

Natural Language Processing in Teacher Training : A Systematic Review

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Abstract: In the previous decade, there has been a growing interest within the research community to apply artificial intelligence (AI), particularly natural language processing (NLP) technology, across various domains such as law, medicine, and finance. More recently, the focus has shifted towards exploring the potential of NLP technology in education, specifically in teacher training. Thus, it becomes crucial to conduct a systematic literature review to comprehensively examine the literature on the use of NLP technology in teacher training. This study concentrates on the applications and use cases of NLP technology in higher education institutions and educational research institutions. Our analysis suggests that significant NLP applications in education include Language Learning, intelligent analysis, assistive technology, automatic content analysis, and speech emotion analysis. Further examination reveals that NLP technology can be effectively utilized to improve teachers' professional abilities, such as helping language teachers improve their accents, ultimately contributing to the delivery of high-quality education. Finally, this paper summarizes the critical lessons learned from the application of NLP technology in teacher training that can guide future research endeavors in this rapidly evolving field.

Keywords: natural language processing, artificial intelligence, teacher training, educational innovation

1. Introduction

In recent years, Natural Language Processing (NLP) has emerged as an important artificial intelligence technology that has had significant impacts in various fields including medicine, finance, law, industry, and entertainment [1]. Education is no exception, and researchers are increasingly exploring the applications of NLP in intelligent education management, language learning and teaching, assessment design, and learning analytics [2]. Teacher training is a crucial aspect of education that can benefit from NLP-based solutions to improve the quality of education and support student learning [3]. However, there is a lack of comprehensive and systematic reviews on the use of NLP technology in teacher training [4]. The use of NLP-based applications in teacher training is growing rapidly worldwide, particularly in teacher training [5]. Researchers are actively engaged in NLP research and have begun implementing NLP-based solutions to train teachers and improve the quality of education, as well as to better support student learning [6].

However, applying NLP technology in teacher training faces several challenges, such as the high threshold for AI technology use and the difficulty in data collection [7]. NLP-based applications are

being introduced in online teacher training to enhance language teachers' oral proficiency, foster collaboration among teachers for research purposes, and establish effective classroom evaluation standards, despite the challenges involved [8]. These applications use AI algorithms and large educational datasets to improve the quality of teacher training, which is beneficial not only for teachers and students, but also for administrators and decision-makers in fulfilling their duties more effectively and efficiently [9]. However, there is currently no comprehensive organization to compile various research results for researchers, educational administrators, and policy makers to reference. Therefore, this study aims to provide a comprehensive and critical review of NLP technology-related research results to identify innovations that support high-quality teacher training.

This study aims to provide a conceptual review that systematically maps the research background of NLP technology in teacher training, including the current state of research in this field. In the article, we describe the research methods, then discuss the findings and conclusions. Finally, we draw some conclusions. What NLP-based applications are being utilized by teacher training institutions, and how are they being employed?

2. Background

2.1. Natural Language Processing

Natural Language Processing (NLP) is a branch of computer science that aims to enable machines to understand, interpret, and generate human language [10]. NLP has a long and rich history that dates back to the 1950s, when researchers first explored the possibility of creating computer systems that could handle human language. Since then, the field has witnessed many groundbreaking developments, such as the establishment of generative grammar by Noam Chomsky in his influential work "Syntactic Structures" [11]. Despite the early challenges of computing power and data availability, NLP made significant advances in the late 1980s with the advent of machine learning algorithms. In particular, Yoshio Bengio and his team developed neural network language models, which had a profound impact on the field [12]. Rule-based systems and statistical models were also applied, enabling NLP systems to learn from large amounts of data.

The combination of abundant digital text data, advancements in deep learning techniques, and the emergence of neural network architectures like Transformers and pre-trained models such as BERT has propelled the progress of NLP, revolutionizing the field and enabling the development of various NLP tasks, including ChatGPT [13]. With these advances, NLP systems have become capable of performing complex tasks with high accuracy, including natural language understanding, question answering, and text generation [10]. Despite these advances, human language analysis and understanding systems continue to be developed. The goal is to create systems capable of performing tasks such as language translation, summarization, and conversation generation with high precision, ultimately enhancing communication between humans and machines [14].

2.2. NLP in Teacher Training

Since the advent of computers in the education sector, the application of natural language processing (NLP) technology in education has emerged, focusing on the development of NLP-based instructional environments, such as sentiment analysis, entity recognition, text summarization, and topic modeling systems [15]. These systems have greatly enhanced the text data processing and analysis capabilities in education. At present, the education sector has been profoundly affected by NLP research, and NLP technology has been utilized by researchers and educators, with various tools, algorithms, and applications showing the potential to transform the field of education [2].

Natural Language Processing (NLP) is an energetic and interdisciplinary realm of computer sci-

ence research [16]. NLP's capability to leverage technical innovations and drive educational innovation, along with its interdisciplinary approach, is crucial for enhancing educational efficiency, quality, and cultivating diverse teacher development, exploring multi-level evaluation systems, and optimizing traditional education [17]. NLP holds the potential to facilitate lasting transformations in various aspects of teacher training, including professional development, teaching evaluation, and university and educational institution management. The integration of Natural Language Processing with various educational backgrounds, such as research, science, linguistics, e-learning, and evaluation systems, has resulted in positive outcomes in other educational contexts [18]. NLP can be applied in three ways in teacher training: (a) to train language teachers through the use of NLP components, such as Language MuseSM, to support their knowledge, awareness, practice, and application [19]; (b) to optimize the BP neural network method for constructing the CETE (College English Teaching Evaluation) system model, which quantifies teacher evaluation indicators as inputs and outputs teaching effectiveness [20]; (c) to provide information to decision-makers at the institutional and national levels through the use of AI (including NLP technology) to identify research patterns of different departments or universities [9]. Additionally, Owoc et al. suggest that NLP can benefit teacher training in several ways, such as automating repetitive and time-consuming tasks such as grading and recording teacher attendance, collecting teacher opinions through NLP-based chatbots to provide feedback to development institutions, and providing spaced repetition and knowledge correction for participating teachers [21].

3. Methodology

This article presents a comprehensive literature review on the utilization of NLP technology in teacher training, utilizing a systematic review approach. This methodology involves a rigorous and replicable search strategy, guided by pre-determined inclusion and exclusion criteria, to investigate previous research studies and address specific research questions [22]. By consolidating empirical evidence from prior research, a systematic review allows for a comprehensive understanding of the progress made in a particular research field, and provides insights into general research questions. Given the recent proliferation of relevant literature, a systematic review is an appropriate method for capturing crucial information regarding the impact of NLP applications on teacher training.

In order to investigate the application of natural language processing (NLP) in the field of teacher training and education over the past decade, we conducted a literature search in Google Scholar and CNKI (China National Knowledge Infrastructure). We used the following keywords for the search in both databases: teacher training, teacher education, NLP, natural language processing. The search was limited to the period between 2012 and 2022. In Google Scholar, we used the advanced search option to search for articles' titles and abstracts, and manually checked the references and related citations of the articles. In CNKI, we used the advanced search function and selected "journal papers" and "conference papers" as the document types, and restricted the publication time and language of the search results. We retrieved all search results and used the following inclusion criteria when screening articles: (1) containing content related to teacher training or education; (2) containing content related to NLP or related fields; (3) containing data related to NLP applications in educational institutions and universities. The search strategy and inclusion criteria were designed to ensure the relevance and quality of the selected articles.

In the initial phase of our research, we conducted a comprehensive search of the databases using title, abstract, and keywords, which resulted in a total of 1483 articles. However, to ensure the relevance of the selected articles to our research questions, we applied inclusion and exclusion criteria and further refined our search strategy. As a result, the number of potential papers was reduced to 187. We then conducted a thorough screening of the abstracts and removed 157 articles that were deemed irrelevant based on our inclusion and exclusion criteria, including conceptual papers, opinion pieces,

review articles, and higher education content that did not pertain to teacher training, but rather focused on historical and cultural changes. Finally, we selected 30 published articles that met our inclusion criteria for further analysis. This rigorous selection process ensured the quality and relevance of the selected articles and contributed to the validity and reliability of our study.

4. Results and Discussion

What NLP-based applications are being utilized by teacher training institutions, and how are they being employed? Several NLP applications have been implemented in higher education worldwide [23]. However, in teacher education, these applications have distinct characteristics. NLP applications are frequently not utilized in isolation within teacher training settings; rather, multiple technologies are typically combined, and some NLP applications are integrated with deep learning [24]. The following section categorizes the main application areas of NLP technology.

4.1. Sentiment Analysis

Sentiment analysis (SA), a natural language processing (NLP) technique, identifies the emotional tone behind text [25]. In education, student feedback is crucial for evaluating and analyzing learning management systems, teaching, instructional procedures, and courses. In teacher training, student feedback helps teachers improve their teaching [26]. The use of SA to analyze feedback is an increasingly common experiment in the field. For example, Guadalupe et al. developed SocialMining, a model that uses a Spanish comment corpus to evaluate teacher performance [27]. Mireia Usart et al. designed and evaluated a gender-sensitive SA method to characterize the emotional atmosphere of teacher trainees in online courses and improve their learning [28]. Somdeep Das et al. investigated the feedback module of an online learning management system (OLMS) and found that combining machine learning algorithms and NLP techniques with OLMS data can improve teaching efficiency [29].

4.2. Language Learning

NLP techniques are widely utilized in language learning to analyze and comprehend language structure, meaning, and context [30]. NLP applications in language learning include machine translation, sentiment analysis, text summarization, speech recognition, and language modeling. Moreover, a comprehensive language learning system that integrates multiple NLP techniques assists language teachers in enhancing their skills, awareness, and practices [31]. For instance, JILL BURSTEIN et al. used Language MuseSM (LM), a web-based application based on NLP, to raise language awareness among teachers and support them in designing language-based instructional support for English language learners (ELLs) [32]. Meanwhile, Jin Xu and Tong Li researched the application of multimodal NLP guidance and speech recognition technology in English oral practice [33]. Pascual Pérez-Paredes et al. studied the role of mobile-assisted language learning (MALL), data-driven learning (DDL), and natural language processing technology (NLPT) as open educational resources (OERs) in second language education [34]. In addition, some studies focused on the combined application of NLP technology and machine learning or deep learning, such as Zhiling Yang et al.'s study on using NLP and DL technology to improve English teaching effectiveness [35].

4.3. Assistive Teaching Technology (Chatbots)

NLP-based chatbots have become commonplace on various platforms, including social networks, websites, and mobile devices. These AI applications provide natural and personalized interaction for users through text or voice [36]. NLP-based chatbots have been widely used in customer service,

education, entertainment, and healthcare, improving efficiency and user experience [37]. They have also been effectively applied in teacher training. For example, Saptarshi Bhowmik et al. developed a chatbot that can program virtual student agents for simulating real STEM classroom environments, enabling pre-service teachers to practice classroom discourse and management [38]. Debajyoti Datta et al. created an open-source conversational agent system that allows pre-service teachers to participate in a specific math scenario and provide feedback on their questioning strategies [39]. Debajyoti Datta et al. also constructed a text-based interactive dialogue agent that helps teachers practice their math questioning skills according to a famous teaching quality assessment [40].

4.4. Computer-based Classification System

Computer-based classification systems use software to sort data or objects by their features [41]. These systems often apply natural language processing (NLP) to handle and analyze text data, such as sentiment analysis, topic modeling, and text classification. NLP methods can enhance the accuracy and efficiency of classification tasks and are useful for teacher training [42]. For instance, Peter Wulff and colleagues trained a computer classifier with NLP and machine learning to categorize written reflections of physics teachers in training on their teaching behaviors in a German university program and provide them with data-driven feedback [43]. Javier Leung et al. used NLP to examine the practical knowledge shared among instructional design and technology (IDT) professionals in four Facebook groups. Their goal was to understand the features and functions of practical knowledge in online communities and offer methods and suggestions for developing teacher training support tools [44]. Wenwen Tian and Stephen Louw's research was based on a strength-based coaching model and explored how the appreciation and advice (AA) feedback practice was used in a teacher training course. The study contributed to teacher training feedback practices by emphasizing the importance of a positive attitude towards professional development for both trainers and trainees [45].

4.5. NLP-based Artificial Intelligence Scoring System

The NLP-based Artificial Intelligence Scoring System is a powerful tool that can be used in various educational settings [46]. For example, Wei Wang et al. conducted experiments on intelligent English teaching assessment based on machine learning in the field of natural language processing [47]. Similarly, Nazaretsky et al. explored the potential of using NLP technology to analyze the performance of teachers and simulated students' interactions in order to evaluate the performance of teachers. These models can also support formative feedback, making them valuable tools for improving teaching quality [48].

Moreover, the NLP-based Artificial Intelligence Scoring System not only has the ability to score scorecards but also offers explanations for the scores that are comparable to those provided by human evaluators [49]. This feature can be especially helpful for teachers and students who need feedback on their work. Furthermore, Zhao Chengling et al. used NLP and content analysis to code and analyze teacher teaching behavior, and found a positive correlation between certain teaching behaviors and learners' course evaluation [50]. These findings suggest that the NLP-based Artificial Intelligence Scoring System has the potential to provide valuable insights into teaching effectiveness and student performance.

5. Conclusions

This systematic review explores how natural language processing (NLP) technology can be used to improve teacher training. NLP technology has been widely used in various fields [51], but its application in teacher education is still relatively limited. However, some higher education institutions around the world have started to use NLP-based applications to address various challenges in teacher

education. This study emphasizes the importance of understanding the potential benefits of NLP technology for teacher education and raising awareness among stakeholders. The results show that NLP technology is mainly used for five purposes: Language Learning, automated content analysis, sentiment analysis, text summarization, and chatbot-style teaching assistants. These applications have shown good results in enhancing teacher capabilities, improving classroom teaching outcomes, and promoting teacher job evaluations. However, there are still some challenges for applying NLP technology in teacher education, such as teachers' lack of NLP expertise and the need for more research on the effects of NLP applications in different environments. Overall, this study provides evidence-based insights into the potential of NLP technology for teacher education and highlights the need for further research in this field.

One concern that study reviews in this area have shown a lack of attention to ethics and data privacy, with few studies obtaining ethical clearance. This highlights the need to establish protocols for personal data protection during the collection and analysis of educational data. As Siemens argued, ethics and privacy are critical issues in education research, especially when using emerging technologies like NLP [52]. Stakeholders should address these privacy concerns and ensure that NLP technology is used ethically and responsibly in teacher education. Otherwise, they could risk violating privacy and causing harm to individuals. Therefore, it is crucial for researchers, educators, and policymakers to prioritize the development of appropriate guidelines and safeguards to protect individuals' privacy when using NLP-based applications in teacher education.

This review has explored how Natural Language Processing (NLP) technology can be used to improve teacher training in various ways. The main findings are that: (a) NLP technology can enhance educational innovation by increasing people's understanding of its potential; (b) NLP applications can address diversity issues in teacher training, instruction, and assessment; (c) NLP applications can improve the quality of teacher training by providing feedback, guidance, and support. In conclusion, this review highlights the need for more education stakeholders and decision-makers to engage with and appreciate the benefits of NLP technology for teacher training.

References

- [1] Amisha, Malik, P., Pathania, M., & Rathaur, V. K. (2019). Overview of artificial intelligence in medicine. *Journal of family medicine and primary care*, 8(7), 2328–2331.
- [2] Chen, X., Xie, H., Zou, D., & Hwang, G. J. (2020). Application and theory gaps during the rise of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 1, 100002.
- [3] Rayati, M. (2021). Neuro-Linguistic Programming and Its Applicability in EFL Classrooms: Perceptions of NLP-Trained English Teachers. *Language Teaching Research Quarterly*, 24, 44-64.
- [4] Ouyang, F., Zheng, L., & Jiao, P. (2022). Artificial intelligence in online higher education: A systematic review of empirical research from 2011 to 2020. *Education and Information Technologies*, 27(6), 7893-7925.
- [5] Kessler, G., & Hubbard, P. (2017). Language teacher education and technology. *The handbook of technology and second language teaching and learning*, 278-292.
- [6] Litman, D. (2016, March). Natural language processing for enhancing teaching and learning. In *Proceedings of the AAAI conference on artificial intelligence (Vol. 30, No. 1)*.
- [7] Gruetzemacher, R. (2022, April 19). *The Power of Natural Language Processing*. Harvard Business Review.
- [8] Kessler, G., & Hubbard, P. (2017). Language teacher education and technology. *The handbook of technology and second language teaching and learning*, 278-292.
- [9] Salas-Pilco, S. Z., & Yang, Y. (2022). Artificial intelligence applications in Latin American higher education: a systematic review. *International Journal of Educational Technology in Higher Education*, 19(1), 1-20.
- [10] IBM. (2020, December 15). What is natural language processing? Retrieved from <https://www.ibm.com/topics/natural-language-processing>
- [11] Foote, K. D. (2019). A brief history of natural language processing (nlp). *DATAVERSITY*, May, 22.
- [12] Bengio, Y., Ducharme, R., & Vincent, P. (2000). A neural probabilistic language model. *Advances in neural information processing systems*, 13.
- [13] Wang, X., Zhao, Y. & Pourpanah, F. (2020)Recent advances in deep learning. *Int. J. Mach. Learn. & Cyber.* 11, 747–750.

- [14] Wu, X., Xiao, L., Sun, Y., Zhang, J., Ma, T., & He, L. (2022). A survey of human-in-the-loop for machine learning. *Future Generation Computer Systems*.
- [15] Shaik, T., Tao, X., Li, Y., Dann, C., McDonald, J., Redmond, P., & Galligan, L. (2022). A review of the trends and challenges in adopting natural language processing methods for education feedback analysis. *IEEE Access*.
- [16] Zaharia, C., Reiner, M., & Schütz, P. (2015). Evidence-based neuro linguistic psychotherapy: a meta-analysis. *Psychiatria Danubina*, 27(4), 0-363.
- [17] Lee, H. S., & Lee, J. (2021). Applying artificial intelligence in physical education and future perspectives. *Sustainability*, 13(1), 351.
- [18] Alhawiti, K. M. (2014). Natural language processing and its use in education. *International Journal of Advanced Computer Science and Applications*, 5(12).
- [19] Burstein, J., Shore, J., Sabatini, J., Moulder, B., Lentini, J., Biggers, K., & Holtzman, S. (2014). From Teacher Professional Development to the Classroom: How NLP Technology Can Enhance Teachers' Linguistic Awareness to Support Curriculum Development for English Language Learners. *Journal of Educational Computing Research*, 51(1), 119–144.
- [20] Zuo, F., & Zhang, H. (2022). College English teaching evaluation model using natural language processing technology and neural networks. *Mobile Information Systems*, 2022.
- [21] Owoc, M.L., Sawicka, A., Weichbroth, P. (2021). Artificial Intelligence Technologies in Education: Benefits, Challenges and Strategies of Implementation. In: Owoc, M.L., Pondel, M. (eds) *Artificial Intelligence for Knowledge Management. AI4KM 2019. IFIP Advances in Information and Communication Technology*, vol 599. Springer, Cham.
- [22] Kitchenham, B., Brereton, O. P., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009). Systematic literature reviews in software engineering—a systematic literature review. *Information and software technology*, 51(1), 7-15.
- [23] Shinde, P. P., & Shah, S. (2018, August). A review of machine learning and deep learning applications. In 2018 Fourth international conference on computing communication control and automation (ICCUBEA) (pp. 1-6). IEEE.
- [24] Deng, L., Liu, Y. (2018). A Joint Introduction to Natural Language Processing and to Deep Learning. In: Deng, L., Liu, Y. (eds) *Deep Learning in Natural Language Processing*. Springer, Singapore.
- [25] Bansal, M., Verma, S., Vig, K., Kakran, K. (2022). Opinion Mining from Student Feedback Data Using Supervised Learning Algorithms. In: Chen, J.I.Z., Tavares, J.M.R.S., Shi, F. (eds) *Third International Conference on Image Processing and Capsule Networks. ICIPCN 2022. Lecture Notes in Networks and Systems*, vol 514. Springer, Cham.
- [26] Elfeky, A. I. M., Masadeh, T. S. Y., & Elbyaly, M. Y. H. (2020). Advance organizers in flipped classroom via e-learning management system and the promotion of integrated science process skills. *Thinking Skills and Creativity*, 35, 100622.
- [27] Esparza, G.G. et al. (2018). A Sentiment Analysis Model to Analyze Students Reviews of Teacher Performance Using Support Vector Machines. In: Omatu, S., Rodríguez, S., Villarrubia, G., Faria, P., Sitek, P., Prieto, J. (eds) *Distributed Computing and Artificial Intelligence, 14th International Conference. DCAI 2017. Advances in Intelligent Systems and Computing*, vol 620. Springer, Cham.
- [28] Usart, M., Grimalt-Álvaro, C. & Iglesias-Estradé, A.M. (2023) Gender-sensitive sentiment analysis for estimating the emotional climate in online teacher education. *Learning Environ Res* 26, 77–96.
- [29] Das, S., Roy, S., Bose, R., Acharjya, P. P., & Mondal, H. (2022, May). Analysis of Student Sentiment Dynamics to Evaluate Teachers Performance in Online Course using Machine Learning. In 2022 International Conference on Applied Artificial Intelligence and Computing (ICAAIC) (pp. 668-673). IEEE.
- [30] Maulud, D. H., Zeebaree, S. R., Jacksi, K., Sadeeq, M. A. M., & Sharif, K. H. (2021). State of art for semantic analysis of natural language processing. *Qubahan Academic Journal*, 1(2), 21-28.
- [31] Amaral, L., & Meurers, D. (2011). On using intelligent computer-assisted language learning in real-life foreign language teaching and learning. *ReCALL*, 23(1), 4-24.
- [32] Burstein, J., Shore, J., Sabatini, J., Moulder, B., Lentini, J., Biggers, K., & Holtzman, S. (2014). From Teacher Professional Development to the Classroom: How NLP Technology Can Enhance Teachers' Linguistic Awareness to Support Curriculum Development for English Language Learners. *Journal of Educational Computing Research*, 51(1), 119–144.
- [33] Xu, J., & Li, T. (2022). Application of Multimodal NLP Instruction Combined with Speech Recognition in Oral English Practice. *Mobile Information Systems*, 2022.
- [34] Pérez-Paredes, P., Ordoñana Guillamón, C., & Aguado Jiménez, P. (2018). Language teachers' perceptions on the use of OER language processing technologies in MALL. *Computer Assisted Language Learning*, 31(5-6), 522-545.
- [35] Yang, Z. (2022). Natural Language Enhancement for English Teaching Using Character-Level Recurrent Neural Network with Back Propagation Neural Network based Classification by Deep Learning Architectures. *JUCS: Journal of Universal Computer Science*, 28(9).
- [36] Sarker, I. H., Hoque, M. M., Uddin, M. K., & Alsanoosy, T. (2021). Mobile data science and intelligent apps: concepts, AI-based modeling and research directions. *Mobile Networks and Applications*, 26, 285-303.

- [37] Borsci, S., Malizia, A., Schmettow, M., Van Der Velde, F., Tariverdiyeva, G., Balaji, D., & Chamberlain, A. (2021). *The Chatbot usability scale: The design and pilot of a usability scale for interaction with AI-based conversational agents. Personal and Ubiquitous Computing.*
- [38] Bhowmik, Saptarshi & Barrett, Alex & Ke, Fengfeng & Yuan, Xin & Southerland, Sherry & Dai, Chih-Pu & West, Luke & Dai, Zhaihuan. (2022). *Simulating students: An AI chatbot for teacher training.*
- [39] Datta, D., Phillips, M., Bywater, J. P., Chiu, J., Watson, G. S., Barnes, L., & Brown, D. (2021, April). *Virtual pre-service teacher assessment and feedback via conversational agents. In Proceedings of the 16th workshop on innovative use of NLP for building educational applications (pp. 185-198).*
- [40] Datta, D., Phillips, M., Bywater, J. P., Chiu, J., Watson, G. S., Barnes, L. E., & Brown, D. E. (2021). *Improving mathematical questioning in teacher training. arXiv preprint arXiv:2112.01537.*
- [41] Sun, Z., & Stranieri, A. (2021). *The nature of intelligent analytics. In Z. Sun (Ed.), Intelligent analytics with advanced multi-industry applications. IGI Global.*
- [42] Zuo, F., & Zhang, H. (2022). *College English teaching evaluation model using natural language processing technology and neural networks. Mobile Information Systems, 2022.*
- [43] Wulff, P., Buschhüter, D., Westphal, A., Nowak, A., Becker, L., Robalino, H., ... & Borowski, A. (2021). *Computer-based classification of preservice physics teachers' written reflections. Journal of Science Education and Technology, 30, 1-15.*
- [44] Leung, J. (2022). *Examining the Characteristics of Practical Knowledge From Four Public Facebook Communities of Practice in Instructional Design and Technology. IEEE Access, 10, 90669-90689.*
- [45] Tian, W., & Louw, S. (2020). *It's a win-win situation: implementing Appreciative Advising in a pre-service teacher training programme. Reflective Practice, 21(3), 384-399.*
- [46] Rahman, M., & Siddiqui, F. H. (2020). *NLP-based automatic answer script evaluation (Doctoral dissertation, DUET Journal).*
- [47] Wang, W. (2022). *Machine Learning-Based Intelligent Scoring of College English Teaching in the Field of Natural Language Processing. Computational Intelligence and Neuroscience, 2022.*
- [48] Nazaretsky, T., Mikeska, J. N., & Beigman Klebanov, B. (2023, March). *Empowering Teacher Learning with AI: Automated Evaluation of Teacher Attention to Student Ideas during Argumentation-focused Discussion. In LAK23: 13th International Learning Analytics and Knowledge Conference (pp. 122-132).*
- [49] Ghosh, S., & Fatima, S. S. (2008, November). *Design of an Automated Essay Grading (AEG) system in Indian context. In TENCON 2008-2008 IEEE Region 10 Conference (pp. 1-6). IEEE.*
- [50] Zhao, C. L., Hu, P., Ling, Y. Z. M., Jiang, Z. H., & Huang, Y. anf Shu, FF (2019). *Using NLP opinion mining to study teaching behaviors in open online courses. Distance Edu. China, 556, 62-70.*
- [51] Chen, X., Alexopoulou, T. & Tsimpli, I. (2021) *Automatic extraction of subordinate clauses and its application in second language acquisition research. Behav Res 53, 803–817.*
- [52] Siemens, G. (2019). *Learning analytics and open, flexible, and distance learning. Distance Education, 40(3), 414-418.*