

Chapter 3

Natural Language Processing for Education



3.1 What Is NLP?

To make computers as intelligent as humans, natural language processing (NLP) is a subfield of computer science and artificial intelligence (AI) that focuses on teaching computers to comprehend written and spoken language (IBM 2022). Figure 3.1 gives a conceptual view of NLP.

Natural language processing (NLP) integrates statistical, machine learning, and deep learning models with computational linguistics (rule-based modeling of human language) (IBM 2022). These tools allow computers to “understand” human speech or written language, including people’s intent and sentiments.

Computer programs are powered by natural language processing, which enables them to translate text from one language to another, respond to voice requests, and quickly summarize massive quantities of material, often in real time. You may have interacted with NLP through voice-controlled GPS systems, digital assistants, speech-to-text dictation software, customer service chatbots, and other modern conveniences. On the other hand, natural language processing (NLP) is becoming increasingly important in enterprise solutions that aim to improve the efficiency of businesses by automating and standardizing routine but crucial tasks.

3.2 Using NLP for Educational Activities

Natural language processing technology has made a breakthrough in digital education possible. Today, natural language processing (NLP) is employed in the classroom for various purposes, including essay grading and feedback generation, question generation, example generation, etc. The use of NLP in online literacy initiatives is on the rise. It also has significant potential in print programs, where

Fig. 3.1 A conceptual view of natural language processing (NLP)

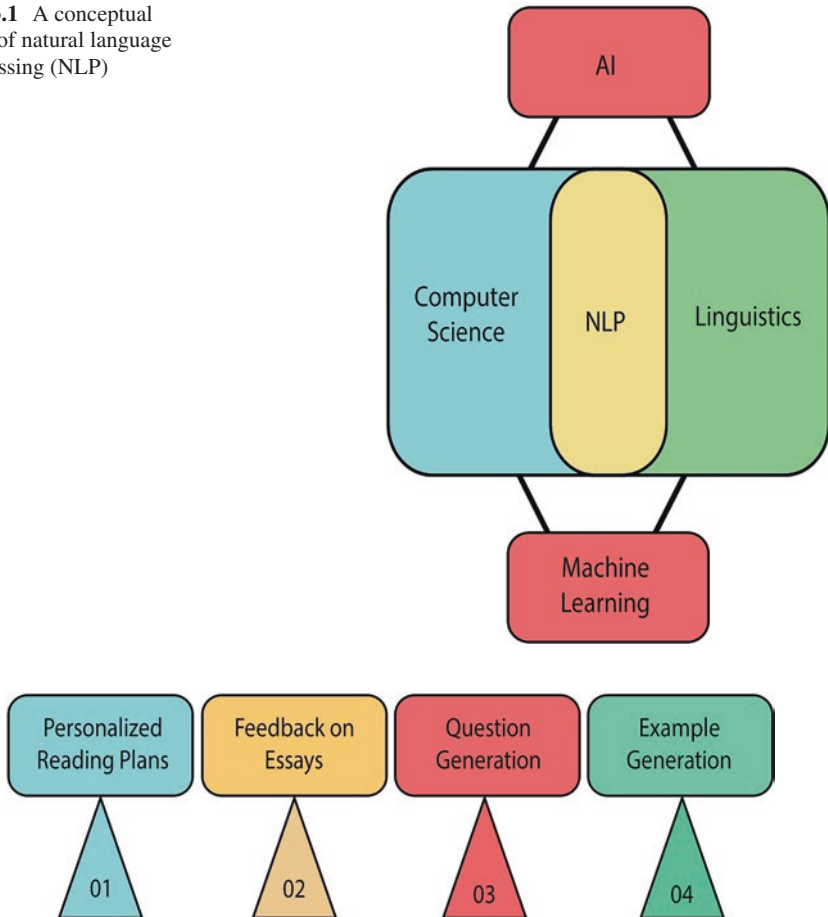


Fig. 3.2 Uses of NLP tools

printed products are crafted with the help of AI. There are newer, more complex NLP tools, many free and open-source (e.g., the latest Transformer NLP technology has several open-source models). We also note that neural technologies do human-like tasks on natural language data with significantly higher accuracy. Some good uses for natural language processing (NLP) tools (see Fig. 3.2) in the classroom (Patel 2021) include:

- *Personalized Reading Plans*: Using natural language processing (NLP) technology, we can provide students with reading materials more appropriate to their skill level. There is open text data on the Internet that can be used by natural language processing algorithms to determine the reading challenges of the text, allowing us to quickly and easily create software that provides students with appropriately graded reading materials.

- *Feedback on Essays:* OpenAI and similar platforms have enabled anybody to create software that provides students with objective and insightful feedback. The software may provide the student with direct, formative input. Training such systems would necessitate creative data collecting, but if done correctly, it might lead to novel applications that lessen the burden on educators.
- *Question Generation:* It is possible to create a wide range of test questions using preexisting learning resources. Despite the field's novelty, academic research has created standards for assessing the quality of Question Generation Models (e.g., see Mostow et al.), and several companies have attempted to commercialize this research.
- *Example Generation:* We can use natural language processing to generate criteria-based content. Using this technological prowess, we may produce worked instances of math problems, construct sentences illustrating multiple ways of using the same term, produce examples of how literature can be summarized, and so on.

3.3 Benefits and Uses of NLP in Education

Suppose you are an educator or tech guru. In that case, you might think this might be useful for enhancing the learning experience of a single student, teacher, parent, or tutor or streamlining a process at large-scale educational institutions, testing organizations, or government agencies. Regardless of what you are trying to do, expanding your knowledge of NLP's applications in education will help you hone your existing ideas and generate brand-new ones.

NLP Helps with Learning and Comprehension From early school to post-graduate study, pedagogy acknowledges that every student's learning process differs. For each student and subject, the rate of student learning varies. Some students have unique demands that call for various instructional strategies.

Although tailored learning is the best approach, there are not enough teachers or hours in the day to give each student what they need. Here is where your educational concept can use NLP to offer a personalized learning environment (Shiraly 2021).

Summarization and Paraphrasing You can incorporate summarizing and paraphrasing to improve reading comprehension in any educational content you create. A summary presents a condensed version of a chapter, article, or lecture that only includes vital concepts and facts. Paraphrasing communicates a summary using alternative words chosen for their reading level, simplicity, accuracy, the regional variety, dialect, or cultural sensitivity. Both traits benefit specialist disciplines like law and medicine, where students must quickly comprehend enormous amounts of knowledge.

Transformer neural networks have made this conceivable. The transformer architecture is a deep neural network with an attention layer system that allows it to

include higher-level intangible elements like semantics, tone, emotions, and long-range context dependencies.

Companies like Google and OpenAI have published transformer models like BERT, GPT-3, RoBERTa, and T5. These models contain latent representations of all human linguistic, cultural, and social conventions visible on the Internet. These models are often trained using web-scraping corpora.

These already-trained models are now absurdly simple to implement and fine-tune with the help of software libraries like spaCy and Hugging Face.

For example, summarization is a downstream job since it begins with a pre-trained model, to which specialized neurons are added and then retrained with data collected for the specific task. Transfer learning, or fine-tuning, refers to adapting a pre-trained, general model to a new application.

A specialized language model is developed by fine-tuning a model that has already been trained using data from the target domain. BioMEDical Natural Language Processing (NLP) Model (BioBERT) is one example, having been educated on the lexicon and syntax of biomedical journals. Regarding the law, LEGAL-BERT is the model for natural language processing technologies.

The first step in summarization and paraphrasing is to feed your training data into a language model to generate embeddings, which are internal data representations. Next, a sequence-to-sequence layer is added, and the whole process is fine-tuned with a summarizing/paraphrasing dataset.

Question Answering Essay-style assessments, quizzes, and flashcards are well-liked by students and teachers, but their manual preparation can be intimidating for teachers with heavy workloads.

Using NLP, you can have questions and answers created for your study materials. It also measures how well a student's written comments match the content of the course. A student's reading level and learning rate, among other factors, can be used to tailor the questions and assessment. Saves time for overworked educators by providing feedback on essay content across four key areas: grammar, structure, semantics, and logic.

A question-answering model can be analogous to a summarization model by adding a sequence-to-sequence layer to a pre-trained transformer model. The expected result is a sequence that corresponds to the input sequence (the question) and provides the correct response. A pre-trained base model and sequence-to-sequence layer assembly are fine-tuned using question-answer datasets from a particular field.

Questions concerning prions are a good test case for this Hugging Face biology question-answering approach. A cloud service like Amazon Kendra offers an alternate, less complicated deployment method for question-answering.

Chatbots Chatbots are another option, as they can function as robotic educators by answering queries and explaining concepts through conversational NLP.

Similar to the model developed for question answering, a sequence-to-sequence model is developed for speech recognition. When a student speaks, the system

transcribes what they say into text. The questions are sent into a question-answering model, which either provides answers or grades the student's work. Text-to-speech synthesis is then used to play back the results to the student.

The synthesized voice can be programmed to provide various human traits important to making a learner feel at ease, including enthusiasm, kindness, warmth, friendliness, and accent.

Chatbots can be implemented using cloud services like Amazon Lex and Google Dialogflow.

NLP Improves Writing and Assessment Writing about concepts aids in the consolidation of knowledge. When given constructive criticism and writing prompts, students are more likely to go deeper into a topic and gather more information about it. This is why essays and quizzes are common evaluation forms across the curriculum.

Unfortunately, teachers do not always have time to respond thoughtfully to students. Natural language processing (NLP) can provide immediate and detailed comments on each and every written assignment (Shiraly 2021). It assesses all the indicators that people assess. Poor spelling and grammar are the foundational issues. Finally, the sentence structure and clarity will be evaluated. The validity and reasonability of arguments are our next stop. Accurate language, free of ambiguities, is essential in higher education domains such as law and science.

To conclude, we evaluate the structure using criteria established by experts in the field. There is a specific format for writing legal documents. A standard format is expected for scientific papers. Natural language processing can do this in milliseconds, right before the student's eyes as they type.

You should investigate natural language processing (NLP) to enhance the quality of feedback and automated scale assessment in large-scale settings, such as testing agencies that evaluate numerous students. Educational apps that provide this feedback can help a single student, parent, or educator.

How Does It Work? Feedback and assessment are written using transformer-architecture models.

For automated essay grading, rudimentary spelling, grammar, and sentence structure standards are already built into the model. Students are asked to use a sequence-to-sequence approach to paraphrase their writing. The model's output may be compared to the original text, with your app drawing attention to any discrepancies and offering suggestions. All grammatical errors will be fixed in the final product.

For example, each new research paper in a discipline like science rests on the shoulders of numerous others. The purpose of a paper's citations is twofold: first, to show proper etiquette, and second, to create a foundational pyramid of assertions upon which to build new ones. Sentences from different papers can be linked together semantically to create a knowledge graph.

Graph transformers are an NLP tool that can analyze knowledge graphs to perform tasks like accuracy checking (Shiraly 2021). Dependencies between sentences

far apart on the knowledge graph can be encoded using graph transformer networks. Your software can provide instantaneous feedback to students when they make logical errors or failure to understand the assertions made in another paper properly.

NLP Benefits Language Learning NLP's third most common application is in the increasingly mainstream language learning activity.

Learning a new language begins with the fundamentals: reading, writing, and speaking the words of a second language by making connections between them and words you already know or images of the things you are familiar with. Learning the intricacies of a language's grammar and syntax requires extensive study of the language's written and spoken forms, literature, and culture.

Using natural language processing's (NLP) built-in language translation skills and making them more engaging through gaming, you may serve students and educators in various contexts worldwide with little more work. If your concept results in educational resources, the audience you will focus on is likely ESL students. In many instances, it is likely to be translated by hand into other languages. Though it may be unrealistic to translate your product into hundreds of languages, limiting your market to just one region could mean missing out on lucrative chances.

Some of the steps used in more advanced language learning can be simulated using NLP techniques (Shiraly 2021):

- Using natural language processing (NLP) and object detection, a smartphone camera stream can produce scene descriptions in a second language.
- Using conversational, natural language processing, speech recognition, and text-to-speech synthesis can facilitate communication with native speakers of different languages, allowing for the mutual acquisition of both.
- A student may read books published in a foreign language using natural language processing and optical character recognition. As the content is read, E-learning tools can show contextual information like part of speech, meaning, and synonyms.

How Does It Work? Given a sentence in the source language, a machine translation system generates an equivalent sentence in the target language using a sequence-to-sequence model.

If you feed a sentence into a model for a specific language, you will return some internal representation, called an embedding, for that language. However, the syntax and semantics of each language need to be recorded first. To accomplish this, we again turn to pre-trained language models like BERT and T5.

We can use these two linguistic models to train a sequence-to-sequence model on a translation dataset like Wikipedia. Native speakers of several languages produce identical pages on Wikipedia. They may not be direct translations of one another from dictionary to dictionary, but they share the same meaning. The sequence-to-sequence model is trained to connect one language's embeddings to another. The embeddings are infused with semantics. A complete sentence in the target language is produced as a result.

This strategy can help you reach a broader audience in more places with little more work.

3.4 Use Cases and Examples/Applications of NLP in Education

Natural language processing (NLP) is widely regarded as a game-changer that will impact education shortly. Solid evidence supports using natural language processing in the classroom (Rundell 2021). Students' reading and writing skills have significantly benefited from this technology, which is widely used successfully.

The advantages of NLP are beginning to shine, whether in the form of parsing and summarizing arguments inside writing, encouraging essay revisions, or simply refining a writer's prose. However, one fundamental question remains on the lips of many businesses, developers, and service managers.

Questions like "Who can gain the most from this technology?" and "What applications can make the most use of this technology?" are subsets of this central question. What other ways may this technology be put to use in the classroom? Please tell us the answer.

Using NLP or Writing Regarding helping children with their reading and writing, NLP is currently employed on the front lines of education (Rundell 2021). These are the most typical use cases for creating and analyzing NLP applications. Let us imagine a student handing in a five-paragraph essay for evaluation; the NLP language learning system can offer suggestions for improving it. This guidance is for more formal writing, including language, grammar, and format. Grammarly, a software that ensures error-free and well-organized writing, is an excellent application of NLP in the classroom. By employing the technology, the program analyzes the text and offers advice on how to enhance it.

In addition, natural language processing (NLP) can provide granular comments, such as pointing out where there is an absence of supporting evidence for a claim or statement in the text.

To make the most of the synergy between NLP and education, teachers must take advantage of the technology to get insight into their student's progress and development rather than simply using it to help students turn in higher-quality work.

More natural language processing (NLP) solutions will be required as technology develops to aid students and educators in defining the cognitive process of students' writing. This will lead to suggestions on enhancing fundamental aspects of students' writing, such as mechanics and structure.

Using NLP and Education for Improved Reading Some uses of natural language processing (NLP) in education can aid students with trouble with reading comprehension in the classroom (Rundell 2021). Since a single instructor cannot provide individual attention to each student in a classroom setting, natural language

processing (NLP) tools are in high demand. The algorithms used in natural language processing can rapidly detect weaknesses in a student's reading comprehension and offer immediate, personalized guidance on how to fix them.

Using natural language processing (NLP) in the classroom also has the beautiful effect of enabling students to be paired with books that are both demanding and conducive to optimal learning. Once again, educators lack time to research this area, so natural language processing technologies that can accomplish this are so welcome.

It has also been demonstrated that natural language processing technology can more accurately grade students' reading scores than conventional methods like the Flesch-Kincaid Grade Level test. This is another reason API-based solutions are gaining traction and being adopted by many enterprises.

Using NLP for Motivating Behavior One of a teacher's most challenging tasks is undoubtedly inspiring their students to put in the effort and grow as learners. It only takes one bored student to throw the entire class off track. We must do everything possible to keep our students interested and enthusiastic about learning.

For this reason, NLP has recently emerged as a promising tool in the classroom.

NLP machine learning technology can analyze classroom discourse to determine how individuals feel at different points in the lesson (Rundell 2021). Teachers can use this analysis to see how their students respond to the instruction techniques and what can be done to make the lessons more interesting.

Teachers can use NLP to identify students having trouble following along in class and suggest how to help them. This has created a need for natural language processing (NLP) monitoring tools to track and analyze students' attention and conduct in real time during class.

Natural language processing examples for education will need to be set up and evaluated to discover how effective this can be; however, stealth testing may be necessary for the most accurate results. Natural language processing (NLP) experts are probably looking into this. In the event of implementation, rules may need to be considered before these services can be offered for profit.

Nonetheless, when all of these factors are considered together, it is easy to see the many beautiful opportunities that NLP technology, and artificial intelligence in education in general, can bring into the world of education, whether it be in the form of active feedback to students and teachers on the quality of the work being produced or in the form of looking into more complex things like the behavior of students, their level of engagement within the classroom learning environment and setting, and their overall academic performance.

Opportunities for businesses to develop natural language software and solutions are opening up in these spaces. Once the benefits have been demonstrated (something happening more frequently and is being worked on constantly), this will be a thriving industry and line of technology.

Question Answering Essay tests, quizzes, and flashcards are popular with students and educators alike, but their manual preparation can burden those with

packed schedules (Rundell 2021). In order to help you out, NLP may generate questions and answers for your course materials. It saves teachers much time because it can evaluate an essay's syntax, structure, semantics, and reasoning. The accuracy with which a student's written comments match the facts presented in the course material can also be assessed in this manner. For example, a student's reading level and learning pace could be used to modify the questions and the assessment.

In the same manner that a summarization model is created by adding a sequence-to-sequence layer to a pre-trained transformer model, a question-answering model is created. In response to a given sequence (the query), it should generate still another sequence (the answer). Subject-specific question-answer datasets fine-tune the pre-trained base model and sequence-to-sequence layer assembly.

Chatbots Conversational artificial intelligence (AI) chatbots are another perk (Rundell 2021) because they can function as robotic teachers. The construction of a sequence-to-sequence model for voice recognition is analogous to that of a question-answering model. The process starts with a literal transcription of the student's spoken input.

Next, a question-answering model will produce answers or grade the student's work. The student is then given a spoken report using text-to-speech synthesis. To put the learner at ease, the synthesized voice can be programmed with affable qualities like excitement, kindness, warmth, friendliness, and accent.

3.5 Conclusion

Natural language processing (NLP) can be a powerful tool for enhancing the classroom experience when applied correctly. When NLP is used in classrooms, it kick-starts learning through natural acquisition. The foundation of this system is proven methods that have been used successfully to address a wide range of educational challenges. Regarding the broader societal and cultural issues affecting language acquisition, natural language processing is a go-to solution provider. This method can benefit teachers, students, authors, and academics because it facilitates research, analysis, and evaluation. In addition to its many applications in research, science, linguistics, e-learning, and assessment systems, natural language processing has also shown promising results in more traditional educational institutions like K-12 and higher-ed institutions.

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