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Development of an AI-Based Student Depression Detection System Using the Multinomial Naïve Bayes Algorithm

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ABSTRACT

Depression among students is a major mental health concern that interferes with both their emotional and academic. Depressed students go unnoticed since they hide their symptoms or confuse them with normal stress. Depression often affects focus and attention, making it hard for students to follow lessons, complete assignments, or retain information. Having a detection system in place enables early intervention that can help educators to detect warning signs early. This research used Agile Software Development Methodology in designing and developing a student depression detection system. This methodology enables continues feedback and enhancement to ensure the system is effective in meeting user needs. The process of development is segmented into short cycles referred to as sprints, with each sprint dedicated to developing particular features. For the evaluation, we selected eight (8) participants and five (5) IT experts for their technical expertise and three (3) mental health professionals for their relevance to the system's purpose. ISO/IEC 25010 is a global standard that outlines software quality characteristics and evaluation criteria to ensure the systems' functionality, reliability, usability, efficiency, maintainability, and portability. With an overall weighted mean of 3.61 for the IT experts rated the system as highly acceptable. Similarly, the Mental Health Professionals evaluated the Student Depression Detection System with a highly acceptable rating of 3.71, reinforcing its support for student well-being. Researchers identified that the student depression detection system is a useful resource for the early identification of depression in students. It is advised to adopt the student depression detection system in colleges and schools to aid in the identification of vulnerable students.

Keywords: Artificial Intelligence, Depression Detection, Multinomial Naïve Bayes Algorithm, Agile Methodology, ISO/IEC 25010.

INTRODUCTION

Student depression nowadays is a serious mental health problem that affects not only their emotional lives but also their academic performance. According to the World Health Organization (2023) depression is the major cause of depression globally is increasing because of personal issues, social demands, and academic pressure. Most students with depression remain undetected because they might conceal their symptoms or confuse them with normal stress, resulting in no early intervention based on Auerbach et al. (2018).

The impact of depression goes beyond emotional pain with cognitive functions. Depressive symptoms have been shown to impair executive function such as unable to attended with classes, submitting the assignments on time, or recall information immediately based on Becker et al. (2020). Additionally, the students with depression can exhibit lower levels of motivation, withdrawal from peers, and risk of dropping out according to Ibrahim et al. (2013). Given these challenges, the early discovery and optimal intervention actions are vital to stopping the adverse effects of depression on students' academic performance.

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Utilizing a proven depression detection system makes it possible for early intervention to occur such that warning signs are noticed before they grow into full-blown mental illness. The common measures of identifying depression among students is through self-reporting surveys and observation by teachers have been criticized on the grounds of stigma, underreporting, and personal bias according to Ibrahim et al. (2013). However, developments like artificial intelligence have brought in more efficient and data-driven methods of early detection. AI-based systems can examine a range of signs of depression such as body language, voice pitch, and social media use to detect at-risk students as explained by Shen et al. (2021).

Machine Learning algorithms can analyze vast amount of data sets by identify subtle behavioral changes and forecasting in mental health issues with significant accuracy as mentioned by Rao et al. (2022). This can be seen in Natural Language Processing (NLP) methods that can evaluate written answers of students in assignments, emails, or chats for detecting distress or negative emotions in the study conducted by Liu et al. (2020). In the same way, the wearable devices and mobile applications is capable of monitoring physiological measures to identify mood variations based on Wang et al. (2021).

By incorporating AI-based detection tools into the learning environment, the schools can offer an early support provided via mental health support, peer mentoring, and individualized academic accommodations. In addition, an AI-based intervention can ease the workload of educators by streamlining mental health screenings and allowing students to receive the assistance they require without delay. A proactive technology-enabled strategy for depression detection not only improves students' overall well-being and it's cultivating a supportive community that deeply respects and upholds both academic achievement and emotional resilience.

LITERATURE REVIEW

Review of Related Studies

The study of Ibrahim et al. (2013) depression is a significant health condition, the third cause of disability following heart and respiratory illnesses. Despite their social privilege, the university students are at greater risk because of academic pressure and changes in lifestyle. Yet rates vary between settings probably because of varying methods of assessment, cultural views, and environmental influences. The identification of these factors is essential to enhance student mental health care.

In addition of Moir et al. (2018) the medical students are subjected to a lot of academic and clinical stress that is majorly responsible for high depression, anxiety, and stress levels. The heavy workload, competition, and emotional demands of caring for patients leave them especially vulnerable. These challenges require attention to protect their academic performance.

As explained by Andrews et al. (2006) the recent findings point towards a reliance on self -report measures and a lack of data on diagnosable mental disorders in university students. This is a concern regarding accuracy and the necessity of more thorough tests to properly assess their mental health. In addition of Buchanan (2012) the National Institute of Mental Health recommends the development of interventions to avert clinical depression in high-risk populations of college students.

This places emphasis on preemptive mental health care in institutions of higher learning. Medical school is an extremely stressful institution, and therefore, medical students are more likely to be depressed than their peers. This highlights the essential value of mental health support in medical education as explained by Puthran et al. (2016).

Review of Related Systems

In the study conducted by Islam et al. (2018) the social networks offer an interactive approach for users with

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their friends and express their emotions by posting messages. These interactions yield important information about users' feelings. By understand ing the social network, the researchers can investigate trends in emotional expression, communication, psychological state, and behavior of the users.

The study of Orabi et al. (2018) Over the past few years, this area of research has developed in parallel with the increased popularity of social media which has become a unified part of everyday life. The intense bond between people and these websites permits social media to mirror individual experience even though with some confines.

In addition of Lin et al. (2020) the depression impacts more than 300 million individuals globally, but most go undiagnosed in their initial stages because of medical equipment and knowledge limitations. Recent studies investigate the potential of using social media for early detection since patterns of text and image posts of users can tell a lot about their mental state.

Based on the study of Deshpande & Rao (2017) the detection system is a developing research area that aims to detect an emotion using text mining. The development of web-based media has created huge user data which allows for sentiment analysis of text. Furthermore, the development of machine learning and the availability of depression data provide an opportunity for developing an early diagnostic system. These systems are important in minimizing the number of affected individuals by diagnosing and addressing concerns before they escalate according to Amanat et al. (2022).

According to Mulyani & Novita (2022) identifying the mood of the people against patients suffering from depression by labeling posts with the Naïve Bayes Classifier (NBC) algorithm, while Term Frequency-Inverse Document Frequency (TF-IDF) is used for feature extraction. In addition of Samanvitha et al. (2021) early detection and treatment of depression will prevent future complications.

As a result of the popularity of social media, most people prefer posting their feelings online instead of going to professional counselors. This research applies the Naïve Bayes Classifier Algorithm to predict depression from social media data early on.

A machine learning model employing the Naïve Bayes Classifier Algorithm was trained to predict levels of depression in university students. The aim was to optimize prediction quality by training the model with 70% of the data and validating it using the remaining 30% as mentioned by Cruz et al. (2023).

METHODOLOGY

Software Development

As explained by Nikolaieva (2024) the Agile software development process is an iterative and incremental process that prioritizes flexibility, customer satisfaction, and rapid delivery of software. The essence of the Agile approach is breaking down the project into smaller units where each iteration involves a cycle of planning, designing, coding, and testing. And this methodology will be necessary for the development of the student depression detection system.

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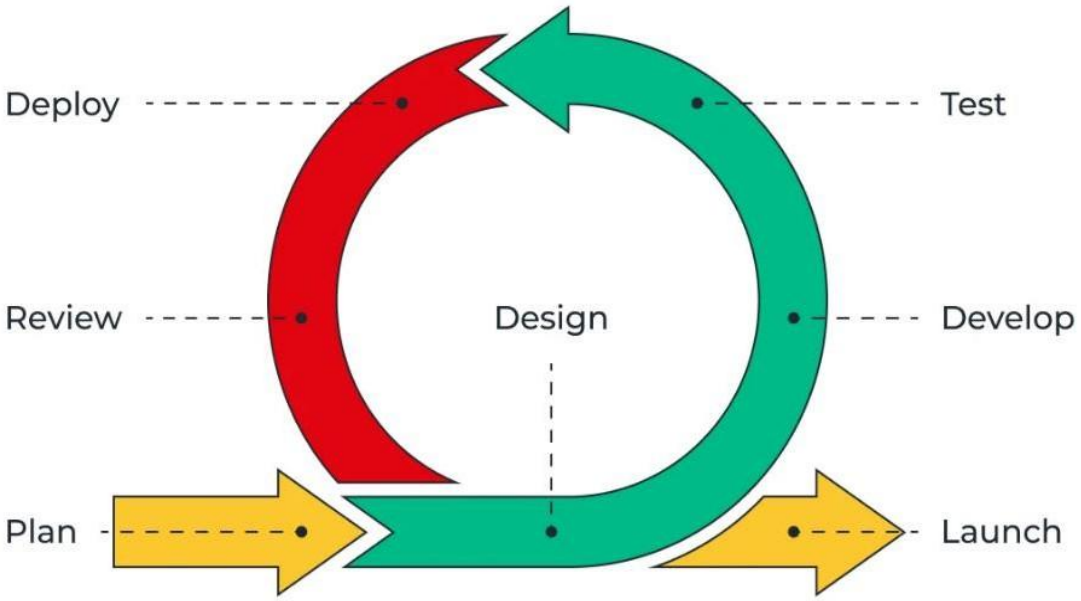
Figure 1. Agile Methodology according to Nikolaieva (2024)



Plan

To support student well-being and academic success, the developing a student depression detection system can help identify early signs of mental health struggles. This system would work by analyzing behavioral patterns through sentiment analysis that could assess written inputs from students like academic reflections to detect emotional distress.

By integrating an early warning mechanism, the system could alert school counselors and educators when a student shows signs of depression allowing a timely intervention. It would also provide personalized mental health resources like recommendations for professional support. And ensuring student privacy and ethical data usage will be a key consideration in its development. With this system in place, educational institutions can create a more supportive environment to reducing dropout rates and promoting overall student well-being.

Design

The design phase of the student depression detection system focuses on structuring its components to ensure accuracy, efficiency, and ethical considerations of the datasets will be used. This stage involves defining the technological capability and student privacy.

A user-friendly interface will be developed for students to interact with the system by allowing them to access self-assessment tools, mental health resources, and optional check-ins. For educators and counselors, a secure dashboard will provide anonymized insights and early warning notifications while maintaining strict data privacy policies. By the end of the design phase, a clear blueprint of the system will be in place by setting the foundation for the development and implementation stages.

Develop

The development phase involves coding and integrating the designed system components to ensure smooth functionality. This stage is one of the longest as it requires implementing both the front-end and back-end structures to create a fully operational web application.

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The front-end development will involve creating the user interface by including the homepage, self-assessment tools, and counselor dashboard using HTML, CSS, and JavaScript. The design will be made responsive with Bootstrap, ensuring compatibility across various devices.

On the back-end development, PHP will be used to handle server-side operations, connecting the system to a MySQL database hosted on an Apache server. This database will store student interaction data, assessment results, and early warning alerts while ensuring data security and privacy compliance.

Additionally, AI-powered sentiment analysis and behavior tracking will be implemented using machine learning models through Python which will analyze students' text inputs to detect signs of distress. Integration with notification systems will allow automated alerts for counselors or educators when intervention is needed. Throughout this phase, continuous testing and debugging will be performed.

Test

The testing phase ensures the reliability, accuracy, and functionality of the student depression detection system before its deployment. This phase involves evaluating the system using multiple testing methods to identify errors, validate its features, and ensure a seamless user experience.

By testing the prototype, we assess how well the system performs under different scenarios. Various test cases are executed to ensure that all components work as intended. A total of nine different and repetitive test case scenarios are conducted to validate system responses, data processing accuracy, and alert mechanisms.

During testing cases, errors encountered during development are documented and resolved to ensure that features like sentiment analysis, data storage, and early warning notifications function correctly. Cross-device testing is also performed to confirm responsiveness across mobile, tablet, and desktop platforms. By the end of the testing phase, the system should be optimized for real-world use with all identified issues addressed before moving forward to deployment.

Deploy and Review

After multiple rounds of User Acceptance Testing (UAT) with stakeholders, the key areas of improvement were identified particularly regarding mobile adaptability. Since most students primarily access digital platforms via smartphones and ensuring full functionality across different screen sizes became a priority.

To address this concern, enhancements were made to improve mobile compatibility to ensure seamless access to all features. This involved refining the responsive design of the web application and optimizing the user interface (UI) for better navigation on mobile devices. Additionally, a dedicated mobile application was considered to provide a more intuitive and accessible experience for students on the go.

Launch

The official launch of the Student Depression Detection System involves a structured rollout. The system is presented to a small group of students for real-world testing allowing them to explore its features and provide feedback. Their insights help assess the system’s effectiveness in detecting early signs of depression and delivering appropriate support resources. Once all enhancements are completed, the system is fully released for institutional use for helping schools and universities proactively support student mental health and well-being.

Evaluation Procedure

According to Estdale & Georgiadou (2018) the ISO/IEC 25010 is an international standard that defines

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software quality characteristics and evaluation criteria to ensure the effectiveness, reliability, and usability of IT systems. When assessing the Student Depression Detection System, this standard is applied in two primary areas which is the IT Evaluation for technical perspective and Mental Health Evaluation for user-centric perspective.

From an IT perspective, the ISO/IEC 25010 standard provides key software quality attributes, and this include the following:

- Functionality – The ability of the system to correctly detect depression indicators using AI-powered sentiment analysis.
- Reliability – Ensures that the system provides consistent and accurate results under different conditions, minimizing false positives, and false negatives in depression detection.
- Usability – Evaluates how intuitive the user interface (UI) and user experience (UX) for students by ensuring ease of navigation.
- Efficiency – Measures the system's performance speed, resource usage, and response time in analyzing data and generating reports.
- Maintainability – Assesses how easily the system can be updated, debugged, and improved over time.
- Portability – Ensures that the system works across multiple platforms without performance loss.

While ISO/IEC 25010 primarily focuses on IT software quality, some of its categories align with mental health standard with the key aspects includes the following:

- Usability (Mental Health Perspective) – The system should be designed to be accessible and non-intimidating the students to feel comfortable
- Reliability (Mental Health Accuracy) – AI-based depression detection should have high accuracy and minimizing misdiagnosis.
- Security (Confidentiality of Student Data) – Complies with privacy standards to ensure that mental health records, assessments, and interactions are securely store.
- Maintainability (Mental Health Content Updates) – The mental health resources should be regularly updated based on the latest psychological research and best practices.

For this system evaluation, we included a total of eight (8) participants of five (5) IT experts and three (3) mental health professionals. The selection of participants was based on their expertise and relevance to the system's intended functionality and purpose. The IT Experts (n=5): These participants were chosen for their technical knowledge in system development and Mental Health Professionals (n=3): Given that the system is designed to support mental health-related functions.

The small but targeted sample size follows an expert evaluation approach where fewer but highly qualified individuals provide in-depth assessments. In system evaluations, the expert reviews are often more effective than large-scale user testing in identifying critical issues early in development. Additionally, this mixed-expertise approach ensures that both technical feasibility and domain-specific applicability are thoroughly assessed leading to a well-rounded evaluation of the system.

As the proponents used Likert scale according to Joshi et al. (2015) on measuring the efficiency and

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acceptability evaluation.

Table 1. Likert Scale on Measuring

Assigned Number	Numerical Range	Categorical Response	Verbal Interpretation
4	3.51 - 4.00	Highly Acceptable	Very High
3	2.52 - 3.50	Moderately Acceptable	High
2	1.51 - 2.50	Slightly Acceptable	Low
1	1.00 - 1.50	Unacceptable	Very Low

Table 1 represents a rating scale used for evaluating responses related to system evaluation. It translates numerical scores into categorical and verbal interpretations to help in analysis.

RESULTS

By applying ISO/IEC 25010, the Student Depression Detection System is assessed both technically and ethically. IT professionals focus on software performance such as Functionality, Reliability, Usability, Efficiency, Maintainability, Portability, while mental health professionals evaluate the Usability, Reliability, Security, Maintainability of the system's intervention mechanisms. This ensures that the system is not only technically sound but also a valuable and ethical tool for supporting student mental well-being.

Table 2. Evaluated by IT Evaluator using ISO 25010:2011 criteria

ISO 25010 Criteria	Rating	Interpretation	Rank
IT Evaluation (Technical Perspective)			
Functionality	3.75	Highly Acceptable	1
Maintainability	3.66	Highly Acceptable	2
Portability	3.65	Highly Acceptable	3
Reliability	3.62	Highly Acceptable	4
Efficiency	3.53	Highly Acceptable	5
Usability	3.44	Moderately Acceptable	6
Over-all Weighted Mean	**3.61**	**Highly Acceptable**	

Table 2 shows that the Student Depression Detection System underwent a thorough evaluation by five (5) IT professionals specializing in (3) Software Engineer, (1) Cybersecurity Specialist, and (1) Project Manager. Their primary focus was to assess the system's overall performance following the ISO/IEC 25010 software quality model.

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Table 3. Evaluated by Mental Health Evaluators using ISO 25010:2011 criteria.

ISO 25010 Criteria	**Rating**	**Interpretation**	**Rank**
Mental Health Evaluation (User-Centric Perspective)			
Maintainability	3.88	Highly Acceptable	1
Security	3.87	Highly Acceptable	2
Reliability	3.55	Highly Acceptable	3
Usability	3.52	Highly Acceptable	4
Over-all Weighted Mean	**3.71**	**Highly Acceptable**	

Table 3 shows that the Student Depression Detection System was also evaluated by three (3) mental health professionals specializing in (2) School Guidance Councilors, and (1) Registered Psychologist to ensure its effectiveness in supporting students while maintaining ethical and privacy standards. Their assessment in the system's intervention mechanisms provide accurate and appropriate mental health support.

DISCUSSION

This study provides a comprehensive overview of the findings derived from the development process of a Student Depression Detection System. The study aims to gain insights into improving the system's accuracy and effectiveness in identifying signs of depression among students. To achieve these goals, experts in IT and Mental Health thoroughly assess the system's components using the guidelines specified in ISO 25010:2011.

The functionality (3.75) reaches the highest of all ISO criteria that gives a meaning of that the system satisfies the user needs which boosts the user engagement and satisfaction. Next is maintainability with the weighted mean of (3.66) which refers to how easily the system can be adjusted to better suit the needs and surroundings in terms of both efficiency and flexibility. Given the use of platforms and devices the concept of portability (3.65) is increasingly significant. The mobility of a systems is assessed on a scale from insufficient to excellent based on its ability to adapt the diverse environments and function seamlessly across devices. Users depend on the systems to be reliable and accessible which makes the reliability (3.62) equally important. The users may always access it without encountering any problems or disruptions. Furthermore, it raises user involvement of efficiency (3.53) is critical to improving the quality of the user experience. The systems have a fast -loading speed, fast response times, and effective resource management. And lastly is usability (3.44) with the lowest and yet not a negative response from the evaluators. The systems that receive a moderately acceptable grade. With an over-all weighted mean of (3.61) a highly acceptable evaluation from the IT Experts.

The evaluation of the Student Depression Detection System yielded highly acceptable results, with an overall weighted mean of (3.71) evaluated by the Mental Health Professionals by affirming its reliability and effectiveness in supporting student well-being. Maintainability (3.88) and security (3.87) received the highest ratings and highlighting the system's adaptability to evolving psychological research and its strong data protection measures. Reliability (3.55) ensures consistent and accurate assessments, while usability (3.52) confirms that students can easily navigate the system with minimal guidance.

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CONCLUSION AND RECOMMENDATIONS

Overall, the system has been deemed highly acceptable by mental health professionals and IT experts, reinforcing its role in providing accurate and accessible mental health evaluations for students. This positive assessment highlights the system's effectiveness in identifying early signs of mental health concerns to allow for timely intervention and support.

Based on the highly acceptable evaluation of the Student Depression Detection System, it is recommended that to any educational institutions particularly schools and universities to adopt and integrate this system into their existing mental health support services.

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Ethical Approval

This study received ethical approval from the appropriate committee. Informed consent was obtained from all participants, and confidentiality was maintained throughout.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

The data that support the findings of this study are available from the authors upon reasonable request.

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