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How Language and Technology Can Improve Student Learning Quality in Engineering? Definition, Factors for Enhancing Students Comprehension, and Computational Bibliometric Analysis

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Abstract
The research aims to review developments in language and technology research that can improve the quality of teaching and learning in engineering. Several factors that can influence the teaching and learning process are explained, supported by a bibliometric analysis (with keywords "Language" AND "Engineering Learning" from Google Scholar from 2020 to 2022). The review includes the definition of engineering education with technology's advantages in engineering education. We also explained about purpose and service of language with what considerations in making strategies in language and technology for teaching and learning engineering education. Explanations about formal and informal learning as well as education level to learn engineering and curriculum development were also added. The application of technology in media and laboratories is also the main factor in improving literacy and language's impact on students. All

factors cannot be separated from language and student characteristics, motivation, teacher-student relationships, therapy, and psychological condition. We also added information regarding language barriers for students with special needs and new language-improving technology for teaching. The results of the co-occurrence analysis expressed several points to be considered, including children, mathematics, STEM, education, and educators' terms. Thus, it obtained that the principle of engineering education refers to the process of teaching and learning about scientific concepts, principles, and practices, and technology plays an important role because it is closely related to scientific principles and investigative methods. Language has an important role in supporting students' understanding and abilities in this subject since it conveys learning information. This paper can be used as a reference for educators to understand current conditions regarding the importance of language in the teaching and learning in the engineering field.

Keywords: Bibliometric; computer science engineering; language; learning; technology

Introduction

Education is the process of learning a group of people about knowledge, skills, and habits that are passed on from one generation to the next through training, coaching, and research (Rosilah, 2016; Morbo, 2021; Yanti & Syahrani, 2021; Kusumawati, 2019; Hermawan, 2019; Mardani & Padmadewi, 2020; Sukmara, 2021; Haristiani & Oktarina, 2021; Aisyah & Nurjaleka, 2022; Husna & Febriyanti, 2022; Sesefanakh & Febriyanti, 2022; Maheswara et al., 2022) Education is a conscious effort to create a teaching and learning environment that supports the development of students' potential (Wirawan et al., 2018; Ammatulloh et al., 2022; Kamaruddin et al., 2014; Sutiyarti et al., 2019; Hermawan, 2019; Judiasri et al., 2019; Mardani et al., 2020; Rifai et al., 2020; Sukmara, 2021; Buhori & Karnawati, 2022). Students must show interest in learning on their own to improve these abilities (Hashim et al., 2021; Fadillah & Maryanti, 2021; Putri et al., 2021; Kamila & Sakti, 2022; Ardiana et al., 2022; Nafilah & Sakti, 2022; Triarisanti & Purnawarman, 2019).

The use of technology in the learning process is one way to increase students' interest in learning (Al Husaeni et al., 2022a; Supriadi & Sa'ud, 2017; Arrasyid et al., 2019; Sarah, 2022). However, apart from the use of technology, good and correct use of language is also an aspect that needs to be paid attention to. Technology acts as a means to accelerate the transfer of knowledge (Carayannis et al., 2006; Yani et al., 2019; Supriadi & Sa'ud, 2017). Meanwhile, language is a medium for delivering knowledge or information from teachers to students (Triyanto et al., 2019).

Language is one of the important aspects in the realm of teaching, thinking, and understanding in various learning subjects (Nugraha et al., 2022). Several studies explain the emphasis on the importance of language in studying science, including engineering. In engineering learning, understanding the language and the ability to communicate is very important, whether in terms of understanding technical concepts, collaborating with a team, or explaining technical solutions to others. In education, the use of language is very important, especially for teachers and students. For example, the use of L1 can be beneficial for escalating students' understanding of learning other languages (Sundari & Febriyanti, 2021; Cakrawati, 2019). Teachers must be aware that language problems involve more than just technical terms and symbols, and know the areas where students experience difficulties. Language, like any subject, is essential for learning and thinking, visualization, and understanding (Haristiani & Oktarina, 2021).

Engineering is often considered a complex and challenging subject (Dim et al., 2005). Language has an important role in supporting students' understanding and abilities in this subject. Students must be made aware that language mastery and learning cannot be separated because understanding is very dependent on language mastery, and poor understanding will produce poor

understanding. Students need to use language to formulate and understand the technical concepts underlying the field of engineering. This includes an understanding of the principles of mathematics, physics, and other sciences that often form the basis of engineering science. Languages are used to plan, design, and implement technical solutions. The ability to explain plans, identify problems, and formulate solutions in clear and systematic language is essential. Therefore, language has an important role in learning in the engineering field.

Communication mathematically is a complex task for even the most advanced students. The ability to communicate effectively (expressive and receptive) through language requires understanding; a strong base of vocabulary knowledge; start; fluency and proficiency with numbers, symbols, words, and diagrams; and comprehension skills. It is important to understand the many and varied difficulties students face in learning material in engineering. Determining teaching strategies and activities to help students overcome these difficulties is very important.

Several studies provide additional information regarding strategies to improve student understanding, especially when students face difficulties in learning material in the fields of science or engineering, as reported in other literature:

(i) Biology studies (Glorifica, 2021; Olumorin et al., 2021; Babalola, 2022; Olumorin et al., 2022; Tipmontiane & Williams, 2022; Abdussemiu, 2022; Ala et al., 2022),
(ii) Chemistry studies (Putri et al., 2022; Wirzal & Halim, 2022),
(iii) Mathematics studies (Dallyono et al., 2020; Hashim et al., 2021; Husnah et al., 2021; Lathifah & Maryanti, 2021; Putri et al., 2022; Marasabessy, 2021; Maryati et al., 2022; Omolafe, 2021), physics studies (Azizah et al., 2022b),
(iv) Computer studies (Grgurović et al., 2013; Pane & Myers, 2001; Sundqvist & Sylvén, 2014),
(v) Mechanical studies (Tasić, 2009; Atasheneh & Naeimi, 2015; Nordmann, 2021), and
(vi) Electrical engineering studies (Rofes et al., 2019; Tambunan & Siregar, 2016).

In this study, we reviewed several factors involving the teaching process in engineering, including the existence of technology and language to transfer knowledge from teacher to student. To support this review, we carried out a research analysis using the bibliometric method. Bibliometrics is a field of scientific research that is increasingly attracting the attention of researchers from year to year (Wei et al., 2016). Bibliometric analysis continues to develop rapidly and has been applied to many research fields. This is because bibliometric analysis is an effective way to evaluate the merits of a particular field of study or journal (Hou et al., 2015). Bibliometric analysis is a scientific discipline that has broad intersections and combinations between philology, information science, mathematics, and statistics in certain fields (Li et al., 2020). The evolution of a particular research direction can be better revealed through bibliometric analysis indicators.

Bibliometrics is an effective method for understanding current research trends and has been used in various fields (see table 1). Based on our previous research on bibliometrics (see table 2) as well as several previous studies on bibliometrics in various fields, there has been no research that uses bibliometric analysis to determine trends in the use and importance of language in learning in the engineering field, complete with a theoretical discussion regarding the influence factors of language on learning. in engineering. Therefore, this research was conducted to analyze developments and trends in language and technology research that can improve the quality of student learning in the engineering field from 2019 to 2022. We add a review of factors that can influence the quality of education in the engineering field through the use of language as a tool for conveying learning information. It is hoped that this research can be a consideration for readers to understand the current condition of the importance of language in learning in the engineering field.

Table 1. Previous studies of bibliometric analysis

No	Contribution Subject	References
1	Simple spectrophotometer in STEM Education	Shidiq *et al*. (2021)
2	Chemistry and special needs education	Bilad (2022)
3	Teaching science engineering	Nordin (2022a)
4	Chemical engineering and special needs education	Wirzal and Putra (2022)
5	Dental aerosol suction developed	Ramadhan *et al*. (2022)
6	Covid-19 research	Hamidah *et al*. (2020)
7	Pure biodiesel (B100) on engine performance	Setiyo *et al*. (2021)
8	Bioenergy	Soegoto *et al*. (2022)
9	Biomass pretreatment	Mudzakir *et al*. (2022)
10	Management information systems	Santoso *et al*. (2022)
11	Correlation between process engineering and special needs	Nordin (2022b)
12	Correlation between chemistry and special needs education	Bilad (2022)
13	Geotechnics	Mulyawati & Ramadhan (2021)
14	Correlation between chemical engineering and special needs education	Wirzal *et al*. (2022)
15	Language Education to Improve Science Student Understanding during Practicum in Laboratory	Fauziah *et al*. (2021)

Table 2. Our works in bibliometric analysis.

No	Topic Discussion	References
1	Development of mechanical engineering education research	Al Husaeni and Nandiyanto (2022)
2	Analyses the scope of techno-economic education	Ragadhita and Nandiyanto (2022)
3	The research developments in the field of materials	Nandiyanto & Al Husaeni (2021)
4	Investigates the reasons and patterns of research on Sustainable development goals (SDGs) in science education	Maryanti *et al*. (2022)
5	A bibliometric analysis of chemical engineering	Nandiyanto *et al*. (2021)
6	Bibliometric analysis of science and Islam research	Al Husaeni & Al Husaeni (2022)
7	The impact of resin matrix composition on brake pad performance	Nandiyanto *et al*. (2022)
8	Bibliometric Analysis of Briquette Research Trends	Al Husaeni (2022)
9	Investigates the evolution of research on engineering	Nandiyanto & Al Husaeni (2022)
10	Examines and validates the impact and globalization of the ASEAN Journal of Science and Engineering Education	Al Husaeni *et al*. (2022b)
11	this study analyzes how to describe the fall in the number of scientific publications in Indonesia.	Nandiyanto *et al*. (2020)

Research method

We collected all bibliographic data from articles published from 2019 to 2023 and indexed by Google Scholar for this research. Data was collected using the Publish or Perish reference management application on September 5, 2023. The results will be saved in *.ris format for mapping using VOSviewer and *.csv for data processing using Microsoft Excel. To build a scientometric network that measures productivity, we used VOSviewer as a data visualization tool after the data was collected. This application generates networks from preprocessed data sets. In the data search, keywords such as “language”, “engineering”, and “learning” were used. Bibliometric analysis of this research was carried out in five stages, namely Preparing Tools and Materials, Harvesting, Screening, Visualization, and Analysis Data.

The first stage in doing bibliometric analysis is to prepare the equipment and resources that will be used. Several applications must be prepared, including the Microsoft Excel application for analyzing and filtering search result data, the Publish or Perish (PoP) application for searching and collecting article data based on keywords, and the VOSviewer application for visualization and mapping of search result data.

The second stage is to collect data. We collect data to analyze publication patterns based on the keywords used. Using the Publish or Perish tool, published research materials (articles) pertaining to the topic "Language for Engineering Learning" are collected at this stage. Keywords ("Language") AND ("Engineering Learning") were used to collect research documents. The article data used was published in the last five years, from 2018 to 2023.

Following that, data filtering was performed in the third stage. Documents gathered during the data-collecting step cannot be evaluated immediately. As a result, data filtering is required. At this point, data is filtered based on the year of publication. Articles that lacked publication dates were included. Furthermore, only journal publications were considered in this study. As a result, items that are not derived from journals will be removed during this stage of data filtering. Some articles were not used due to insufficient metadata.

Data visualization is the fourth stage. The saved data in (*.ris) format is then uploaded to the VOSviewer application for data visualization. At this point, the terms in the VOSviewer network mapping visualization are filtered. The article data is mapped using the source database. This study employs three methods of visualization: network visualization, overlay visualization, and density visualization.

The next step is to do data analysis. At this point, the data that has been visualized has been analyzed, and the results will be displayed in the “Result and Discussion” section. Microsoft Excel is used to improve data analysis processes.

Results and discussion

Definition of engineering education

Engineering education refers to the process of teaching and learning about scientific concepts, principles, and practices. Engineering education includes the acquisition of knowledge, skills, and attitudes related to the scientific method, scientific investigation, and understanding of nature (Alsop & Watts, 2003). Engineering education aims to develop scientific literacy, which includes the ability to critically analyze and evaluate scientific information, make informed decisions, and engage in scientific reasoning and problem-solving (Alsop & Watts, 2003).

Engineering education does not only focus on cognitive aspects but also recognizes the importance of affective factors (Alsop & Watts, 2003), referring to emotions, attitudes, beliefs, motivation, self-confidence, and self-efficacy in the context of engineering education. Emotions play an important role in the teaching and learning process, as emotions teachers often recount episodes of wonder, joy, and excitement in their work. The emotional bonds and relationships established with students are an integral part of effective engineering education practices.

In addition, engineering education refers to the process of teaching and learning about scientific concepts, principles, and theories (Carey, 1986). Carey (1986) also states that engineering education involves conveying knowledge and understanding about the physical, biological, and social world, as well as the scientific process itself. The goal of engineering education is to help students develop a deep, counterintuitive understanding of scientific phenomena and to equip them with the skills to think critically, analyze data, and engage in scientific inquiry (Hofstein & Lunetta, 2004; Carey, 1986). Engineering education also aims to

bridge the gap between students' existing knowledge and the scientific theories taught, by overcoming misunderstandings and encouraging conceptual change (Carey, 1986).

Technology's advantages in engineering education

Technology plays an important role in engineering education because it is closely related to scientific principles and methods of inquiry. Engineering education should include discussions about the nature of technology and its interdependence with science. It should also provide practice of the skills necessary to plan, execute, and deploy technology designs. By integrating technology into the engineering curriculum, students can interact with real objects from their everyday experiences, making the subject more interesting and motivating (DeBoer, 2000). The use of technology in engineering education provides several benefits, including:

(i) Better Learning Opportunities: Technology in engineering education provides students with better learning opportunities by offering interactive and engaging resources. Students can access visualization, simulation, and modeling tools that help them understand complex scientific concepts more effectively (Lin, 2003; Kim et al., 2007).

(ii) Personalized Learning: Technology-enabled personalized learning experiences in engineering education. Students can customize their learning tools based on their interests, learning preferences, and specific course requirements. These adjustments help students engage more actively in their learning and promote deeper understanding of scientific concepts (Lin, 2003; Kim et al., 2007).

(iii) Access to Information: Technology gives students easy access to a large amount of information and resources. Students can search databases, interpret models, and critique electronic resources to gather information and support their scientific investigations. Access to this information helps students develop research skills and stay abreast of current scientific developments (Lin, 2003; Kim et al., 2007).

(iv) Collaboration and Communication: Technology facilitates collaboration and communication between students and teachers in engineering education. Online discussion boards and collaborative platforms allow students to engage in scientific discourse, share ideas, and collaborate on projects. This collaboration encourages critical thinking, problem-solving, and teamwork skills (Lin, 2003; Kim et al., 2007).

(v) Future Preparation: Technology in engineering education prepares students for the demands of the modern world. Students learn how to use digital tools, interpret data, and analyze scientific information, which are critical skills for success in higher education and the workplace. Technological literacy is becoming increasingly important along with increasingly rapid technological advances (Lin, 2003; Kim et al., 2007).

Overall, the use of technology in engineering education offers many benefits, including increased learning opportunities, personalized learning experiences, access to information, collaboration and communication, and preparation for the future. It empowers students to become active learners, critical thinkers, and scientifically literate individuals.

What purpose does language serve?

Language plays an important role in international knowledge transfer. Language functions as a means of communication and understanding between individuals from different cultural backgrounds (Welch & Welch, 2008). When people speak the same language, exchanging ideas, sharing information, and collaborating effectively becomes easier. Language also helps build trust and build strong relationships, which are important for successful knowledge transfer (Welch &

Welch, 2008). Without a common language, knowledge transfer is difficult and can lead to misunderstandings and misinterpretations. Therefore, language is important in facilitating effective communication and encouraging successful knowledge transfer in international contexts.

Bracken and Oughton (2006) also stated that language plays an important role in interdisciplinary research and collaboration. This allows experts from different disciplines to communicate effectively and understand each other's perspectives. Without a common language, misunderstandings can arise, hindering the progress of a research project. Apart from what has been explained, language also plays an important role in various aspects of society and education. According to Coleman (2010), language provides benefits in the world of education, including:

(i) Students can learn more effectively when taught in their mother tongue because there are no barriers to understanding, thereby facilitating the formation of basic concepts
(ii) Language can integrate children's daily interactions, games, and television programs into the classroom and will enhance their learning experience.
(iii) With language reading and writing skills are acquired more easily in a familiar language, allowing children to connect sounds with written symbols.
(iv) The technique of learning the mother tongue first and then moving on to a second or foreign language, such as English, will result in more successful language acquisition.
(v) Education is becoming more connected to children's home environments, allowing them to connect school and everyday life.

Based on what has been explained, it can be concluded that language is very important for social integration, educational success, cultural preservation, and access to knowledge. Language empowers individuals to communicate, learn, and contribute to their communities and the world.

Considerations in making strategies in language and technology for teaching and learning engineering education

Formal and Informal Learning

Formal learning is learning that is deliberate, organized and structured (Alonderienė & Pundzienė, 2008). Formal learning is generally regulated by institutions and guided by a formal curriculum or program. Examples of formal learning are credit courses and programs offered by community colleges and universities. Formal learning has learning goals and expected outcomes and formal credit is given in these situations.

Meanwhile, informal learning is learning that is not organized and is often experiential and spontaneous (Yaşar & Karadeniz, 2011). Informal learning is not guided by a rigid curriculum and does not have aims and objectives from the learner's perspective. Informal learning can take place anywhere and at any time (Harrop & Turpin, 2013), and is often overlooked as legitimate learning during the school years. This is the most difficult thing to measure or track, but it is important for young people's cognitive development. Examples of informal learning include learning from conversations with friends or study partners, watching documentaries or educational programs, and gaining knowledge from family members or friends who are experts in a particular field.

The main difference between formal and informal learning is that formal learning is deliberate, organized, and structured, while informal learning is spontaneous, based on experience, and unorganized.

Education level to learn engineering

Education level is important to ensure the quality in transferring knowledge (Al-Momani & Rababa, 2022; Adeoye, 2022). When studying engineering, there is a specific level of education

required and it varies depending on the type of engineering. Engineering is a very diverse field with many subdisciplines (Gilmore & Millar, 2018). Thus, the requirements or level of education can differ depending on the area of engineering specialization itself. The following are the education levels to learn engineering:

(i) High school. at this level students can take mathematics and science courses, especially calculus, physics, and chemistry. Participate in engineering-related extracurricular activities, such as robotics clubs or science fairs, to build practical skills and show your passion.

(ii) Higher Education (College or University). A bachelor's degree in engineering or a related field is the minimum educational requirement for most engineering positions. This process usually takes four years to complete. There are several engineering disciplines at the higher education level such as mechanical, electrical, civil, chemical or computer engineering

(iii) Master's Degree. Some engineering fields may benefit from a master's degree, especially if you want to specialize in a particular area, conduct research, or pursue a higher-level role. A master's degree in engineering usually takes an additional 1-2 years after a bachelor's degree.

(iv) Ph.D. level. Ph.D. is typically pursued by those interested in research and academia or specialized engineering roles.

(v) Engineering Certification. In some engineering disciplines, obtaining a professional license or certification may be required or strongly recommended. This often involves passing an exam and meeting certain experience requirements.

Curriculum development

A curriculum is a planned and organized framework that specifies what will be taught to students, how it will be taught, what resources and methods will be used, and how learning progress and accomplishments will be assessed. Many papers on curriculum have been well-reported (Widiaty et al., 2020; Landero et al., 2022; Rosina et al., 2021; Maryanti & Nandiyanto, 2021; Maryanti et al., 2021; Jamiu, 2022).

To direct the teaching and learning process, the curriculum includes goals, objectives, subject matter, and learning experiences (Wahyuni, 2016). The curriculum serves as a guide for teachers and students, ensuring that educational objectives are met and that learning is organized and purposeful. From particular topic syllabi to more general program levels or national education requirements, curricula can differ substantially in depth and detail.

The act of developing a structured plan or framework for a course or educational program is known as curriculum development (DeLuca et al., 2010). The process of developing criteria entails selecting the resources, teaching techniques, objectives, and content that will be used to promote learning (Maryanti & Nandiyanto, 2021). To give students a cogent and productive educational experience, curriculum building is a difficult and comprehensive process (Bordage & Harris, 2011). To produce engaging and effective educational experiences for children, curriculum creation is a dynamic and iterative process that calls for cooperation between educators, administrators, and stakeholders. The process of creating a curriculum can be broken down into numerous steps, such as:

(i) Needs Assessment: The first stage in developing a curriculum is to determine the needs and objectives of the students as well as the educational setting. This entails determining intended learning outcomes and objectives as well as understanding the past knowledge, talents, and skills of the students.

(ii) Goal Setting: Making clear, measurable learning objectives is a necessary step in goal-setting. By the end of the course or program, students are expected to have the knowledge, skills, and abilities outlined in these goals. Goals should be consistent with need assessments and relevant academic requirements.
(iii) Content Selection: The topics, substance, and subject matter that will be addressed in the course are chosen by curriculum developers. This decision must be consistent with the established goals and pertinent to the wants and needs of the pupils.
(iv) Learning Strategy: The resources that will be used to deliver content and accomplish learning objectives are decided upon by curriculum creators. This can involve lectures, group discussions, practical exercises, technological aids, and more.
(v) Assessment and Evaluation: To gauge student learning and determine if objectives have been fulfilled, assessment methods and instruments must be developed. This entails creating projects, tests, quizzes, and other methods of evaluation.
(vi) Sequencing and Planning: The curriculum is organized into a logical sequence or structure. This includes determining the order of topics to be covered and how they will complement each other to facilitate learning progress.
(vii) Alignment: Ensuring alignment between objectives, content, teaching strategies, and assessments is critical. All elements of the curriculum must work together in an integrated manner to support the expected learning outcomes.
(viii) Incorporation of Diverse Perspectives: Curriculum developers must consider multiple perspectives, cultures, and backgrounds to create a curriculum that is inclusive and represents different experiences and viewpoints.
(ix) Resource Development: Developing or selecting textbooks, materials, technology, and other resources that will support the curriculum is an important step.
(x) Pilot Testing: Before full implementation, the curriculum can be tested in a small-scale pilot program to identify any issues and make necessary adjustments.
(xi) Teacher Training: Teachers and instructors who will deliver the curriculum need to be trained and given the necessary resources and support.
(xii) Implementation: The curriculum is put into practice, and students are involved in the learning and assessment activities outlined in the curriculum.
(xiii) Evaluation and Revision: It is crucial to continually analyze and evaluate the curriculum. When necessary, updates and adjustments are made based on student, teacher, and other stakeholder feedback.
(xiv) Continuous Improvement: Assuring that a curriculum is successful and current over time requires constant review and adaptation, which is why curriculum development is not a one-time exercise.

Application of technology in media to enhance the language used in teaching engineering subjects

For some cases, engineering needs introduction from simple experiment to support the way to transfer knowledge from teacher to student (Rahmat, 2021; Andika & Putra, 2022).

An efficient method for teaching and learning languages is to use technology in media to help students' language abilities. Technology has the potential to make learning more engaging, interactive, and effective (Al Husaeni et al., 2022). There are many technologies available that can be used to develop language skills to aid in the understanding of chemistry. Students have more

flexibility and accessibility because of the use of technology in media (Izzo, 2012). Students can routinely practice speaking and develop their listening, speaking, reading, and writing abilities in the language they are studying thanks to technology. The following technologies can be used as learning tools to hone language abilities.

(i) For smartphones and tablets, there are a variety of language learning applications that provide interactive courses, vocabulary drills, and pronunciation drills (Heil et al., 2016).
(ii) Language Exchange Platforms: Tandem, HelloTalk, and Speaky are a few examples of online tools that pair language students with native speakers for language exchange (Kessler, 2021). Through text, voice, or video chat, students can hone their speaking and listening skills with native speakers.
(iii) Augmented reality (AR) and virtual reality (VR) both offer immersive language learning opportunities (Blyth, 2018).
(iv) Students can gain exposure to native language use and cultural understanding through online language communities, online forums, discussion groups, or social media communities devoted to language study (Lomicka, 2020).
(v) Websites and platforms for language learning abound, including BBC Languages, Duolingo, and Memrise (Bczkowska, 2021).
(vi) Language learning games, or the "gamification" of language learning, can make the learning process more engaging and enjoyable (Prathyusha, 2020).
(vii) Listening to podcasts or audiobooks in the target language might aid with pronunciation and listening comprehension (Gündüz, 2006).
(viii) Students can translate materials from their native language to the target language and vice versa with the aid of automatic translation tools like Google Translate (Stapleton & Kin, 2019).
(ix) E-books and E-readers, as well as e-books in languages, can aid students in developing their vocabulary and reading comprehension (Chen et al., 2013). For quick word lookups, built-in dictionaries are frequently provided in e-readers.
(x) Language Learning YouTube Channels: According to de Azevedo Fay and Matias (2019) there are a lot of YouTube channels devoted to teaching languages.

Improving literacy and language's impact

Improving literacy and language effects are important goals because these abilities allow a person to communicate better, understand information better, and participate in society more effectively. Here are some ways to improve literacy and language effects:

(i) Read on a regular basis. Reading on a regular basis is the most effective way to enhance literacy (Teguh, 2020). Poems, books, magazines, news stories, and so on. Don't limit yourself to one form of reading material. Reading will help you enhance your vocabulary and knowledge.
(ii) Discussion and debate. Talking and debating with others might help you achieve your goals by boosting your confidence and expanding your knowledge of various perspectives (Iman, 2017).
(iii) Writing Exercises. Writing can help you better organize your thoughts and improve your written communication skills (Mascle, 2013).
(iv) Analytical exercises for the text. Learning to critically examine texts entails being able to detect arguments, assess data, and evaluate evidence. This activity can aid comprehension of the material read (Pratama, 2016).

(v) Enroll in a Language Class. An experienced instructor can provide direction and feedback during this activity.
(vi) Speaking with Others. Conversations with others, particularly those who speak different languages or come from diverse cultural backgrounds, will improve your understanding of language use in many circumstances (Kramsch, 2014).
(vii) Read about Topics of Interest. Reading about topics of interest can sharpen your understanding of the specific language in that field.
(viii) Listen to music and see movies in the language you're learning. Watching films, listening to music, or watching television shows in the language you are studying are all enjoyable activities to improve your grasp of the language (Kurniawan, 2019).

Utilizing technology in the lab to enhance the language used to teach engineering subjects

Technology integration in lab settings can be an effective way to boost language proficiency (Vanderplank, 2010), particularly in educational settings where students must utilize a second language to conduct experiments and present their findings. Technology integration in the lab environment enables instructors to design immersive, language-rich laboratory experiences that increase students' language proficiency as well as their capacity for conducting experiments and effectively communicating in scientific contexts. Many papers regarding the need for laboratory, technology, and practical experiments for improving students' understanding have been reported (Kumbu-ani et al., 2021; Nuhu et al., 2021; Azizah et al., 2022; Deximo & Lucero, 2021; Akiatan et al., 2021; Rosina et al., 2021; Ana, 2020). This method might be especially helpful in multicultural or multinational educational settings.

(i) Students can conduct experiments in a digital setting using a virtual laboratory simulation called Virtual Lab (Balamuralithara & Woods, 2009). The instructions and explanations for these simulations are frequently provided in the target language, assisting students in developing their reading and comprehension abilities.
(ii) The use of laboratory software in the target language can help employees become more proficient with technical terms.
(iii) Collaborative Online Platforms, by using a collaborative online platform, participants can work together on experiments, discuss relevant topics, and provide information in the target language (Erdal & Seferoglu, 2017).
(iv) Mobile applications can be used to collect data during experiments, as described in Mobile Apps for Lab Data Collection (Zheng et al., 2018). Students can use the target language to take notes, record data, and discuss outcomes in real time.
(v) With the help of digital lab notebooks, students can preserve thorough electronic notes of their investigations (Bird et al., 2013).
(vi) Both mixed reality (MR) and augmented reality (AR) exist today (Mills, 2022). Understanding is aided by the use of AR and MR technologies, which can overlay data, instructions, and explanations in the target language over actual laboratory conditions and equipment.

Language and student characteristics, motivation, teacher-student relationships, therapy, and psychological condition

Over the past 30 years, language has been at the center of learning and teaching strategies that aim to displace mechanistic learning based on prescriptive principles by fostering learners' metalinguistic proficiency in speaking. As a result, it is not unexpected that the idea of language

awareness is used extensively in both language teaching and education as a whole. Because language in the classroom environment encourages teachers and students to connect to increase students' abilities, language has a relationship to the situations of pupils (Cahyaningrum, 2017).

In actuality, the linguistic resources available to kids in this learning environment aid in their acquisition of fundamental skills like counting, reading, writing, listening, and expressing their needs or feelings. Aside from that, language learning facilities in the classroom can be a location to help students develop their social, self-discipline, and responsibility skills, all of which will affect how well they do in school. The degree of students' motivation to engage in learning activities is one characteristic that has a significant impact on how well their education goes.

Motivation is a force that can energize students' attempts to accomplish particular objectives. Education and motivation go hand in hand (Lumbantobing, 2020). Many papers discussed about motivation in enhancing students' understanding (Permana et al., 2021; Suhana et al., 2022; Sopian et al., 2022; Adeoye, 2022; Hernawati et al., 2021). This is very crucial because student motivation affects how they behave, react, and perform throughout educational events. In other words, kids require incentives to help and make the learning process enjoyable for them. Students who lack motivation will quickly get bored. This is due to the fact that everyone requires motivation to attain success in life.

Language barriers for students with special needs

For people with exceptional needs, language limitations can pose serious obstacles in a variety of spheres of their lives. That is the main reason that special needs students need some consideration and support from surrounding, including assistive technology (Maryanti et al., 2021; Rahmat, 2022; Rahmat, 2021; Sudarjat, 2022; Alimi et al., 2022; Olumorin et al., 2022).

These obstacles may make it more difficult to communicate, get an education, or take part in society. Effective communication can be challenging for people with speech and language impairments because they may have trouble understanding spoken language or expressing words clearly (Prelock et al., 2008). The correct spelling of words and the comprehension of written text may be difficult for people with writing and reading difficulties such as dyslexia or cerebral palsy (Roitsch & Watson, 2019; Abidin et al., 2021). Children with special needs who use sign language may run into difficulties if they come across individuals who do not understand or use sign language.

The use of visual aids or alternative communication techniques may be necessary for some people because they may comprehend information better when it is delivered in the form of images or symbols. Information must be provided in a simplified manner since people with language processing impairments may have trouble understanding complex or lengthy sentences (Booth et al., 2000). According to Gittins et al. (2018), people who have been diagnosed with autism or a related communication disorder may struggle with social communication and may need specialized communication techniques.

For people with special needs, it is crucial to take an inclusive stance and take into account various communication techniques that are suited to each person's needs. Using communication aids, sign language interpreters, augmentative and alternative communication (AAC) devices, or other assistive technology can help people with special needs overcome linguistic challenges (Baxter et al., 2012). Additionally, fostering a more inclusive atmosphere for those who experience language problems can be accomplished through raising awareness and understanding of their needs. It is crucial to understand that communication is not just confined to spoken or written words; other means can also be appropriate and successful.

New language-improving technology for teaching

Modern educational technological breakthroughs, particularly in language teaching, result in a significant amount of conveniently accessible materials, knowledge, and information for language learners. Educators and academics have employed technology to improve language learning and education for many years. Technology is described as the use of technological techniques, methods, or expertise to accomplish a task. Many reports regarding the utilization of technology such as information technology in addition to laboratories to increase students' understanding (Rachmawati, 2019, Shah, 2022; Bolaji & Adeoyo, 2022; Arciosa, 2022; Dwiana et al., 2022; Jadhav et al., 2022; Bolaji & Jolaoye, 2022; Setiyo et al., 2019; Bugarso et al., 2021; Azizah et al., 2022; Nuhu et al., 2021; Widodo et al., 2020).

Based on this description, we define technology in this study as the application of technological processes, methods, or knowledge to the completion of a learning activity or instructional goal. Educators today have greater options to employ technology for teaching as a result of recent technical breakthroughs. Several scholars looked at similar studies to see which technology was employed in language learning, as indicated in table 3.

Table 3. Reviewed technologies, their brief descriptions, and some affordances of each

Technologies	Ref	Description in Brief	Language study affordances examples
Schoolhouse- or classroom-based technologies Course management system (CMS)	Zhang et al. (2022)	A server-based application that displays blended or remote learning content and services (for example, syllabi, compulsory readings, calendars, and so on). A web browser is used by teachers and students to access a CMS across a network via a menu-driven interface.	● Allow for the sharing of course materials, giving access to content at any time and from any location. ● Facilitate course content organization as well as teacher-student and student-student communication.
Interactive whiteboard	Aldhafiri (2020)	An interactive display is made up of a computer, a projector, and a display panel, which is a big freestanding or wall-mounted touch-sensitive screen. The projector shows a picture of the computer screen on the screen, which all pupils in the classroom may see.	● Encourage students and teachers to participate in interactive activities and collaborate on projects. ● Improve learning motivation and attitudes. ● Incorporate real-world internet information into classroom lessons.
ePortfolio	Mathur and Mahapatra (2022)	A learner's student work digital archive that preserves evidence of the learner's experiences, progress, achievements, and self-reflections.	● Encourage student autonomy and self-evaluation. ● Place more emphasis on the learning process than the products of learning. ● Encourage the development of self-assessment skills and the establishment of learning objectives.
Electronic dictionary	Levy and Steel	A handheld or online electronic dictionary	● Accelerate searches for lexical elements so that looking up

Technologies	Ref	Description in Brief	Language study affordances examples
	(2015)		words does not interfere with reading. ● Allow for various search choices and learning styles. ● Encourage specific and detailed feedback.
Automatic speech recognition (ASR) and pronunciation program	Sidgi and Shaari, (2017).	A method of allowing a computer to recognize words spoken into a microphone. ASR is widely employed as a component of speech-pronouncing software, recognizing and providing feedback on certain elements of the learner's output, such as prosody or specific sounds.	● Provide comments on the student's pronunciation concerning the desired pronunciation. ● Allow the learner to practice speaking skills at his or her speed. ● Allow pupils to interact with a digital agent in a simulated discourse.
Network-based social computing Virtual world	Golonka et al. (2014)	A virtual world is a program that allows pupils to navigate a character representation, or "avatar," across a three-dimensional graphical environment. A serious game is a virtual environment or typical computer game in which the program guides or limits the user's activity and they must fulfill a specific objective or set of goals.	● Make virtual meeting rooms available. ● Allow students to navigate simulated environments that are modeled after target language places and include culturally relevant artifacts. ● Allow pupils to take on the roles of several characters in a scenario to encourage role-play.
Social networking	Toetenel (2014)	Social networking services such as Facebook and MySpace enable peer-to-peer communication and cooperation. Users create personal profile pages and then join networks based on geography, interests, associations, or friendships to construct their social networking presence.	● Encourage user networking and communication with people who have similar interests. ● Allow interaction with native speakers and other students learning the target language. ● Allow both synchronous and asynchronous communication.

Results in bibliometric analysis: metrics, annual publication report, article trends, co-occurrence analysis

Bibliometric analysis is a quantitative method used to measure the use and impact of scientific publications. In educational research, bibliometric analysis can provide valuable insight into trends, patterns, and impact of research in the field. This analysis involves the use of various metrics and indicators that help measure the quantity, quality, and impact of research output. Based on the results of the literature study conducted, it is known that there are several main metrics and indicators used in bibliometric analysis for educational research, including: The first metric used in bibliometric analysis is the number of publications (Donthu, 2021; Thanuskodi, 2010). This

metric indicates the amount of research output in a given field. Researchers can use these metrics to identify the most productive authors, institutions, and countries in educational research. However, the number of publications alone does not indicate the quality or impact of the research. The second metric used in bibliometric analysis is the number of citations (Thanuskodi, 2010). Citations measure the number of times a publication is cited by other researchers.

This metric is used to measure the impact and influence of research output. The third metric used in bibliometric analysis is the h-index (Norris, 2010). The H-index measures the productivity and impact of a writer's research output. This is calculated based on the number of publications an author has and the number of times those publications have been cited by other researchers. The fourth metric used in bibliometric analysis is the journal impact factor (Ellegaard, 2015). The journal impact factor is a measure of the average number of citations received by articles published in a particular journal. It is used to evaluate the quality and impact of research output from a particular journal. Researchers can use these metrics to identify the most influential journals in educational research. The fifth metric used in bibliometric analysis is collaboration networks (Segura-Robles, 2020). Metric data related to the number of publications, citations, and h-index of the language in engineering learning research subject (see table 4).

Table 4. Result metrics publication on language in chemistry learning

Publication years	2019-2023
Citation years	4
Papers	995
Citations	9780
Cites/year	2445
Cites/paper	9.83
Author/paper	2.81
h-index	48
g-index	77
hI, norm	26
hI, annual	6.50
hA-index	27

Research trends related to language in engineering learning was taken based on the volume of publications published each year. In 2019, the number of documents related to research in this field was 159 documents (16.63%). In general, research subjects in this area began to develop globally starting from 2020-2022, which was marked by a relatively increasing number of related article documents. The number of documents for 2020-2022 is 172 (17.99%), 230 (24.05%), and 231 (24.16%) documents respectively. The increase in the number of publications from 2020-2022 is likely due to the high need for effective communication and the demand for engineers with well-rounded skills that include proficiency in languages as well as because Engineers who know multiple languages will be better prepared to work in diverse and multicultural environments, thus encourage collaboration and better understanding among team members. Apart from that, language proficiency improves important soft skills such as public speaking, writing, and negotiation.

These skills are invaluable in an engineering career, especially for roles that involve client interaction, project management, or leadership. As for 2023, research related to this subject will experience a decline because there may be an assumption that engineering students already have adequate language skills, especially in areas where the main language of instruction is also the mother tongue of the majority of students. As a result, educators and researchers may focus their

efforts on other areas of need. Additionally, the availability and improvement of translation technology may give rise to the perception that language barriers can be overcome without intensive language education. Although technology can aid communication, it may not completely replace the language skills required in an engineering context.

Citations are crucial in academic writing and research. They respect academic integrity values by crediting the producers of information, supporting research arguments, and helping to build a firm foundation in the broader scientific literature (Jomaa and Bidin, 2017). Furthermore, citations are the most often used approach for evaluating the effect and, in some situations, the quality of a publication in a particular field. They also disclose connections between authors, research groups, research topics, or countries. In this study, we present ten related articles with various testing statistics, which collectively accumulated excellent citations, as shown in table 5.

Table 5. Top 10 articles with high citation-related research subject

No	Journal Source	Title	Year
1	National Academies Press	Science and engineering for grades 6-12: Investigation and design at the center	2019
2	ASEAN Journal of Science and Engineering	Bibliometric Using Vosviewer with Publish or Perish (using Google Scholar data): From Step-by-step Processing for Users to the Practical Examples in the Analysis of Digital Learning Articles in Pre and Post Covid-19 Pandemic	2022
3	British Journal of Educational Technology	Explanatory learner models: Why machine learning (alone) is not the answer	2019
4	Computers & Education	The effect of using Kahoot! for learning–A literature review	2020
5	Computers in Human Behavior	A collaborative working model for enhancing the learning process of science & engineering students	2020
6	Science education	Coming to terms: Addressing the persistence of “hands-on” and other reform terminology in the era of science as practice	2019
7	Innovations and Research	STEM Integration	2020
8	Technology in Society	Scientific mapping to identify competencies required by industry 4.0	2021
9	IEEE Transactions on Industrial Informatics	Joint learning of degradation assessment and RUL prediction for aeroengines via dual-task deep LSTM networks	2019
10	Educational Research Review	Meta-analysis of the impact of Augmented Reality on students' learning gains	2019

The results of the co-occurrence analysis are shown by network and overlay visualization analysis, which are shown in figures 1 and 2 respectively. This network and overlay visualization are represented by connected nodes and edges. Nodes represented by circles can be publications, journals, researchers, or keywords; while edges indicate relationships between pairs of nodes. In addition, edges not only indicate the existence of a relationship between two nodes but also the strength of that relationship, which is represented by distance. The closer the distance between one node and another node indicates the higher the relationship between the nodes. Mapping and clustering are complementary and complement each other. Mapping can be used to get a detailed

picture of the structure of a network, while clustering is used to get insight or an overview of bibliometric groupings.

In the visualization shown in figure 1, each circle represents a keyword or term that appears frequently, taken from the title and abstract of the article. The size of the circle indicates the number of publications that have a relationship with that term, both in the title and abstract of the article. The larger the size of the circle, the greater the number of articles that are relevant to that keyword or term. Adjacent terms that appear frequently tend to be located close to each other in the visualization. From the results of the analysis, it was found that the metadata of 995 articles could be grouped into five clusters, each of which could be identified based on its color. In detail, the cluster division is presented in table 6.

Table 6. Cluster network visualization classification.

Cluster	Frequently Appearing Keywords	Related Explanation	Reference
Cluster 1 (Red, total link strength = 50, Occurrences = 35)	Child, mathematics, stem, education, and educator	Integrating engineering concepts into STEM education frequently necessitates the use of multidisciplinary teaching methods. In such circumstances, language serves as a link between different STEM subjects, allowing students to grasp the interdependence of science, technology, engineering, and mathematics.	Thibaut et al., 2018
Cluster 2 (Green, Total link strength = 49, Occurences = 34)	University, community, higher education, and industry	The relationship highlights the significance of language in engineering learning in a variety of settings, including universities, communities, higher education, and industry. Language is vital for the successful integration of engineering education into various areas, which promotes innovation, collaboration, and societal growth.	(Sterzuk, 2015)
Cluster 3 (blue, Total link strength = 63, Occurences = 34)	English language, first language, evaluation, and foreign language	The challenges and strategies associated with learning engineering in a language that is not the students' first language, especially when that language is English. It highlights the need for tailored language support and evaluation methods to facilitate effective engineering education in linguistically diverse environments.	(Pun and Jin, 2021)
Cluster 4 (Yellow, Total link strength = 80, Occurences = 55)	System, application, software engineering, machine, and performance	The connection emphasizes the importance of language in comprehending, explaining, and optimizing diverse technical elements such as systems, applications, software, machinery, and performance. Students must be fluent in the language of engineering learning to flourish in these areas and effectively contribute to the profession of engineering.	(Raschka et al., 2020)
Cluster 5 (Purple, Total link strength = 101,	Teacher, engineering design, integration, computational thinking, and	Language proficiency is required for effective communication, comprehension of engineering concepts, successful design processes, and the incorporation of computational thinking, all of which contribute to the professional development of	(Lu and Fletcher, 2009)

Cluster	Frequently Appearing Keywords	Related Explanation	Reference
Occurences = 69)	professional development	both teachers and students in the field of engineering education.	

After identifying mapping and clustering through network visualization, research trend mapping was then carried out based on the year the article was published. Information obtained from the overlay visualization results can be used to detect and identify the state of the art of certain research subjects presented with the overlay visualization as shown in figure 2. In this visualization, the color of a node represents a keyword, while the color of the node indicates the year the article containing the keyword was published. The darker the color of the node, the longer the topic is discussed in the research. The overlay visualization shows that topics related to teachers, professional development, and performance are topics that will be discussed ahead of 2022-2023, which are topics that are still hot and have great research opportunities.

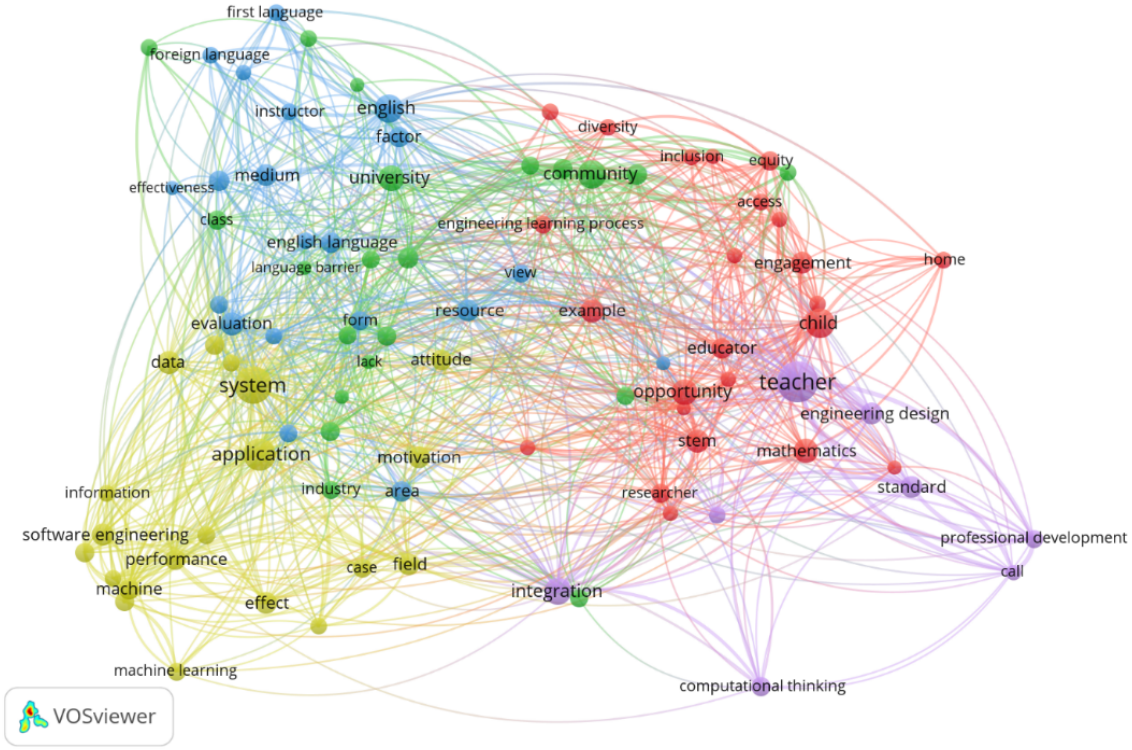

Figure 1. Network visualization

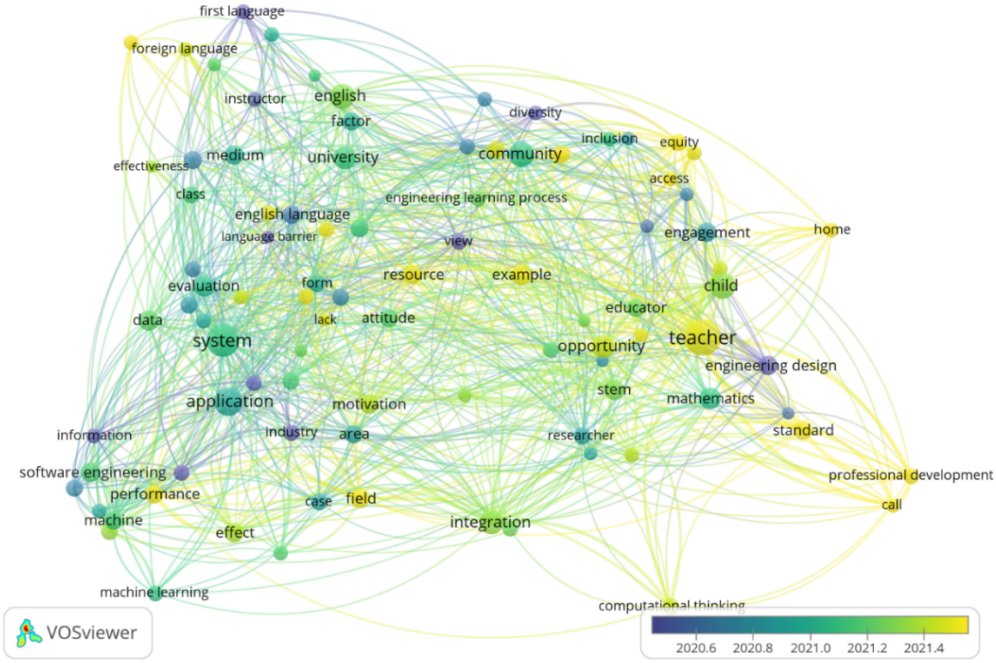

Figure 2. Overlay visualization

Conclusion

The paper reviews developments in language and technology research that can improve the quality of teaching and learning in engineering, supported by explanation of several factors influencing the teaching and learning process and a bibliometric analysis (with keywords "Language" AND "Engineering Learning" from Google Scholar from 2020 to 2022). It can be concluded that the principle of engineering education refers to the process of teaching and learning about scientific concepts, principles, and practices. And, technology plays an important role because it is closely related to scientific principles and investigative methods. Also, language has an important role in supporting students' understanding and abilities in this subject since it conveys learning information. This paper can be used as material for readers to consider in understanding the current conditions regarding the importance of language in the teaching and learning process in the engineering.

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