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ARTIFICIAL INTELLIGENCE FOR DETECTING SIGNS OF STUDENT BURNOUT AND PSYCHOLOGICAL DISTRESS : Machine Learning, Wearables, and Smartphone-Based Studies: A Review Paper

[1]Gayatri Shinde, [2]Prof. Ashima Mahendra

[1]Student, [2]Project Guide
[1,2] Department of Artificial Intelligence & Data Science Engineering
[1,2] Ajeenkya DY Patil School of Engineering, Pune, India

Abstract

Student stress and burnout are major educational problems for college students, who often work under heavy demands such as examinations, large workloads, and tight deadlines. As a result, students' well-being is seriously threatened. Usually, the problem is spotted only after a student's performance declines, with performance being the only indicator. This paper reviews eight studies (2021–2026) that examine the potential of Artificial Intelligence and Machine Learning in detecting student burnout and stress. The studies cover explainable machine learning, the demands–resources model of burnout, questionnaire and behavioural data used as algorithm inputs, data obtained through wearable sensors, and passive smartphone sensing. Their approaches, results, and limitations are compared. Overall, the findings show that machine learning can be used to classify or forecast stress states. However, many studies rely on grade or self-reported data, use very small datasets, require specialised equipment, or raise privacy concerns. If these issues are addressed first, such systems could become a practical part of higher education and a valuable aid to student mental health support.

Keywords: Student burnout, Academic stress, Machine learning, Wearable sensors, Smartphone sensing, Explainable AI, Mental health, Higher education

Introduction

Stress arising from academic workloads, exams, and deadlines can affect students' motivation, attendance, performance, and overall mental health. Some students give their all and attend regularly until one day they leave their studies altogether. Traditionally, teachers and counselors have intervened only when a student fails a test, misses an expected grade, or reaches a last chance before dismissal. At that point, they see only the result and not the symptoms that came before it. Changes in behaviour or academic performance, which are indicators of a student's mental health, are usually noticed only late.

AI can provide insight into students' behavioural and physiological signals and thereby flag potential concerns early. The goal of this paper is to show how AI can be used to identify and detect signs of academic burnout, stress, and psychological distress. The review covers data collection techniques, the types of stress considered, data sources, machine learning features, models, results, and the limitations reported across the studies.

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Relevance to Current Technology

AI technology offers a way to capture students' behavioural signals as well as physical changes recorded through wearable devices and mobile apps with sensing capability. This paper is a review of how student stress can be identified using current technological solutions. The features used in different papers, the types of machine learning models, and the sensors employed by each group of authors are explained, and the limitations of using these technologies to monitor student mental health are discussed.

The technologies discussed here, namely passive data collection through smart devices, wearable sensors, and machine learning techniques, can work together to identify student support needs far more effectively than a reactive approach.

Problem Statement and Objectives

Student burnout and stress may go unnoticed or unaddressed until a student shows poor academic achievement or stops attending classes regularly. By then, the student may already be too stressed to continue, and support offered at that stage is less likely to be effective. Early identification of red flags can therefore be of great help.

The key objectives of this paper are: (i) to examine how AI can identify signs of student burnout; (ii) to study learning and behavioural patterns; (iii) to provide a means for teachers to detect students showing signs of distress; (iv) to build a deeper understanding of students; (v) to help students continue and complete their programmes; and (vi) to support research while promoting responsible use of AI in education that protects students and institutions.

Literature Review

Table 1 summarises the eight studies on which this review is based. The articles are grouped by the kind of data and the methods used to explore stress and burnout.

Table 1: Summary of Reviewed Studies

Study	Approach	Key findings	Limitations
Omarbekova et al. (2026)	Explainable ML: RF, LR, GB, SVM and MLP, with SHAP	Academic stress was classified and the factors driving the predictions were identified.	Testing with diverse student groups and field data is recommended.
Sathyanarayana et al. (2026)	Scoping review of wearable devices, biomarkers, and machine learning	Supports continuous monitoring and early intervention.	Limited datasets; no analysis of changes over time.

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Study	Approach	Key findings	Limitations
Ta et al. (2025)	Smartwatch, machine learning, and mobile-health intervention; randomized controlled trial	Stress recognition and potential for stress reduction support were demonstrated.	No long-term evaluation or personalisation.
Gedam et al. (2025)	ML with ECG, GSR, and skin-temperature data from wearables	Precise stress detection; low-cost, continuous monitoring.	Dependence on worn devices; wider validation needed.
Shvetcov et al. (2024)	Supervised ML with passive smartphone sensor data	Undergraduates' stress levels were predicted from mobile phone signals.	Privacy concerns, incomplete sensor data, poor generalizability.
Kang et al. (2023)	Physiological signals combined with machine learning	Academic performance influenced by stress was reflected in physiological responses.	Very small sample and few study conditions.
Jagodics & Szabó (2022)	Statistical and structural analysis using the demands–resources model	Higher workload and weaker support were linked to burnout.	Psychological study; no real-time AI involved.
Rois et al. (2021)	ML on demographic, behavioural, and lifestyle data	Perceived stress was modelled and contributing factors identified.	Self-reported measures and a small sample.

Explainable Machine Learning for Academic Stress

Omarbekova et al. (2026) implemented several machine learning classifiers, namely Random Forest, Logistic Regression, Gradient Boosting, Support Vector Machine (SVM), and a multilayer perceptron. They also adopted SHAP to explain which factors most strongly influence the model's predictions. Their work links the interpretation of stress factors with the recognition of student stress.

Wearable and Physiological Sensing

Sathyanarayana et al. (2026) reviewed wearable sensors, biopotentials, and machine learning strategies for stress monitoring. They propose that such multimodal systems could be used not only for continuous stress tracking but also for timely identification of the need for early intervention. Some of the works reviewed, however, rely on small or dated datasets and do not address how stress changes over time. Ta et al. (2025) combined smartwatch data, machine learning, and mobile-health interventions in a randomized controlled trial. Their approach was effective in detecting acute stress and supporting stress relief, although the authors

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acknowledge that long-term outcomes and performance across different student types need further investigation.

Gedam et al. (2025) studied machine learning combined with electrocardiography (ECG), galvanic skin response (GSR), and skin-temperature data. The results were promising as an inexpensive way to monitor stress, but dependency on wearables remains and broader real-world validation is needed. Kang et al. (2023) used skin temperature, heart rate, and electrodermal activity (EDA) to examine stress levels and academic outcomes. The limitations of their work are a small sample and a setting largely confined to a university campus.

Smartphone-Based Passive Sensing

Shvetcov et al. (2024) used supervised machine learning to extract features from passively collected smartphone data, including location and accelerometer-based activity. The signals served as markers for predicting student stress without requiring students to complete a questionnaire each time. Still, passive data collection raises privacy concerns, sensors may not always work properly, and results may differ across student populations.

Psychological and Behavioural Perspectives

Starting from the demands–resources model and statistical methods, Jagodics and Szabó (2022) investigated factors associated with student burnout. Their main conclusion, supported by the strongest evidence so far, is that very high workload combined with insufficient resources may be why students burn out. Even with this understanding of burnout, their approach does not deliver real-time, AI-based burnout detection. Rois et al. (2021) built a model of student stress profiles from demographic, behavioural, and lifestyle data to predict perceived stress levels at university. Because their data were self-reported and the sample was small, the findings may not generalise beyond the particular groups of students studied.

Discussion

The studies show that researchers use machine learning in different ways, with various types of data, either to detect and classify stress levels or to predict them. Physiological approaches (Sathyanarayana et al., 2026; Ta et al., 2025; Gedam et al., 2025; Kang et al., 2023) typically provide continuous signals, but students must constantly wear a sensor, which many find inconvenient. Smartphone sensing (Shvetcov et al., 2024), on the other hand, allows data to be collected with little or no effort from students; the main issues are valid privacy concerns and the possibility of missing data. Combining questionnaires with behavioural data (Omarbekova et al., 2026; Rois et al., 2021) can be a relatively simple and inexpensive collection method, although reliability remains questionable when self-reports are involved. The psychological analysis by Jagodics and Szabó (2022) does not predict burnout but helps explain the causes of stress.

Common drawbacks mentioned include small study groups, lack of field validation in real teaching and learning situations, very limited research on stress patterns and progression over time, and generalised methods instead of individualised ones.

Research Gap

Current methods fall short in several areas. In many situations, schools rely heavily on marks and so largely miss other indicators that a student's emotions or behaviour may give off. Some techniques require students to wear specific devices, do not permit sufficient real-time monitoring, and raise concerns about collecting students' confidential information. A new, effective system should allow early recognition of burnout signs,

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work reliably in every school context, go beyond academic grades, and, most importantly, ensure that students' data remain private.

Ethical Considerations

Collecting burnout or stress data involves very sensitive and personal information, so privacy and responsible data use must be key considerations from the design phase through implementation. Students should be informed about what data will be collected and how the programme will use it. Prediction models should be transparent, and access to students' personal data should be kept to a minimum. AI should be a tool that helps teachers and counselors find students who need help; it should not make the final decision, and its output should be treated as a suggestion.

Conclusion

Burnout is common among students, and AI may help identify those in need of early support before they reach a point where they can no longer cope. The eight studies reviewed indicate that explainable machine learning, wearable devices, smartphone tracking, and diverse psychological methods can all be used and appear promising. However, the results should be examined closely because datasets are very small, validation in real settings is limited, privacy issues may arise, and long-term and real-time measurements are lacking. Future researchers should test different student groups, personalise the methods, and design systems in which privacy and human supervision play the main role.

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