

Natural Language Processing in Education

Matthew N. O. Sadiku¹, Paul A. Adekunle², Janet O. Sadiku³

¹Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA

²International Institute of Professional Security, Lagos, Nigeria

³Juliana King University, Houston, TX, USA

ABSTRACT

Natural language processing (NLP) is a branch of artificial intelligence that has emerged as a transformative force across various sectors. Its applications in education holds significant promise for revolutionizing how students learn, how teachers teach, and how institutions operate. NLP in education bridges the gap between AI and human communication, offering scalable tools that enhance learning and operations. This technology is pivotal in improving how institutions, teachers, and learners engage with educational instructional tools and processes. Natural language processing education offers a range of practical advantages that help institutions deliver better learning experiences and outcomes. From streamlining administrative tasks to personalizing learning, NLP has become essential in modern education systems. NLP is redefining the potential of education, bringing scalability, personalization, and measurable outcomes to the forefront. This paper explores the diverse applications of NLP in education, highlighting its benefits, challenges, and future trends.

KEYWORDS: *natural language processing (NLP), computational linguistics, education, learning, teaching, students, educators, applications.*

INTRODUCTION

The education sector is undergoing a seismic shift, driven by the integration of cutting-edge technologies. Among these, natural language processing (NLP) stands out as a transformative force. NLP is rapidly reshaping various sectors, and education is no exception. NLP has captivated the attention of educators over the past three decades. It has emerged as a transformative force in education, offering unprecedented opportunities to enhance communication and understanding in the learning process. By enabling computers to understand, interpret, and generate human language, NLP offers innovative solutions to long-standing challenges in learning and teaching, from personalized learning experiences to administrative efficiencies. NLP leverages linguistics and computer technology to create intelligent systems, and its use in education has grown due to the abundance of educational content. It addresses challenges faced by educators and students, particularly in generating relevant, context-based word problems that enhance online learning [1].

Implementing NLP education solutions is essential to modernizing learning settings and improving student and educator outcomes. NLP bridges the gap between complex computational systems and natural communication, making interactions with technology more intuitive and user-friendly. NLP in education redefines how institutions deliver teaching, streamline operations, and engage learners. It reshapes how learning is designed, delivered, and assessed. It bridges the gap between technology and the complexities of human communication, offering practical tools that improve efficiency and outcomes. As artificial intelligence develops, NLP technologies are essential for creating personalized, accessible, and efficient learning conditions. From automating repetitive tasks to tailoring instruction to individual needs, NLP offers scalable solutions that align with the needs of modern education [2].

FUNDAMENTALS OF NLP

Natural language processing is a subfield of artificial intelligence that empowers computers to understand, interpret, and generate human language. It is a

How to cite this paper: Matthew N. O. Sadiku | Paul A. Adekunle | Janet O. Sadiku "Natural Language Processing in Education" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-10 | Issue-3, June 2026, pp.308-316, URL: www.ijtsrd.com/papers/ijtsrd102027.pdf



Copyright © 2026 by author (s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (<http://creativecommons.org/licenses/by/4.0>)



technique where machine can become more human and thereby making human to communicate with the machine easily. NLP seeks to make software intelligent enough to process a natural language as humans. For example, imagine a machine that takes instructions by voice.

NLP analysis generally consists of the following three levels [3]:

- *Syntax*, the study of sentence structure. Syntax deals with the formation of a sentence from individual words. Syntax alone suggests the proper interpretation of “Jimmy loves Lucy.”
- *Semantics*, the study of context-independent meaning. This derives the meaning of a sentence based on the meanings of the words/phrases. For example, semantics determines whether the word “bank” refers to a river bank or to a financial institution.
- *Pragmatics*, the study of context-dependent meaning. Pragmatics deals with how meaning changes in the presence of a specific context and how the contexts affect the meaning of the sentences. This level is concerned with the purposeful use of language in situations.

As a foundational pillar of modern artificial intelligence, NLP encompasses a wide array of tasks, including speech recognition, text classification, natural language understanding (NLU), and natural language generation (NLG). NLP encompasses a wide range of tasks, such as information retrieval (IR), named entity recognition (NER), relation extraction, text classification, topic modeling, semantic textual similarity, machine translation, and question answering (QA). Figure 1 shows how NLP transforms raw acoustic data into meaningful interactions [4], while Figure 2 shows different components of NLP [5].

Recently, large language models (LLMs) have shown their ability in learning universal language representations, text understanding and generation. LLMs refer to a model with a large number of parameters, vast training data, and substantial compute, enabling it to capture complex language patterns. In LLM-based NLP, pre-processing is followed by prompt engineering, which guides LLMs to produce outputs that align with extraction requirements during inference without altering the model’s parameters. Models like GPT are pushing the boundaries of language understanding, enabling nuanced and context-aware applications. The GPT (Generative Pretrained Transformer) is a large-scale language model developed by OpenAI that consists of multiple layers of transformer blocks, each with a

self-attention mechanism and a forward neural network [6]. GPT-based systems can summarize complex reports or generate creative content like essays, making them versatile in both academic and professional environments. ChatGPT uses NLP techniques to understand prompts. When you enter a prompt, the chatbot comprehends it and provides relevant replies. Figure 3 shows how NLP works [7], where Figure 4 depicts some applications of NLP [8].

NLP IN EDUCATION

Natural language processing (NLP) is a branch of artificial intelligence that focuses on the interaction between computers and human language. It stands at the forefront of educational innovation, offering unprecedented opportunities to personalize learning, streamline administrative tasks, and create more inclusive and engaging environments. It is rapidly reshaping the educational landscape. It has been widely applied to the education domain and its applications have enormous potential to help teaching and learning.

By enabling computers to understand, interpret, and generate human language, NLP offers innovative solutions to long-standing challenges in teaching and learning. NLP supports more personalized and efficient education systems through automating tasks like text analysis, accessibility enhancements, and real-time feedback. It addresses challenges such as tailoring instruction to individual needs, reducing administrative burdens, and creating inclusive learning experiences. NLP applications in education address core challenges with measurable solutions that improve efficiency, inclusivity, and outcomes. From personalized tutoring systems to advanced accessibility tools, these innovations are reshaping education while aligning with institutional goals [9].

Understanding the return on investment (ROI) of natural language processing in education is essential for institutions seeking to align their resources with measurable outcomes. While integrating NLP involves upfront costs, its benefits in terms of efficiency, accessibility, and personalization can deliver significant long-term value. Enhanced learning outcomes are another key metric for evaluating ROI. NLP-powered tools permit personalized learning experiences that support higher student engagement and retention rates. Institutions can measure the impact through improved grades, graduation rates, and student satisfaction scores [2]. NLP in education refers to the use of AI-driven language technologies to enhance learning experiences, automate administrative tasks, and make education more accessible and inclusive.

APPLICATIONS OF NLP EDUCATION

The integration of NLP into education manifests in several key applications. NLP's capabilities are being harnessed across various facets of education, from personalized learning experiences to administrative efficiencies. In education, NLP is used for personalized learning, automated grading, language translation, chatbots, sentiment analysis, and content generation. These applications are designed to enhance student engagement, support educators, and foster a more inclusive learning environment. Common applications of NLP in education include the following [10,11]:

- *Intelligent Tutoring Systems (ITS)*: NLP is instrumental in the development of intelligent tutoring systems and virtual teaching assistants. These systems offer 24/7 support, answering student questions and guiding them through complex subjects. ITS powered by NLP provide students with highly individualized support. These systems analyze a student's performance data, engagement patterns, and comprehension levels to deliver tailored lessons and exercises. For example, advanced NLP models can pinpoint specific misconceptions in a student's understanding of a subject, such as mathematics, and adapt the teaching approach accordingly. This personalized approach makes the learning process more engaging and effective, while also offering educators real-time insights into student progress, allowing for timely intervention when necessary. Unlike traditional software that provides binary corrections, NLP-powered ITS engage students in Socratic dialogue, offering scaffolded hints and immediate, nuanced feedback. These systems analyze student responses to identify comprehension gaps and guide learners towards self-discovery, thereby fostering deeper understanding rather than rote memorization. Stanford education researchers are at the forefront of building natural language processing systems to support teachers and improve instruction. Figure 5 shows a teacher tutoring some students [12].
- *Automated Assessment*: One of the most time-consuming tasks for educators is grading. The burden of grading, especially for written assignments, can be significantly alleviated by NLP. NLP-powered tools streamline this process by automating the evaluation of written assignments, including essays and short answers. These tools utilize algorithms to assess grammar, coherence, and overall content quality, providing consistent and accurate results. Beyond just grading, these systems offer detailed, constructive critiques that highlight areas for improvement, fostering a more immediate connection between students and their learning progress. This not only reduces the administrative burden on teachers but also improves the scalability of assessments. Automated grading systems can evaluate essays, detect plagiarism, and even analyze the sentiment of student feedback.
- *Sentiment Analysis*: Understanding student sentiment is vital for improving educational quality. NLP-driven sentiment analysis tools examine written feedback to detect emotions, concerns, and suggestions. These insights offer a deeper understanding of student experiences, enabling educators and administrators to make data-backed decisions and implement meaningful changes. By identifying trends and addressing challenges proactively, institutions can enhance student satisfaction and improve retention rates.
- *Teacher Support*: According to a 2022 Gallup poll, US teachers in grades K-12 are the most burnt-out workers in any profession. NLP tools can support these teachers. They are emerging as valuable assistants for teachers, helping to streamline administrative tasks and provide pedagogical support. These tools can assist with generating lesson plans, grading, drafting emails to parents, and even act as “nonjudgmental coaches” that observe lessons and suggest improvements. NLP applications can significantly reduce the time educators spend on administrative tasks. They can automate lesson plan generation and summarize educational content, streamlining curriculum design.
- *Adaptive Curriculum*: NLP supports adaptive curriculum development by analyzing performance data and aligning course content with current and future needs. To ensure educational curriculums remain relevant to industry requirements and emerging skill needs, NLP algorithms can analyze vast amounts of data, including course outcomes and workforce trends. These insights help educators prioritize relevant content, identify outdated material, and align learning objectives with actual skills needed in the future. This data-driven approach to curriculum development enhances the value of the learning experience and supports long-term educational success.
- *Writing Skills*: NLP tools are at the forefront of improving students' reading and writing abilities. These applications can analyze student submissions, such as essays, and provide

immediate, actionable feedback on grammar, prose, and overall writing mechanics. A prime example is Grammarly, which utilizes NLP to help students produce clear and error-free text. Beyond basic corrections, NLP can identify more complex issues, such as the absence of supporting arguments or insufficient evidence in a piece of writing.

- *Reading Skills:* For reading, NLP algorithms can pinpoint areas where students struggle and offer real-time feedback for improvement. This personalized approach is invaluable in a classroom setting where individual attention from teachers is often limited. Furthermore, NLP can match students with appropriate reading materials based on their proficiency and learning pace, fostering engagement and productivity. Studies have shown that NLP technologies can grade student reading scores more accurately than traditional methods.
- *Language Education:* The ultimate goal of NLP is to read, decipher, understand, and make sense of human language in a valuable way. From powering voice assistants like Alexa to analyzing text for sentiment analysis, NLP has numerous applications across various sectors, with language education being one of them. In language education, NLP serves as a bridge between humans and technology, enabling a more interactive and efficient learning process. Its significance lies in its ability to understand and analyze language patterns, which play a crucial role in language acquisition and learning. Figure 6 shows a representation of NLP in language education [11].
- *Language Translation:* Real-time translation capabilities break down language barriers, making educational content accessible to a wider range of students. Pronunciation assessment software and grammar correction tools provide immediate, personalized feedback, helping learners practice and refine their language skills. These NLP services are particularly beneficial for English as a second language (ESL) learners and those studying foreign languages, making the process more engaging and manageable.
- *Chatbots:* In the 1960s, early NLP applications like ELIZA, a chatbot, laid the groundwork for human-computer interaction. Chatbots and virtual assistants instantly use NLP to answer student queries, provide study support, and create a more interactive learning condition. Chatbots handle routine student inquiries regarding financial aid or registration, freeing up staff for more complex

and repetitive tasks. While today's chatbots are so far helping teachers to increase their efficiency on tasks like quickly generating lesson plans or writing emails to parents, two Stanford scholars are studying options that could go beyond shaving a few minutes off the workday.

BENEFITS

The integration of NLP into education yields several significant benefits. NLP plays a crucial role in overcoming language barriers and enhancing accessibility. It holds transformative potential for education, offering innovative ways to personalize learning, streamline administrative tasks, and enhance accessibility. NLP enhances education by addressing scalability challenges, improving accessibility, and maximizing the impact of instructional efforts. Other benefits of NLP in education include the following [10]:

- *Automation:* One of the most immediate areas of impact is the reduction in administrative workloads. Automating tasks such as grading, feedback generation, and data analysis saves time for educators, allowing them to focus on instruction and student engagement. Tasks such as grading, administrative record-keeping, and generating feedback are automated using NLP, allowing educators to focus on teaching and mentoring students.
- *Personalization:* One of the most impactful applications of NLP in education is its ability to facilitate personalized learning experiences. NLP enables the delivery of highly individualized learning experiences to a large number of students simultaneously. By analyzing student data, NLP systems can identify unique learning styles, strengths, and weaknesses, and then adapt content and instructional strategies accordingly. This level of personalization was previously unattainable, allowing educators to cater to diverse student populations more effectively. Mobile learning applications and learning management systems (LMS) leverage NLP to recommend resources that align with a student's pace and preferences, transforming education from a one-size-fits-all model into a tailored experience.
- *Enhanced Efficiency:* NLP automates many time-consuming tasks, such as grading, administrative inquiries, and content curation. This automation frees educators from repetitive duties, allowing them to dedicate more time to high-value activities like one-on-one mentorship, curriculum development, and addressing complex student needs. The result is a more efficient allocation of

human resources and improved overall productivity within educational institutions.

- *Improved Engagement:* Through sentiment analysis, NLP tools can monitor the emotional state of students by analyzing their written communications in forums or assignments. This capability allows for the early detection of frustration, confusion, or disengagement, enabling timely interventions from educators. Such proactive support models contribute to enhanced student engagement and well-being, particularly in online learning environments.
- *Greater Inclusivity:* NLP plays a crucial role in making education more accessible and inclusive for diverse student populations. By breaking down language barriers through translation and providing alternative input methods via speech recognition, NLP makes education more accessible to a wider range of students. This includes multilingual learners, students with learning disabilities, and those with physical impairments, ensuring that all individuals have equitable opportunities to participate and succeed in their academic pursuits. For students with disabilities, speech recognition and NLP tools enable them to express themselves accurately, dictating written responses without the physical challenges of typing or handwriting.
- *Student Support:* Beyond academics, NLP contributes to enhanced student support and engagement. Chatbots can handle administrative queries, freeing staff from repetitive tasks. More advanced applications include mental health monitoring through text analysis, which can identify students at risk and prompt timely interventions. AI can also predict dropout risks, enabling schools to proactively support vulnerable students. These educational NLP applications foster a more responsive and caring learning environment, crucial for student success.

CHALLENGES

In spite of its immense potential, the deployment of NLP in education is not without its complexities and challenges, which must be addressed to maximize its potential. These challenges span technical, pedagogical, social, and ethical domains, necessitating careful consideration and innovative solutions for NLP to truly augment the learning process. Challenges related to algorithmic bias, data privacy, explainability, and complexity of human language must be carefully addressed. Addressing these concerns requires a collaborative effort between technologists, educators, and policymakers. Other

challenges of NLP in education include the following [10]:

- *Technical Challenges:* One of the primary technical hurdles for NLP in education lies in accuracy and reliability. The effectiveness of NLP systems, such as large language models like ChatGPT and Google Bard, is heavily dependent on the quality, diversity, and complexity of their training data. Inaccuracies can arise when the training data lacks sufficient diversity or is of low quality, leading the system to learn incorrect or incomplete patterns. When students provide unclear or ambiguous input, the system may struggle to generate accurate or relevant responses, particularly if they are unable to articulate their queries precisely.
- *Pedagogical Challenges:* The integration of NLP tools introduces significant pedagogical challenges, particularly concerning the development of critical thinking skills. There is a tangible risk of over-reliance on these technologies, where students might passively accept AI-generated responses without engaging in critical evaluation or independent inquiry. This can impede the cultivation of higher-order thinking skills, such as problem-solving, analytical reasoning, and the ability to discern reliable information from unreliable sources. Educational institutions must therefore provide clear guidance on using NLP as a supplementary tool rather than a replacement for intellectual engagement.
- *Ethical Challenges:* Ethical considerations are paramount in the deployment of NLP in education. A significant concern is bias and inequality. If the data used to train NLP models is biased or unrepresentative, the systems can perpetuate and even amplify existing societal inequalities and discriminatory practices. Data privacy is another critical ethical challenge. Educational data often contains sensitive personal information about students, including academic performance, behavioral patterns, and personal communications.
- *Social Challenges:* The digital divide poses a social challenge. Unequal access to advanced NLP tools and the necessary technological infrastructure can exacerbate existing disparities between students from different socioeconomic backgrounds or geographical regions. This can create a two-tiered educational system, where those with access to cutting-edge AI tools gain an unfair advantage, further widening the gap in educational opportunities and outcomes.

- **Algorithmic Bias:** A primary concern is the potential for algorithmic bias. NLP models are trained on vast datasets, and if these datasets are not diverse or representative, the models can inadvertently perpetuate or amplify existing societal biases. This can lead to unfair assessments or discriminatory treatment of students from certain linguistic backgrounds, socioeconomic statuses, or demographics. Rigorous auditing and the use of inclusive training data are essential to mitigate this risk.
- **Data Privacy:** Educational data is highly sensitive, and the use of NLP systems necessitates strict adherence to data privacy regulations such as GDPR and FERPA. Institutions must implement robust security measures, including end-to-end encryption and advanced anonymization protocols, to protect student information. Maintaining trust between students and institutions is paramount, requiring transparent data handling practices and clear consent mechanisms.
- **Data Quality:** Quality data is essential for successful NLP applications. Organizing datasets like student records, course materials, and feedback forms ensures the technology performs as intended. Well-prepared data enhances the accuracy and efficiency of NLP tools.
- **Explainability:** Many NLP models operate as “black boxes,” making it difficult to understand how they arrive at their conclusions. For educational applications, especially in assessment, this lack of transparency can be problematic. The development of Explainable AI (XAI) is crucial to provide clear reasoning for feedback and scores, fostering trust and enabling both students and faculty to understand and critically engage with AI tools. Promoting AI literacy among all stakeholders is vital for effective adoption and responsible use.

FUTURE OF NLP EDUCATION

The field of NLP in education is continuously evolving, with several promising directions for future research and development. The future of NLP in education looks promising, with significant growth anticipated in the coming years. The global market for NLP in education is projected to grow significantly in the coming years. This growth is driven by the increasing adoption of NLP-powered chatbots, virtual tutors, and advanced analytics tools that are transforming traditional educational paradigms. As these technologies continue to evolve, we can expect even more sophisticated applications

that further personalize learning and empower educators.

The ongoing advancements in NLP technology promise a future where education is more adaptive, accessible, and effective for all learners. Future NLP systems will aim for greater generalization, capable of effectively supporting learning across a wider array of academic subjects and languages. The rapid advancements in large language model (LLM) systems suggest a future where these powerful models are seamlessly integrated into educational platforms. The push for Explainable AI (XAI) will continue, with a focus on making NLP tools in education more transparent and understandable. As the technology advances and its adoption grows, NLP will undoubtedly play a central role in shaping the future of education, making it more efficient, accessible, and effective for all learners [10]. The future of NLP in education lies in personalized learning, global accessibility, and the rise of AI-powered virtual tutors.

CONCLUSION

Natural language processing is a powerful tool that is revolutionizing education by providing personalized learning experiences, automating administrative tasks, and fostering a more inclusive environment. It is poised to revolutionize education by offering personalized learning experiences, automating tedious tasks, and providing intelligent support for both students and educators. It has shown immense potential in transforming educational practices, from personalized learning experiences to automated assessment. By embracing these technologies responsibly and strategically, educational institutions can harness the full potential of NLP to transform learning and teaching for generations to come. As NLP technologies continue to evolve, their potential to create more engaging, effective, and equitable learning environments will only grow, paving the way for a truly transformative educational future.

Successfully adopting natural language processing in education involves aligning technology with measurable goals, fostering collaboration between educators and technology providers, and focusing on inclusion and long-term benefits. By fostering interdisciplinary collaboration among AI researchers, educators, policymakers, and ethicists, we can develop NLP solutions that are not only technologically advanced but also pedagogically sound, equitable, and ethically responsible, ultimately enriching the educational landscape for all learners. More information about the integration of NLP in education can be found in [13-17] and the following related journals:

- Natural Language Processing Journal
- Journal of Emerging Technologies and Innovative Research

REFERENCES

- [1] S. P. Bode and R. S. Satpute, "Natural language processing in education system," *Proceedings of the 2024 2nd DMIHER International Conference on Artificial Intelligence in Healthcare, Education and Industry*, November 2024.
- [2] "5 Examples of natural language processing in education," January 2025, <https://lumenalta.com/insights/5-examples-of-natural-language-processing-in-education>
- [3] J. Hirschberg, B. W. Ballard, and D. Hindle, "Natural language processing," *AT&T Technical Journal*, Jan./Feb. 1988, vol. 67, no. 1, 1988.
- [4] A. Jain, "What is the role of NLP in voice assistants?" August 2024, https://www.analyticsinsight.net/nlp/what-is-the-role-of-nlp-in-voice-assistants#google_vignette
- [5] "How Google uses NLP to improve SERPs, featured Snippets & UX," <https://digitalguider.com/blog/what-is-google-nlp/>
- [6] X. Jiang et al., "Applications of natural language processing and large language models in materials discovery," *NPJ Computational Materials*, vol. 11, no.79, 2025.
- [7] "What is NLP? How it works, benefits, challenges, examples," June 2025, <https://www.shaip.com/blog/what-is-nlp-how-it-works-benefits-challenges-examples/>
- [8] A. Arif, "NLP in finance: Examining the impact of natural language processing in financial and banking services," July 2023, <https://www.johnsnowlabs.com/examining-the-impact-of-nlp-in-financial-services/>
- [9] "Natural language processing in education," February 2026, https://www.meeple.com/en_us/topics/natural-language-processing/natural-language-processing-in-education
- [10] <https://manus.im>
- [11] "Natural language processing (NLP) in language education," <https://classx.org/natural-language-processing-nlp-in-language-education/>
- [12] A. Whitten, "Designing natural language processing tools for teachers," October 2023, <https://ed.stanford.edu/news/designing-natural-language-processing-tools-teachers>
- [13] S. Vajjala et al., *Practical Natural Language Processing*. O'Reilly Media, 2020.
- [14] H. Lane and M. Dyshel, *Natural Language Processing in Action*. Manning Publications, 2nd edition, 2025.
- [15] S. K. Assayed (ed.), *Educational Applications of Natural Language Processing, Chatbots, and AI*. IGI Global, 2025.
- [16] E. C. K. Cheng, T. Wang, and T. Schlippe (eds.), *Artificial Intelligence in Education Technologies: New Development and Innovative Practices: Proceedings of 2024 5th International Conference on Artificial Intelligence in Education Technology*. Springer, 2024.
- [17] M. von Davier and V. Yaneva (eds.), *Advancing Natural Language Processing in Educational Assessment*. Taylor & Francis, 2023.



Figure 1 A representation of NLP [4].

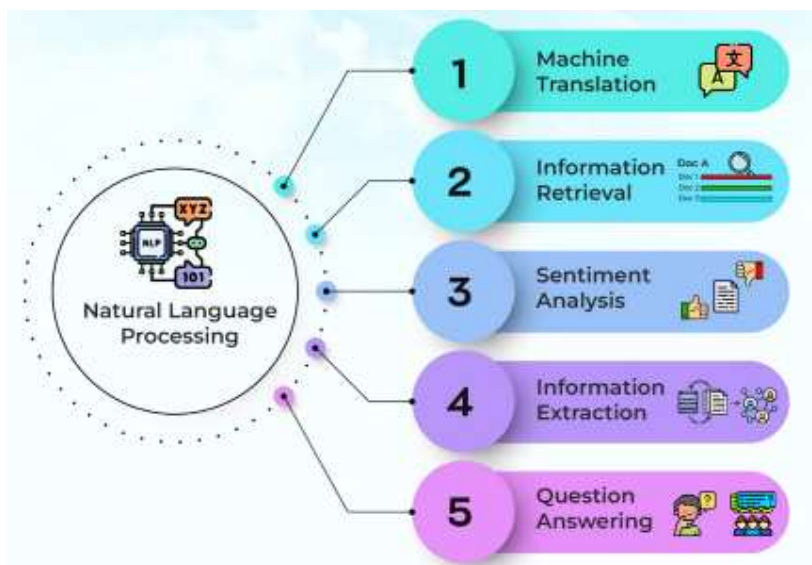


Figure 2 Different components of NLP [5].

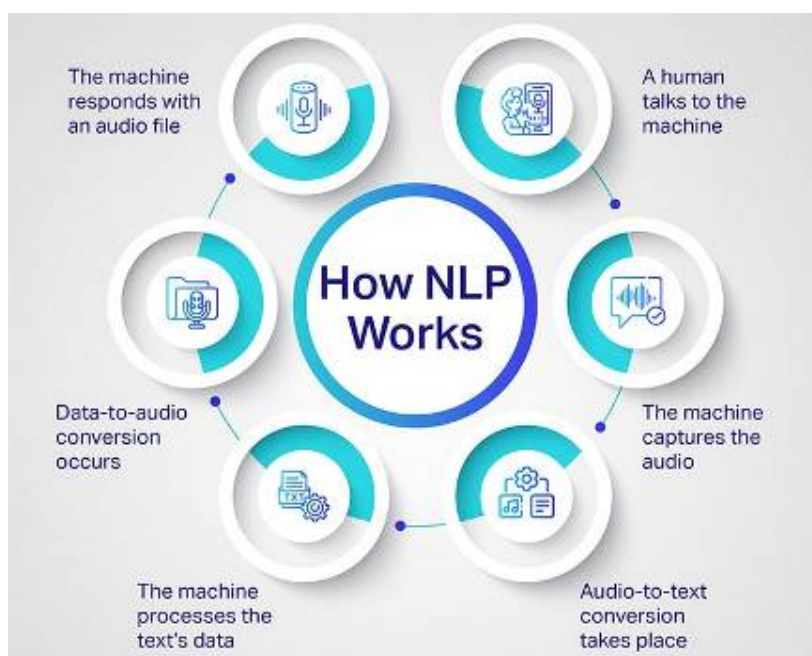


Figure 3 How NLP works [7].



Figure 4 Some applications of NLP [8].



Figure 5 A teacher tutoring some students [12].

Natural
Language
Processing
(NLP) in
Language
Education
AI
in Education



Figure 6 A representation of NLP in language education [11].