Among the twelve existing studies, the first perspective highlights the use of expert systems in diagnosing students' academic stress. Amalia (2023) found that by calculating IF THEN ELSE using forward chaining, researchers succeeded in analyzing students' stress levels effectively. The second perspective focuses on developing expert systems using the backward chaining method, as discussed by Doni (2023), and involves studies from Najib (2022), Maisa (2021), Ramanda (2020), Harahap (2020), Bakri (2021), and Andiarna (2020), all of whom look at it from the perspective of student academic stress. The third perspective includes the combined use of forward chaining and backward chaining methods, as explained in research by Wahyudi (2023), Ibrahim (2021), and Apriliyani (2022), which assesses the effectiveness of both methods in measuring and analyzing students' academic stress levels.

In light of the growing concern over student stress and the potential of expert systems in psychological assessment, this research aims to develop an innovative instrument for measuring students' stress levels during their study completion phase. By leveraging an expert system that incorporates both forward-chaining and backward-chaining methods, we seek to create a more accurate and comprehensive tool for stress assessment. This study is unique in its integration of web-based technology for real-time stress diagnosis, its focus on creating supportive learning environments through comprehensive stress analysis, and its contribution to enhancing the professionalism of teaching staff by providing them with sophisticated tools for student support.

The primary objective of this research is to examine the development of an instrument for measuring students' stress levels in completing studies based on an expert system using forward chaining and backward chaining methods, as well as producing a web application to detect stress levels. Through the application of forward chaining and backward chaining algorithms, this research is expected to create an accurate and reliable tool for measuring academic stress, so that it can provide a clearer picture of students' psychological conditions during the study process.

This study hypothesizes that the integration of forward chaining and backward chaining methods in an expert system will significantly improve the accuracy and efficiency of stress level assessment among students completing their studies. This research was conducted at IAIN Batusangkar, where the test instruments developed were tested and implemented to ensure their effectiveness and efficiency in

helping students manage academic stress. By addressing these questions and testing our hypothesis, we aim to contribute to the growing body of knowledge on academic stress management and the application of expert systems in educational settings.

This research aims to examine the development of an instrument for measuring students' stress levels in completing studies based on an expert system using forward chaining and backward chaining methods, as well as producing a web application to detect stress levels. Through the application of forward chaining and backward chaining algorithms, this research is expected to create an accurate and reliable tool for measuring academic stress, so that it can provide a clearer picture of students' psychological conditions during the study process. This research was conducted at IAIN Batusangkar, where the test instruments developed were tested and implemented to ensure their effectiveness and efficiency in helping students manage academic stress.

The study of developing an instrument to measure students' stress levels in completing studies based on an expert system using forward and backward chaining methods has several important unique features. First, this study integrates technology in web-based student academic stress diagnosis, which allows easy and real-time access for students to identify their stress levels. Second, through comprehensive stress level analysis, this instrument aims to create more comfortable and supportive learning conditions, as well as provide targeted counseling for students in completing their studies. Third, the development of this instrument also contributes to increasing the professionalism of teaching staff by equipping them with more sophisticated and efficient tools in providing excellent service to students, so as to help them manage academic stress more effectively.

2. METHODS

The type of research used is research and development (R&D) (Setiawati, 2023), which is a method used to produce and test the effectiveness of specific products (Sugiyono, 2018). In this case, the product is an expert system for measuring stress levels. The expert system utilizes forward and backward chaining methods for inference. The development follows the Borg and Gall (2010) design, which includes 10 steps: (1) Literature study, (2) Preliminary study, (3) Stress Scale Design, (4) Scale Validation, (5) Scale Revision, (6) Expert system design, (7) System trial, (8) System revision, (9) Recommended Expert System, and (10) Wider use of expert systems (Amparore & Donatelli, 2013).

The research data source was Batusangkar IAIN students, with a population of 6,500. Using the Slovin formula, a sample size of 376 was determined. Data collection used two instruments:

- a. A print-out Guttman model academic stress scale (SSA) with "Yes" (scored 1) and "No" (scored 0) options for positive statements.
- b. An application-based instrument for measuring students' academic stress levels.

Development of the print-out instrument involved: (1) defining stress operationally, (2) creating a grid, (3) writing scale items, (4) validating with two psychologists, and (5) conducting a trial to analyze item validity and reliability using SPSS. Items with a correlation coefficient ≥ 0.30 were retained (Azwar, 2012, p. 164). Out of 58 items, 48 were valid and included in the expert system application.

The application development process included: (1) designing the expert system, (2) determining system rules based on expert analysis, (3) designing the interface, (4) implementing the inference engine with forward and backward chaining, (5) completing the system according to rules, (6) testing the application, and (7) validating it through expert judgment. Validation focused on ease of use, interface design, and effectiveness of chaining methods.

$$\alpha = \frac{N}{1 + n e}$$

Descriptive analysis is used to determine stress levels by converting raw scores into percentiles. Points are classified into three categories, namely high, medium, and low stress levels, with the criteria as in Table 1.1.

Table 1. Category of Academic Stress Level

Score	Percentile	Category
≥ 24	67-100	High
15-23	34-66	Medium
≤ 14	0-33	Low

The categorization in Table 1.1 provides a clear framework for interpreting the stress levels of students. Scores are classified into three distinct categories: high, medium, and low. This classification allows for a nuanced understanding of students' stress levels and guides appropriate interventions.

Interpretation of results based on Table 1.1:

- High stress level (≥ 24): Students in this category are experiencing significant academic stress. It is recommended that they learn to manage this stress, potentially channeling it as energy for academic success. These students may benefit from stress management techniques and additional support.
- Medium stress level (15-23): This range indicates a moderate level of academic stress. Students in this category are generally managing their emotions well in relation to academic tasks. They are encouraged to maintain this balanced level of stress, which can contribute to increased responsibility and motivation.
- Low stress level (≤ 14): While a low stress level might seem positive, in an academic context it could indicate low engagement or concern for academic tasks. Students in this category are recommended to increase their academic involvement to a moderate level, which may lead to better motivation and academic performance.

This categorization system, as presented in Table 1.1, provides an accessible way to measure and interpret academic stress levels. It helps students and educators to better understand and manage stress in academic settings, allowing for targeted interventions and support based on individual stress levels.

3. FINDINGS AND DISCUSSION

3.1 Manual Academic Stress Level Measurement Scale

The academic stress level measurement application was developed from an initial manual scale consisting of 58 items, which was refined to 48 items through rigorous validation and statistical testing. This digital transformation enhances efficiency and accuracy in measuring student stress levels. The validation process involved expert review by two psychologists and statistical analysis using SPSS, ensuring that each item effectively contributes to the assessment of academic stress. By transitioning from a manual to a digital format, the application not only improves accessibility but also enables real-time data analysis and immediate feedback, crucial features in today's fast-paced academic environments.

3.2 Expert System Application

The application allows users to register, log in, and answer 48 questions about their academic stress. After completion, users provide feedback and receive an analysis of their stress level along with expert recommendations. The system utilizes both forward and backward chaining methods for inference, enabling comprehensive analysis of user responses. This approach not only provides accurate stress level assessments but also offers personalized recommendations based on the specific stressors identified, making it a powerful tool for individual stress management and institutional support planning.

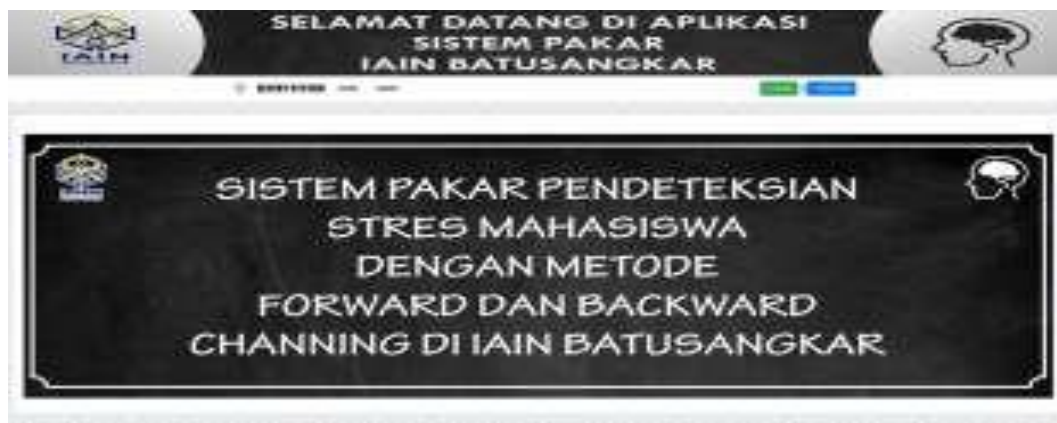


Figure 1. Application Home

The home screen displays the objectives and components of the expert system application.



Figure 2. Registration Page

Users register by filling in their biodata and creating a username and password.

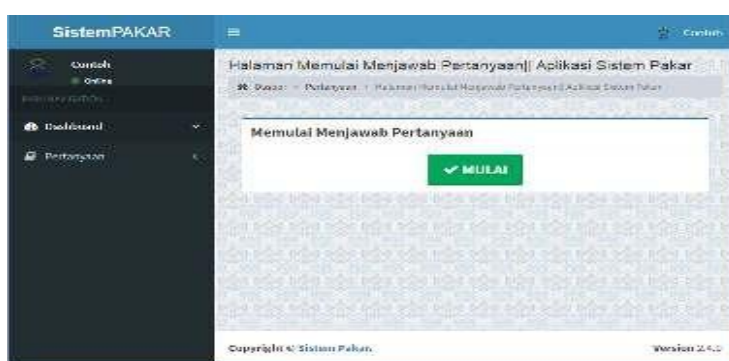


Figure 3. Page to start answering questions

This page prepares users to begin the stress assessment.



Figure 4. Confirmation before starting the application

Confirmation before starting the application A confirmation step ensures users are ready to proceed.



Figure 5. Application inquiry page

Users answer 48 questions with "Yes" or "No" responses, saving each answer.

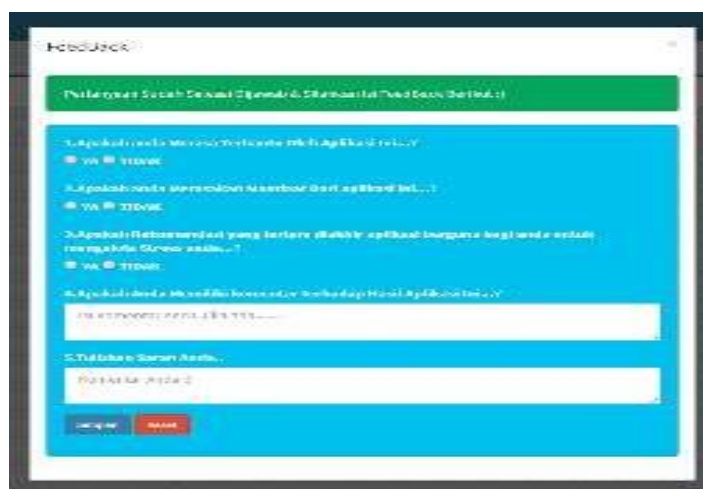


Figure 6. Application user satisfaction feedback page

After completing the questions, users provide feedback on the application.

The series of interfaces presented in Figures 1-6 illustrate the user journey through the expert system application, from registration to receiving stress level analysis. This user-friendly design is crucial for ensuring wide adoption and accurate data collection. The step-by-step process, including registration, question-answering, and feedback collection, not only facilitates a comprehensive assessment of academic stress but also provides valuable data for continuous improvement of the system. By combining an intuitive user interface with robust backend analysis, this application bridges the gap between complex psychological assessment and accessible digital tools, making it a powerful instrument for both individual stress management and institutional support planning.

3.3 Key Findings and Significance

Table 2. Academic Stress Level Score

Percentile Points	Classification/Category	F(%)
67 - 100	High	111 (34,8) %
34 - 66	Medium	104 (32,6) %
0 - 33	Low	104 (32,6) %

Table 1.2 presents a critical finding: over a third (34.8%) of respondents experienced high levels of academic stress. This significant proportion highlights the prevalence of stress among students and underscores the need for targeted interventions. The even distribution between medium and low stress levels (32.6% each) suggests a diverse range of experiences among students, emphasizing the importance of personalized support strategies.

The high percentage of students experiencing elevated stress levels may be attributed to various factors, including academic pressure, social expectations, and personal challenges. This distribution pattern indicates a pressing need for comprehensive stress management programs in educational settings.

3.4 Broader Implications and Practical Implementation

1. **Early Intervention:** The ability to identify students with high-stress levels early allows for timely interventions, potentially preventing academic performance decline and mental health issues.
2. **Personalized Support:** With accurate stress level data, educational institutions can develop tailored support services, such as counseling programs, stress management workshops, or academic assistance targeted to different stress level groups.
3. **Resource Allocation:** Understanding the distribution of stress levels can guide the allocation of mental health resources and academic support services more effectively.
4. **Policy Development:** These findings can inform institutional policies on workload management, exam scheduling, and student support services to create a more stress-conscious academic environment.
5. **Curriculum Design:** High stress levels may indicate areas where curriculum or teaching methods need adjustment to better support student well-being without compromising academic rigor.
6. **Teacher Training:** Equipping educators with this data can enhance their awareness of student stress, leading to more empathetic and supportive teaching practices.
7. **Longitudinal Studies:** Regular use of this tool can facilitate longitudinal studies on stress trends, allowing institutions to assess the effectiveness of interventions over time.
8. **Peer Support Programs:** Understanding stress distribution can inform the development of peer support networks, particularly beneficial for those in the high-stress category.

3.5 Interpretation of Quantitative Data

The even distribution between medium and low stress levels suggests that while a significant portion of students manage academic pressures effectively, there remains a substantial group facing high stress. This distribution may reflect varying coping mechanisms, differing academic pressures across disciplines, or the impact of personal factors on stress perception.

The high-stress group (34.8%) is particularly concerning. It may indicate systemic issues within the academic environment, such as excessive workload, high-stakes assessments, or insufficient support systems. Alternatively, it could reflect broader societal pressures on students, including future career concerns or financial stresses. The reliability coefficient ($r_{xy} = 0.785$) of the Academic Stress Scale

indicates a robust and valid instrument, enhancing the credibility of these findings and their potential impact on educational practices.

3.6 Conceptual Framework and Application

The conceptualization of stress in this study aligns with Molloy's (2010, p. 116) categorization of stress levels: anticipatory stress, situational stress, and chronic stress. This framework provides a nuanced understanding of the various ways students might experience academic stress, from anxiety about future events to ongoing pressures in the academic environment.

Greenberg's (2011) classification of external stressors into cataclysmic events, personal stressors, background stressors, and work stressors offers a comprehensive lens through which to view the multiple sources of stress that students may encounter. In the academic context, these could range from major life changes (personal stressors) to ongoing academic pressures (background stressors).

The internal aspects of stress, as highlighted by Lazarus and Folkman (1984), are particularly relevant in understanding how individual perceptions and coping mechanisms influence stress levels. This cognitive appraisal theory underscores the importance of considering not just external factors, but also how students interpret and respond to these stressors.

The application of expert systems in stress management aligns with recent research demonstrating their effectiveness in dealing with various psychological issues. For instance, studies have shown that expert systems can be an effective solution for addressing hysterical personality disorder (Gaol, 2016; Sahrul et al., 2022). The integration of human knowledge into a system capable of solving complex problems makes expert systems particularly suited to the multifaceted nature of academic stress.

The use of forward and backward chaining methods in our web-based expert system offers several advantages, as noted in previous research. These include easy accessibility, enhanced user interaction, rich content presentation, flexibility in updating information, and the ability to reach multiple users simultaneously (Amparore & Donatelli, 2013). These features are crucial in ensuring that the stress measurement tool is not only accurate but also user-friendly and widely accessible to students. Moreover, the expert system's ability to provide personalized recommendations aligns with current trends in educational psychology that emphasize the importance of individualized interventions in stress management (Setiawati, 2023). This personalized approach is particularly valuable given the diverse ways in which students experience and cope with academic stress.

The high reliability coefficient ($r_{xy} = 0.785$) of our Academic Stress Scale highlights the instrument's strength. This degree of reliability is essential for ensuring that the stress evaluations conducted by the expert system are consistent and dependable, which is a crucial aspect of its influence on educational practices and student support services. In summary, this expert system application for assessing academic stress levels not only offers valuable insights into student well-being but also marks a significant advancement in using technology to tackle psychological challenges in educational environments. By integrating well-established stress theories with advanced computational techniques, this tool provides a thorough, accessible, and tailored approach to managing academic stress.

4. CONCLUSION

This research represents a significant advancement by creating a standardized academic stress scale, validated with a larger sample size. This approach has the potential to shift how student academic stress levels are classified, incorporating not just their semester level but also their faculty and gender. For example, the findings can inform interventions such as tailored counseling programs that address the unique stressors faced by students in different faculties or genders. Additionally, policies could be developed to adjust academic workloads and assessment schedules based on the identified stress patterns at various stages of study, from the first semester to the final thesis or project stage.

The research also introduces an expert system application designed to detect and manage academic stress through forward chaining and backward chaining methods. This application could be implemented in educational institutions to provide real-time stress assessments and counseling-based

solutions. For instance, universities could integrate the system into their student services, allowing for early identification of high-stress individuals and offering personalized support plans. The system's ability to generate tailored recommendations based on specific stress levels could significantly enhance the effectiveness of interventions, ensuring that students receive the most appropriate and timely support.

The development of the stress scale and the expert system application are closely linked, as the scale provides the foundation for accurate stress assessment, while the expert system translates these assessments into actionable solutions. The smooth integration of these two components creates a cohesive framework for addressing academic stress, offering educational institutions a comprehensive tool that not only measures stress but also actively contributes to reducing it. Through testing on 319 respondents, the research revealed that 34.8% of students experience high levels of stress, 32.6% moderate, and 32.6% low. These findings highlight the need for institutions to adopt this expert system to monitor and mitigate academic stress effectively, ultimately contributing to improved student well-being and academic success.

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