STM JOURNALS

Research & Reviews: A Journal of
Health Professions

ISSN: 2277-6192
Volume 15, Issue 3, 2025
September–December
DOI (Journal): 10.37591/RRJoHP

https://journals.stmjournals.com/rrjohp

Review RRJoHP

Language Processing in Everyday Applications: From Classrooms to Clinics

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Abstract

Natural Language Processing (NLP) is transforming everyday sectors like healthcare and education by creating new opportunities for efficiency, accessibility, and early intervention. This paper investigates the function of natural language processing (NLP) in computer education. Tools like automated grading systems, intelligent tutoring assistants, and multilingual translation platforms are revolutionizing traditional teaching methods. Despite its benefits, adoption is still being slowed down by problems like data privacy, integration with education, and technical limitations. Simultaneously, natural language processing (NLP) is emerging as a useful healthcare ally that enables the early detection of cognitive decline through the detection of subtle alterations in speech patterns. In addition to techniques like lexico-syntactic and auditory analysis, models like BERT transformers and advanced machine learning classifiers are increasing the potential for non-invasive diagnosis. Early research in the field suggests a promising future despite challenges like limited data availability and low explainability. This study examines recent developments, highlights significant challenges, and forecasts the future of NLP in the domains of healthcare and education.

Keywords: Cognitive Decline, Computer Education, Data Privacy, Early Diagnosis, Machine Learning, Natural Language Processing (NLP)

INTRODUCTION

Computer education is currently a fundamental component of modern educational systems and is essential to the advancement of economic growth, technological innovation, and scientific understanding. Due to the quick development of information technology, computer education currently covers a wide range of subjects, such as big data analytics, artificial intelligence, and software development. Innovative thinking, sophisticated problem-solving skills, and vital 21st-century competencies like cybersecurity, cloud computing, and data analytics are all fostered by it. Aside from enhancing technical skills, computer education enables students to participate in the global economy, democratizes knowledge access via online learning platforms, and stimulates creativity by incorporating modern technologies into classroom settings. Through the use of adaptive technology, which increases educational accessibility for students with impairments, it also fosters inclusiveness. The ongoing development of computer education is crucial to ensuring that students are ready for success in a world that is becoming more digital and linked by the day [1].

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Received Date: June 10, 2025
Accepted Date: December 19, 2025
Published Date: December 27, 2025

Citation: Aritro Chakraborty, Sheetal Singh, Khushi Singh, Sujeet Kumar, Mukesh Kumar. Language Processing in Everyday Applications: From Classrooms to Clinics. Research & Reviews: A Journal of Health Professions. 2025; 15(3): 22–27p.

AI technology is changing the healthcare industry in ways that are revolutionary, and it is also making education better. Machine learning and deep learning models are being used more and more to help with diagnosis, prognosis, and treatment planning, especially for diseases like cancer that need to be treated right away. AI is helping to make cognitive health one of the most important areas of healthcare. Cognitive skills like thinking, learning, remembering,

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judging, and making decisions are important for everyday life. Alzheimer's disease, dementia, and Parkinson's disease are some examples of conditions that can make these skills worse. This can make life much worse, especially for older people [2].

AI-powered chatbots are becoming more and more common as virtual assistants that can handle both written and spoken conversations. They learn how their users like to talk and write over time. When used in telemedicine platforms, these voice-based technologies could be very useful in the healthcare field. By turning speech into text and using Natural Language Processing (NLP) techniques, these systems can pick up on small changes in speech that are often noticeable before more obvious signs of cognitive decline show up. NLP uses methods like acoustic and lexico-syntactic analysis to find problems early on in a way that does not hurt anyone, does not cost much money, and can be used on a large scale. This makes early diagnosis and intervention strategies better [2–3].

This review study looks closely at the role of natural language processing (NLP) in two important areas: cognitive healthcare and computer education. It gives a full picture of how NLP technology has changed over time, the problems it faces, and the opportunities it offers to researchers, teachers, and doctors who want to learn more about and make these important applications [1–2].

METHODOLOGY

This review study investigates the practical uses of natural language processing (NLP) in healthcare and education using a narrative-based qualitative technique. Relevant literature was gathered using keywords like "NLP in education," "clinical NLP," and "language models in real-world applications" from scholarly databases including IEEE Xplore, ACM Digital Library, ScienceDirect, PubMed, and Google Scholar. Peer-reviewed publications released between 2021–2024 were the main focus of the review. Studies showing real-world applications of NLP were the focus of the inclusion criteria; theoretical or irrelevant works were not. Important details including goals, NLP methods, datasets, and results were taken out and subjected to theme analysis. Applications were categorized into helpful and educational sectors, emphasizing new developments and moral issues such as model bias and data privacy.

APPLICATIONS OF NLP IN EDUCATION

Natural language processing (NLP) has changed the way we learn by bringing in cutting-edge tools and methods that improve learning outcomes, make administrative tasks easier, and make everyone feel welcome [1, 3].

Automated Essay Scoring and Feedback

NLP-based systems are widely used to evaluate written assignments, including essays and reports. These systems assess grammar, coherence, vocabulary usage, and semantic significance using deep learning and natural language understanding (NLU) techniques. For instance, the e-rater engine, developed by the Educational Testing Service (ETS), is frequently used to automatically score essays on standardized tests such as the TOEFL and GRE.

Intelligent Tutoring Systems (ITS)

Natural language processing (NLP) is used by intelligent tutoring systems to mimic individualized one-on-one training. These tools evaluate student answers, spot misunderstandings, and modify their teaching methods accordingly. Natural language processing (NLP) is used by platforms like Carnegie Learning's MATHia to provide personalized assistance with mathematical problem-solving, greatly enhancing learning outcomes [4–5].

Language Translation and Language Learning

Real-time machine translation powered by natural language processing enables students to access educational materials in multiple languages. Additionally, NLP is utilized by language learning apps such as Duolingo to offer pronunciation assistance, grammatical corrections, and real-time feedback—all of which increase the effectiveness of learning a second language [6].

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Speech Recognition and Accessibility

By utilizing Natural Language Processing (NLP) and Automatic Speech Recognition (ASR) technologies to translate spoken content into written text, accessibility can help students with hearing or learning disabilities. Thanks to programs like Microsoft's Immersive Reader and Google Live Transcribe, which provide text-to-speech and real-time captioning, classrooms are becoming more inclusive [7–9].

Content Summarization

Long academic texts can be abstracted and extracted with the help of sophisticated NLP models like BART and T5. When researchers and students use apps like Scholarcy to rapidly extract the most important information from lengthy study materials, they save time and improve comprehension [10].

Plagiarism Detection

Natural language processing (NLP) tools are crucial for upholding academic integrity because they can detect plagiarism. Systems like Turnitin employ semantic analysis and cross-referencing against extensive academic databases to identify duplicated or paraphrased content, even after significant rewording has taken place.

Chatbots for Student Support

Educational institutions use NLP-based chatbots to provide academic counseling, suggest courses, and respond to administrative inquiries. For example, by offering students real-time assistance during the enrollment process, Georgia State University's Pounce chatbot has effectively reduced "summer melt."

APPLICATIONS OF NLP IN HEALTHCARE

By enhancing clinical documentation, patient engagement, and medical research, natural language processing (NLP) is propelling notable progress in the healthcare industry [2, 4].

Clinical Documentation Automation

Natural language processing (NLP) systems significantly reduce the amount of paperwork that healthcare workers have to complete by automating the transcription and summarization of doctor-patient interactions. With real-time note-taking tools like Nuance's Dragon Medical One, clinicians can spend more time caring for patients.

Electronic Health Record (EHR) Analysis

Unstructured types of healthcare data are commonly found in electronic health records. NLP techniques are used to extract, organize, and analyze this data in order to identify trends, support clinical decision-making, and enhance patient care.

Medical Chatbots and Virtual Health Assistants

NLP-capable chatbots assist patients with appointment scheduling, medication management, post-treatment follow-up, and symptom evaluation. Apps like Babylon Health and Ada Health improve access to healthcare by providing preliminary health assessments based on user interactions [3].

Predictive Healthcare Analytics

By looking at clinical records and patient conversations, NLP models can predict the chance of illness, hospital readmissions, and potential outcomes. By employing NLP-based technologies, institutions such as the Mayo Clinic have successfully enhanced early intervention strategies.

Medical Literature Mining

Researchers and clinicians can stay up to date on the latest scientific developments because NLP facilitates the rapid analysis of biomedical literature. Platforms like Semantic Scholar employ NLP techniques to extract relevant results from sizable databases of medical research publications.

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Mental Health Monitoring

Natural language processing (NLP) models look at linguistic patterns in text and voice to find early signs of mental health issues like PTSD, anxiety, and depression. Studies have demonstrated the effectiveness of using chat transcripts and social media data for mental health surveillance through NLP-driven sentiment analysis.

Radiology and Imaging Reports Interpretation

By removing crucial information from imaging data, NLP applications in radiology aid in speedier diagnosis and case prioritization. Businesses like Qure.ai have developed tools to assist radiologists in efficiently managing imaging data.

ANALYSIS OF THE OUTCOME OF NLP IN THE FIELD OF EDUCATION

Pros

- *Learning Personalization:* Natural language processing (NLP) enables the development of personalized learning experiences by analyzing each learner's distinct learning preferences, habits, and performance. Adaptive learning systems increase student engagement and retention of the content by changing the material's level of difficulty, recommending additional resources, and providing tailored feedback.
- *Enhanced Efficiency:* Academic and administrative tasks like grading, creating feedback, and organizing course materials are automated through the integration of natural language processing (NLP). Teachers' workloads are lessened by intelligent tutoring platforms and automated essay grading systems, which free up more time for creative and interesting lesson plans.
- *Global Access and Language Inclusivity:* NLP-driven translation and multilingual content delivery systems enable learners with different language backgrounds to access educational materials. Real-time translation systems facilitate cross-cultural learning and global learning environments while removing language barriers.
- *Improved Accessibility and Inclusion:* Students with disabilities, such as those with cognitive, visual, or hearing impairments, benefit from reading comprehension tools like text-to-speech and speech-to-text technology. By giving every student an equal opportunity, these resources ensure inclusive education.

Cons

- *Algorithmic Bias:* Unfair judgments or stereotypes may be inadvertently reinforced by NLP models trained on biased datasets. For instance, essay scoring systems might favor writing styles that are common among specific groups, leading to unfair academic assessments.
- *Over-reliance on Technology:* An over-reliance on AI-based educational resources may impair students' capacity for creativity, critical thinking, and problem-solving. Furthermore, educators risk becoming overly reliant on automated systems, which would restrict their capacity to use complex judgment in the classroom.
- *Privacy and Data Security Issues:* Educational platforms collect private student data to customize instruction. Inadequate data protection measures may lead to unauthorized data use, privacy violations, and potential exploitation of children's information.
- *Deep Understanding Limitations:* Despite significant progress, NLP models often struggle with complex cognitive tasks, such as interpreting humor, sarcasm, irony, or deep contextual understanding. This limitation could affect the quality of content analysis and automated tests in a number of academic domains.

ANALYSIS OF THE OUTCOME OF NLP IN THE FIELD OF HEALTHCARE

Pros

- *Time Efficiency in Clinical Workflows:* NLP systems automate clinical documentation through the transcription of doctor-patient conversations, the creation of structured reports, and the summarization of medical notes. Reducing the administrative burden allows healthcare providers to devote more time to patient care, improving healthcare delivery in general.

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- *Early Risk Detection and Intervention:* By looking at clinical notes, patient communication patterns, and electronic health records (EHRs), natural language processing (NLP) systems can identify early signs of diseases like diabetes, cardiovascular conditions, or mental health disorders. This improves patient outcomes and enables timely interventions.
- *Improved Patient Support Services:* Chatbots and virtual health assistants driven by natural language processing (NLP) provide 24/7 medical support, including symptom assessment, medication reminders, and lifestyle advice. In underserved or isolated locations where it could be challenging to locate medical professionals, these systems are extremely beneficial.
- *Medical Research Acceleration:* Large volumes of biomedical literature can be swiftly processed by natural language processing (NLP) tools, which can then extract relevant information for systematic reviews, meta-analyses, and the creation of clinical guidelines. This expedites scientific research and keeps physicians abreast of medical advancements.

Cons

- *Misdiagnosis or Error Risk:* NLP-driven diagnostic tools can occasionally misinterpret clinical data due to model errors, a lack of context, or a failure to understand medical terminology. If these errors are not sufficiently confirmed and monitored, they may lead to inappropriate treatments, which could endanger patient safety.
- *Data Sensitivity and Privacy Issues:* Healthcare data is particularly sensitive and is subject to strict confidentiality regulations. Applications using natural language processing (NLP) that handle patient data must guarantee strong data encryption, anonymization, and adherence to laws such as HIPAA. Serious ethical, legal, and financial consequences could result from any infraction.
- *Bias and Health Inequities:* Minority groups may experience poor performance from NLP models that were trained on datasets with low demographic diversity, exacerbating already-existing healthcare disparities. Ensuring equity and fairness in medical natural language processing systems is a significant research and policy challenge.
- *Regulatory and Ethical Complexities:* When using NLP technologies in the healthcare sector, strict regulatory frameworks need to be adhered to. Furthermore, ethical concerns about informed consent, patient autonomy, explainability of AI decisions, and accountability for errors are enduring issues that require careful thought.

FUTURE PROSPECTS OF NATURAL LANGUAGE PROCESSING IN THESE FIELDS

In the Field of Education

- *Personalized Learning:* Natural language processing will drive intelligent tutoring systems that understand students' learning preferences, strong points, and areas for development. Chatbots and virtual tutors can customize lesson plans and provide real-time feedback [1].
- *Automated Assessment and Feedback:* Advanced natural language processing models can reduce the need for manual grading by evaluating essays, assignments, and even oral presentations for originality, coherence, argument strength, and grammar.
- *Language Learning:* By providing immediate corrections and cultural context, real-time conversational agents will assist students in practicing foreign languages with nearly native fluency.
- *Accessibility:* NLP tools have the potential to foster inclusivity in education by providing real-time captioning, translation services, and content adaptation for students with disabilities.
- *Curriculum Development:* NLP can help teachers create better courses that are relevant to future skills by analyzing research papers, student feedback, and global educational advancements.

In the Field of Medical

- *Clinical Documentation Automation:* Physicians spend a lot of time on paperwork. NLP will enable automatic transcription and summarization of doctor-patient conversations, increasing documentation accuracy and speed.
- *Medical Chatbots and Virtual Assistants:* AI-powered health assistants will communicate with patients to check symptoms, schedule appointments, remind them to take their medications, and provide post-treatment support.

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- *Predictive Diagnostics:* To assist physicians in making early disease predictions, NLP can examine patient records, medical literature, and persistent symptoms.
- *Research Support:* NLP tools can swiftly search through a large body of biomedical literature to locate pertinent studies, spot patterns, and produce hypotheses more quickly.

CONCLUSION

NLP, or natural language processing, has emerged as a revolutionary technology with significant applications in healthcare and education. In the healthcare sector, natural language processing (NLP) offers a promising, non-invasive, and cost-effective way to identify cognitive impairments like dementia and Alzheimer's disease early on by examining speech and language patterns. Through the use of transfer learning models like BERT, deep learning, and machine learning, researchers have generated encouraging results that point to improved patient outcomes and earlier intervention. Through intelligent tutoring, automated scoring systems, and multilingual translation, NLP has significantly improved resource accessibility and individualized learning experiences in the field of education. Its potential, obstacles to broad adoption still exist, including a lack of standardization, linguistic diversity, data scarcity, and worries about data security and privacy. Strict data governance and strong model development will be essential to overcoming these constraints. In general, NLP has the potential to transform educational technology and early healthcare diagnostics, paving the way for more inclusive, effective, and flexible systems in both fields in the future.

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