International Journal of Language Education
Volume 7, Number 3, 2023, pp. 527-562
ISSN: 2548-8457 (Print) 2548-8465 (Online)
Doi: https://doi.org/10.26858/ijole.v7i3.56014

How to Improve Student Understanding in Learning Science by Regulating Strategy in Language Education? Definition, Factors for Enhancing Students Comprehension, and Computational Bibliometric Review Analysis

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Received: 2 September 2022
Reviewed: 5 July 2023-3 August 2023
Accepted: 1 September 2023
Published: 30 September 2023

Abstract
The purpose of this study is to explain language education development research for improving student comprehension in learning science. This study also reviews the definition of these strategies, identifies factors that contribute to improving students' comprehension, and conducts a computational bibliometric review analysis to determine the efficacy of these approaches using Google Scholar with keywords "Language" and "Learning Science" from 2019 to 2023. There are also explanations for formal and informal learning, as well as educational levels for researching techniques and developing curriculum. The use of technology in media and laboratories is also a significant factor in increasing students' literacy and language

impact. Language and student characteristics, motivation, teacher-student relationships, therapy, and psychological conditions are all inextricably linked. We also included information about language barriers for students with special needs, as well as new technologies that improve language learning, in which these can be factors in increasing student's understanding of learning science. The bibliometric analysis results show that the trend of language research in learning science is decreasing year after year. This is due to the possibility that the focus of educational research has shifted to other areas, such as educational technology, science learning, or educational policy. The co-occurrence analysis results show several keywords that are frequently researched and should be paid attention to, including "language model," "natural language processing," "deep learning," "student," and "language learning." These keywords denote important parameters that can improve the learning experience because they enable personalized, interactive, adaptive educational interventions, particularly in language learning contexts, by adapting content and feedback to each student's needs and preferences. This paper will be useful to educators in better understanding the current state of affairs concerning the importance of language in engineering teaching and learning.

Keywords: Bibliometric; language; learning; science

Introduction

Language is the main factor in learning, acting as a catalyst in determining the success of learning so that it becomes an important aspect in teaching, thinking, and understanding subject matter (Kusumawati, 2019; Nurjaleka, 2019; Chandrawisesa et al., 2019; Sanjaya and Rosiah, 2019; Yamashita, 2020; Kusumawati, 2020; Rahayu et al., 2020; Maarif, 2021; Asmarani, 2021; Najoan, 2021; Amalia and Haristiani, 2022). Language is also a main thing in science learning (Dela Fuente, 2021). The function of language in science teaching and learning is currently a bigger issue compared to 20 or 30 years ago. The nature and role of language have changed a lot, developments in technology and science as well as changes in society are one of the triggers (Maheswara et al., 2022; Judiasri et al., 2019; Mardani et al., 2020; Rifai et al., 2020; Rasiban et al., 2020; al., 2021; Sukmara, 2021; Buhori and Karnawati, 2022; Adeoye, 2023; Aneros and Herniwati, 2023), so this has an impact on the role of language in schools (Childs et al., 2015). The language of science is very unique and has character, the choice of diction in science is very important, especially in explanations of scientific phenomena and everyday language. However, science learning is not just about language learning. This shows that language, science learning, facts, and concepts must go hand in hand. Therefore, mastery of scientific language is a basic requirement in science learning (Markic and Childs, 2016; Childs et al., 2015). Models, methods, and learning media are aspects that can help in science learning. The importance of language lies in this. Thus, language is not only interpreted in technical terms or symbols. But more than that, language is important in visualizing a model, method, or learning media. Facilitates direction in thinking and understanding of science teaching and learning, as in any subject (Tsai et al., 2023).

Students must receive direction and guidance in learning science, especially in developing students' attitudes and learning experiences (Ward et al., 2016), as well as in using language that is appropriate to the conditions which are important because it will have an impact on students' understanding. Using incorrect and inappropriate language will hinder students' understanding of science learning, resulting in students' understanding of competition being incorrect. Students' understanding of science is limited by language skills and/or understanding of mathematical symbols such as comprehension components (reading and listening) and expression components (speaking and writing) (Lara-Alecio et al., 2018; Gomez et al., 2020; Afrian et al., 2018; Gomez et al., 2020; Afrian et al. al., 2020; Widodo, 2017). Science learning is supported by two pillars, namely language and mathematics (Lamrani and Abdelwahed, 2020). Both are used as tools to understand, apply, and communicate scientific concepts and even language and mathematics skills

are the basis for science learning (Parvez et al., 2019). Science cannot be learned if you cannot read and write using numbers, this is the basis for why literacy and numeracy are important in learning science (Junge et al., 2021; Nugarha et al., 2022; Widodo, 2017; Afrian et al. al., 2020; Nugraha et al., 2022; Yani and Mulyadi, 2022). Difficulties in literacy and numeracy are one of the reasons why learning science is a difficult subject (mathematics, physics, chemistry). That is why research on literacy among students and teachers is very important (Ward et al., 2016; Chamdani et al., 2019; Wirza et al., 2023), as an effort to increase abilities in science learning.

There are many difficulties that students must overcome in terms of language and symbols in science learning. Especially in terms of mathematical communication. Effective communication (expressive and receptive) in science learning through science language, begins with good science knowledge, then lots of science vocabulary, then flexibility, fluency, and proficiency in reading numbers, symbols, words, and diagrams. Many students have difficulty understanding words or symbols in science learning (Yani et al., 2022). Sometimes many students are hampered in learning science because of their ability to understand science material in textbooks. Apart from that, there are various other difficulties. Finding the right methods and strategies to overcome these difficulties is the task of science teachers. Understanding science is described by the ability to communicate and reason using written and verbal scientific language. Therefore, language functions as a mediator in science teaching and learning, especially in the process of transferring knowledge from teachers to students (Kusumawati, 2019; Martawijaya and Radhiya, 2019; Yamashita, 2020; Mardani and Padmadewi, 2020; Sukmara, 2021; Asmarani, 2021; Haristiani and Oktarina, 2021). Apart from the language factor, there are several ways to improve students' understanding (Maheswara et al., 2022; Judiasri et al., 2019; Mardani et al., 2020; Rifai et al., 2020; Rasiban et al., 2021; Sukmara, 2021; Buhori and Karnawati, 2022; Adeoye, 2023; Aneros and Herniwati, 2023) in science learning, as reported in several other literatures such as:

- Biology studies: Glorifica (2021), Olumorin et al., (2021), Babalola (2022), Olumorin et al., (2022), Tipmontiane & Williams (2022), Hofifah & Sumiati (2023), Alhassan et al., (2024), Abdussemiu (2022). Babalola et al., (2023), and Ala et al., (2022)
- Chemistry studies: Francis & Baba (2023), Putri et al., (2022), Wirzal & Halim (2022), Barke & Buechter (2023), Sombria et al., (2023), and Swafiyah et al., (2023)
- Mathematics studies: Dallyono et al., (2020), Hashim et al., (2021), Vijayarani, et al., (2023), Akinoso (2023), Radiamoda (2024), Husnah et al., (2021), Lathifah & Maryanti (2021). Putri et al., (2022), Marasabessy (2021), Maryati et al., (2022), Ogunjimi & Gbadeyanka (2023), Obafemi et al., (2023), and Omolafe (2021).
- Physics studies: Azizah, et al., (2022b), Susilowati et al., (2023), Ibrahim (2023), Lestari, et al., (2024), and Abosede et al., (2024).

Mastery of scientific language is an important aspect of the continuation of science learning. Through good language mastery, understanding of science learning material will also be good. A study shows that mastery of scientific language can determine the success of science learning and predict learning outcomes (Odden, 2021). Proficiency in the field of science is determined by a complex combination of understanding of concepts, procedures, analysis, and problem-solving as well as language (Aiman et al., 2020; Braun et al., 2022; Hidayat et al., 2022), including the ability to think logically and mathematically. can be achieved by problem-based learning and the application of self-regulated learning (Rohaeti et al., 2014; Mairing, 2020; Kusmaryono and Wijawanti, 2023). The bibliometric method of analysis is one way to study language literature in science learning.

Bibliometrics is an analytical method for measuring and evaluating distribution structures, quantitative relationships, change patterns, and quantitative management of literature data based on scientific publications. This method is growing very rapidly and is popular using mathematics and statistics as well as other measurements. Various bibliometric analysis studies are shown in tables 1 and 2 (Nandiyanto et al., 2023a; Nandiyanto et al., 2023b; Al Husaeni and Nandiyanto, 2022a).

Table 1. Previous studies on bibliometric analysis

No	Title	Reference
1	Dental suction aerosol: Bibliometric analysis.	(Ramadhan et al., 2022)
2	A bibliometric analysis of Covid-19 researches using VOSViewer.	(Hamidah et al., 2020)
3	The latest report on the advantages and disadvantages of pure biodiesel (B100) on engine performance: Literature review and bibliometric analysis	(Setiyo et al., 2021)
4	A bibliometric analysis of management bioenergy research using VOSviewer application	(Soegoto et al., 2022)
5	Oil palm empty fruit bunch waste pretreatment with benzotriazolium-based ionic liquids for cellulose conversion to glucose: Experiments with computational bibliometric analysis	(Mudzakir et al., 2022)
6	Biomass-based supercapacitors electrodes for electrical energy storage systems activated using chemical activation method: A literature review and bibliometric analysis.	(Hamidah et al., 2023)
7	Bibliometric analysis of nano metal-organic frameworks synthesis research in medical science using VOSViewer	(Shidiq, 2023)
8	Past, current and future trends of salicylic acid and its derivatives: A bibliometric review of papers from the Scopus database published from 2000 to 2021.	(Ruzmetov et al., 2023)
9	Correlation between process engineering and special needs from bibliometric analysis perspectives.	(Nordin, 2022)
10	Bibliometric analysis for understanding the correlation between chemistry and special needs education using VOSviewer indexed by Google.	(Bilad, 2023)
11	Computing bibliometric analysis with mapping visualization using VOSviewer on “pharmacy” and “special needs” research data in 2017-2021.	(Sudarjat, 2023)
12	Nutritional research mapping for endurance sports: A bibliometric analysis.	(Firdaus et al., 2023)
13	Bibliometric and visualized analysis of scientific publications on geotechnics fields.	(Mulyawati et al., 2021)
14	A bibliometric analysis of computational mapping on publishing teaching science engineering using VOSviewer application and correlation.	(Nordin, 2022)
15	What is the correlation between chemical engineering and special needs education from the perspective of bibliometric analysis using VOSviewer indexed by Google Scholar?	(Wirzal et al., 2022)
16	Counselling guidance in science education: Definition, literature review, and bibliometric analysis.	(Solehudin et al., 2023)
17	Phytochemical profile and biological activities of ethylacetate extract of peanut (Arachis hypogaea L.) stems: In-vitro and in-silico studies with bibliometric analysis.	(Sahidin et al., 2023)

No	Title	Reference
18	A bibliometric analysis of materials research in Indonesian journal using VOSViewer	(Nandiyanto, 2021)
19	Research trend on the use of mercury in gold mining: Literature review and bibliometric analysis	(Nandiyanto et al., 2023)
20	Bibliometric analysis of educational research in 2017 to 2021 using VOSViewer: Google Scholar indexed research.	(Al Husaeni et al., 2023)
21	Bibliometric analysis of special needs education keyword using VOSviewer indexed by Google Scholar	(Al Husaeni et al., 2023)
22	Sustainable development goals (SDGs) in science education: Definition, literature review, and bibliometric analysis.	(Maryanti et al., 2022)
23	Computational bibliometric analysis of research on science and Islam with VOSViewer: Scopus database in 2012 to 2022.	(Al Husaeni et al., 2022)
24	Resin matrix composition on the performance of brake pads made from durian seeds: From computational bibliometric literature analysis to experiment.	(Nandiyanto et al., 2022)
25	Bibliometric Analysis of Briquette Research Trends During the Covid-19 Pandemic.	(Al Husaeni, 2022)
26	Computational Bibliometric Analysis on Publication of Techno-Economic Education.	(Ragadhita and Nandiyanto, 2022)
27	How bibliographic dataset portrays decreasing number of scientific publications from Indonesia	(Nandiyanto et al., 2020)
28	Research trends from the Scopus database using keyword water hyacinth and ecosystem: A bibliometric literature review	(Nandiyanto et al., 2024)
29	Bibliometric analysis of high school keyword using VOSviewer indexed by google scholar	(Al Husaeni and Nandiyanto, 2023)
30	How to calculate bibliometric using VOSviewer with Publish or Perish (using Scopus data): Science education keywords	(Al Husaeni and Al Husaeni, 2023)
31	Bibliometric analysis for understanding “science education” for “student with special needs” using VOSViewer	(Nursaniah et al., 2023)
32	Bibliometric analysis of research development in sports science with VOSViewer.	(Al Husaeni, 2023)
33	Bibliometric analysis of engineering research using VOSviewer indexed by Google Scholar	(Nandiyanto and Al Husaeni, 2022)
34	Bibliometric computational mapping analysis of publications on mechanical engineering education using VOSViewer	(Al Husaeni and Nandiyanto, 2022b)
35	Introducing ASEAN Journal of Science and Engineering: A Bibliometric Analysis Study	(Nandiyanto et al., 2023)
36	Introducing ASEAN Journal of Science and Engineering Education: A Bibliometric Analysis Study for Understanding Internationalization	(Al Husaeni et al., 2022)
37	Exploring Iron Oxide's Role in Hydrogen Production: Bibliographic and Bibliometric Analysis	(Nandiyanto et al., 2023b)
37	How Technology Can Change Educational Research? Definition, Factors for Improving Quality of Education, and Computational Bibliometric Analysis	(Al Husaeni et al., 2024)
38	Is Universitas Pendidikan Indonesia Ready for Internationalization? A Bibliometric Analysis in The Science and Technology-Related Publications	(Nandiyanto et al., 2023c)

No	Title	Reference
39	Social Impact and Internationalization of "Indonesian Journal of Science and Technology" the Best Journal in Indonesia: A Bibliometric Analysis	(Nandiyanto et al., 2023d)
40	Mapping of nanotechnology research in animal science: Scientometric analysis	(Kumar, 2021)
42	How to Calculate Statistics for Average Difference Test Using IBM SPSS Software: A Case Study of the Effect of Using Experimental Demonstration Methods on Students' Understanding of the Concept of Steam Engines as Power Generation	(Fiandini et al., 2023)

Given the scarcity of bibliometric studies of language research trends in learning science, this study aims to comprehensively analyze research progress and future directions in science teaching language. We take a macro approach to this topic by identifying and analyzing papers in the Scopus database using bibliometric methods. This study organizes large amounts of data and provides valuable insights for future researchers, allowing for precise analysis of the current situation

Research method

This research uses bibliometric analysis and visualization. Bibliometric analysis is a descriptive bibliometric that characterizes the characteristics of literary works. The sample used was 995 publications from the Scopus database using Publish or Perish software and the keywords "language", "science" and "learning". The research data collection period is from 2019-2023 and publications are in the form of journal articles, reviews, and books. The collected journal article documents are not directly used for visualization analysis with VOSviewer but are selected through selection with the criteria that the articles have important identifiers. Once the data meets requirements, it is then analyzed using VOSviewer. Detailed information regarding bibliometrics can be found in previous literature (Al Husaeni and Nandiyanto, 2022; Azizah et al., 2021) (see figure 1).

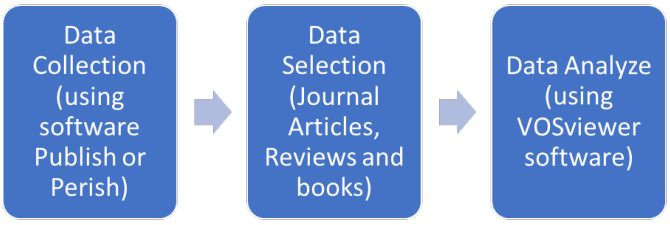

Figure 1. Bibliometric research procedures

Data analysis using VOSviewer software produces bibliometric visualization (Kelly et al., 2014). A map produced by VOSviewer software displays an in-depth bibliometric map. Thus, users can get comprehensive and in-depth data about bibliometric analysis (Manojkumar et al., 2019). VOSviewer produces three types of display results: network visualization, overlay visualization, and density visualization.

Bibliometric analysis techniques are divided into two, namely performance analysis and mapping (Kelly et al., 2014). Performance analysis was carried out to determine the number of publications per year, documents with the most citations, institutions with the most citations, and journals with the most citations as well as the use of the keyword Co-author. Meanwhile, mapping

is used for visualization which consists of network visualization, overlay visualization, and density visualization.

Results and discussion

Definition of learning science

Learning science is the process of acquiring knowledge, understanding, skills, and knowledge or values and new factors. Science learning covers all aspects related to the science learning process for students (Sjöström et al., 2015). Therefore, learning science is not only learning about concepts but also developing practical skills and understanding of scientific concepts in various aspects of life (Nuraeni et al., 2019; Dori & Sasson, 2013). Experts convey different definitions of learning science, including:

- Learning science is the systematic study of physical and natural structures and behavior.
- Learning science is learning science by individuals or groups through various approaches and methods, including laboratory experiments, conceptual learning, and the use of educational technology.
- Learning science includes learning and teaching processes that involve students in understanding concepts, developing laboratory skills, and understanding the application of science in everyday life.
- Learning science is learning about science and how to teach science to students effectively and efficiently.

Learning science involves the study of how students understand and learn science, as well as the development and application of effective teaching strategies and materials (Cheung, 2008). The aim of learning science is to increase conceptual understanding of science and increase students' ability to represent natural phenomena at various levels, such as symbolic, macroscopic, and particulate or submicroscopic (Herga et al., 2016). It also focuses on improving students' abilities in interpreting and using symbolic language, such as chemical equations, physics, and mathematics formulas.

Why is language important in learning science?

Language is a tool for human communication and cultural preservation. It is very important for society (Beckner et al., 2009; Medani & Sakti, 2022). Language is the main mechanism used by humans to convey ideas, concepts, and thoughts, including emotions and information to each other (Velentzas & Broni, 2014). Teamwork and group discussions will be effective if communication occurs very well. Individuals convey ideas and thoughts as well as feelings and desires through language (Kholila et al., 2023). Through language, a person can interact well with other people. Everyone can negotiate and agree to build social relationships (Haristiani & Rifai, 2021).

Language is very important in learning. Language as a medium for students to understand concepts and theories. Language skills are very necessary for academic performance (Elder et al., 2007). So it can be said that language development can influence students' cognitive development. Language helps individuals to think, reason, and solve problems (Baldo et al., 2015), and allows individuals to think abstractly so they can solve complex problems. As a group, language can be used to negotiate, exchange ideas, and even resolve conflicts. Therefore, the main function of language is to solve problems and make decisions (Sliwa, 2012). In other words, language is a fundamental aspect of human civilization that underlies communication, thought, culture, and

society. Furthermore, the importance of language in aspects of personal development to social interaction, education or learning, and scientific progress.

Consideration in making strategies in language for learning science

Formal and informal learning

Formal education is carried out in a structured, systematic manner and follows standard rules (Alonderien & Pundzien, 2008). Implemented institutionally and guided by a formal curriculum or program. Credit courses and programs offered by community colleges and universities are examples. Formal learning aims to produce recognition in the form of formal credit in a course. Meanwhile, informal learning is carried out unstructured and systematic and is carried out spontaneously (Yaşar & Karadeniz, 2011). This learning is carried out without using a curriculum and does not have definite aims and objectives. Informal learning can occur anytime and anywhere (Harrop & Turpin, 2013), and is often overlooked as real learning during the school year. Informal learning is the most difficult to measure but is important for students' cognitive development. Based on this description, it can be concluded that the difference between formal and informal learning is that formal learning is deliberate, measurable, and systematic, while informal learning occurs spontaneously, based on experience, and is not organized.

Education level to learning science

Education levels in the field of science can be differentiated based on the level of understanding, interests, and goals. The following are the levels of education related to learning science:

- Basic education (primary and middle school). At this level students will study the basics of science, for example in chemistry students learn about atomic structure, the periodic table, chemical properties, and simple chemical reactions such as acids and bases (Tanrere & Side, 2012; Citra et al., 2015; Apriani et al., 2020).
- Upper secondary education. At this level, students can choose to take further science subjects. Usually, students study chemistry in subjects such as organic and inorganic chemistry, advanced biology, and advanced mathematics (Priliyanti et al., 2021; Anggorowati, 2020).
- Higher education (college or university). If you want to study chemistry in depth, students can study chemistry at a university (Khalik & Talib, 2022), or mathematics, biology, or physics can also be studied at a university. All advanced topics in the field of science are studied at universities (Ethica and Si, 2020).
- Postgraduate (masters and doctorate). If students want to become experts in the field of science, they can continue their studies at the postgraduate level. Here students can pursue master's and doctoral degrees in the field of science. The studies are more advanced and may involve significant scientific research.

Apart from formal education, science learning can also be done through independent learning sources, such as journals, books, online courses, and tutorials. Science learning is a very broad field. Thus, it is important for students to determine the level of education that suits the students' goals and interests.

Curriculum development

The curriculum is a directed and structured plan and framework that describes what students will learn as they study, contains learning methods and resources as well as assessments and evaluations that will be used to measure success in learning (Johnson et al., 2023). Many papers

have been published so that the data can be retrieved (Widiaty et al., 2020; Namasivayam et al., 2023; Landero et al., 2022; Madaniah and Maryanti, 2023; Susilowati et al., 2023; Glushchenko, 2023; Rosina et al. al., 2023; al., 2021; Maryanti and Nandiyanto, 2021; Maryanti et al., 2021; Nursaniah, 2023; Glushchenko, 2024; Gatta et al., 2023; Jamiu, 2022). The curriculum consists of goals, objectives, content, and learning experiences as the main activities in the teaching and learning process (Wahyuni, 2016). The curriculum is created as a guide to teaching and learning for teachers and students, ensuring learning objectives are achieved and the learning process is cohesive and relevant.

Curriculum development is the process of creating a curriculum plan and structure for an educational program or course (DeLuca et al., 2010; Widiaty et al., 2020). Curriculum development refers to the content of the curriculum, namely content, objectives, methods, assessments, and learning resources used to facilitate learning (Maryanti & Nandiyanto, 2021). Apart from being complex and complicated, curriculum development aims to provide learning experiences to students in a coherent and effective manner (Bordage & Harris, 2011). Curriculum development is dynamic and focused, requiring collaboration between stakeholders to achieve a good learning experience for every student. Some steps that can be taken are:

- Needs Assessment: The first step in curriculum development is to assess the needs and goals of the learners and the educational institution. This involves understanding students' prior knowledge, skills, and abilities, as well as identifying desired learning outcomes and objectives.
- Goal Setting: Clear and measurable learning goals are set. These objectives define what students should know, understand, and be able to do by the end of the course or program. Goals should be aligned with needs assessments and relevant educational standards.
- Content Selection: Curriculum developers select the content, topics, and subject matter that will be covered in the course. This selection must be in line with the objectives that have been set and relevant to the needs and interests of students.
- Learning Strategy: Curriculum developers decide on the teaching methods, teaching materials, and resources that will be used to deliver content and achieve learning goals. This can include lectures, discussions, hands-on activities, technology-based tools, and more.
- Assessment and Evaluation: The development of assessment methods and tools is critical to measuring student learning and determining whether goals have been achieved. This includes designing quizzes, tests, projects, and other evaluation techniques.
- 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.
- 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.
- 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.
- Resource Development: Developing or selecting textbooks, materials, technology, and other resources that will support the curriculum is an important step.
- Pilot Testing: Before full implementation, the curriculum can be tested in a small-scale pilot program to identify any issues and make necessary adjustments.

- Teacher Training: Teachers and instructors who will deliver the curriculum need to be trained and given the necessary resources and support.
- Implementation: The curriculum is put into practice, and students are involved in the learning and assessment activities outlined in the curriculum.
- Evaluation and Revision: Continuous assessment and evaluation of the curriculum are essential. Feedback from students, teachers, and other stakeholders is used to make improvements and updates when necessary.
- Continuous Improvement: Curriculum development is not a one-time process; this involves ongoing review and adaptation to ensure it remains effective and relevant over time.

Technology in the laboratory as media to improve the way of language in delivering subjects in science

Integrating technology into laboratory environments can help students improve their language skills (Vanderplank, 2010), especially in educational contexts where students need to use a second language to conduct experiments and communicate their findings. Many papers are about how practical experiments, technology, and laboratories are used to improve students' understanding of what they are doing (Lumbu-ani et al., 2021; Nuhu et al., 2021; Azizah et al., 2022; Barke and Buechter, 2023; Owokoniran, 2024; Deximo and Lucero, 2021; Akiatan et al., 2021; Sison et al., 2024; Rosina et al., 2021; Ana, 2020).

Integrating technology in a laboratory environment allows educators to create immersive, language-rich laboratory experiences that not only improve students' language skills but also enhance their ability to conduct experiments and communicate effectively in scientific contexts. This approach can be particularly useful in international or multilingual educational environments.

- Virtual Lab is a virtual laboratory simulation that allows students to conduct experiments in a digital environment (Balamuralithara and Woods, 2009). These simulations often come with instructions and explanations in the target language, helping students improve their reading and comprehension skills.
- Multilingual Language Lab Software. The use of laboratory software in the target language can help students become more familiar with technical vocabulary.
- Collaborative Online Platforms, by using collaborative online platforms, students can work together on experiments, discuss findings, and share insights in the target language (Erdal and Seferoglu, 2017).
- Mobile Apps for Lab Data Collection (Zheng et al., 2018), mobile applications can be used for data collection during experiments. Students can record data, take notes, and communicate results in real-time, all while using the target language.
- Digital Lab Notebooks, digital laboratory notebooks allow students to keep detailed notes of student experiments in electronic format (Bird et al., 2013).
- Augmented Reality (AR) and Mixed Reality (MR) (Mills, 2022). AR and MR technologies can overlay information, instructions, and explanations in the target language onto real-world laboratory equipment and environments, thereby aiding comprehension.

Correlation between language and student condition, motivation, and teacher-student relationship, counselling, and psychological condition student relationships, counselling, and psychological conditions

Over the past 30 years, language has been central to approaches to learning and teaching that seek to replace mechanistic learning based on prescriptive principles by developing learners'

understanding of, and metalinguistic skills in, speaking. Therefore, it is not surprising that the concept of language awareness is largely applied in language teaching as well as education more broadly (Koller, 2018). Language has a relationship with students' conditions because language in the classroom environment facilitates teachers and students to interact with each other to develop students' abilities (Peeters, 2018). Language facilities in this learning environment help students acquire basic knowledge such as counting, reading, writing, listening, and expressing their needs or feelings. Apart from that, language facilities in the classroom can also be a place to build students' self-confidence, discipline, responsibility, and social skills which will have an impact on students' educational success (Mirrahimi et al., 2011). One factor in the success of students' education is greatly influenced by students' motivation in carrying out learning activities. Motivation is energy that can stimulate students' efforts to achieve certain goals. Motivation cannot be separated from education. This is because motivation determines students' conditions, responses, and quality of students in learning activities (Sulihin et al., 2020). In short, students need motivation to support and make them enjoy the learning process. Students who are not motivated will easily get bored. This is because everyone needs motivation in their life to achieve achievements.

Furthermore, much evidence supports a link between language learning difficulties and behaviour in young children and this is especially true for children raised in disadvantaged social conditions. Little is known about the way various aspects of language, especially pragmatics, interact with behaviour. The exact mechanism of the relationship between emotional health and language ability is still unclear. The developmental factors that may be involved fall into two main categories: gene-environment influences and factors internal to the child. Gene-environment influences may include the fact that parents of children with language barriers experience higher rates of emotional health problems which in turn may impact the level of family support available to children and adolescents. Additionally, developing relationships with peers can also be problematic for children with language barriers (Griffiths et al., 2020).

Other research also shows that the way people use words conveys a lot of information about themselves, their audience, and the situations they face. A person's choice of words can provide clues about their social status, age, gender, and motives. We sense whether the speaker or writer is emotionally close or distant, thoughtful or shallow, and perhaps extraverted, neurotic, or open to new experiences. Literature provides some interesting examples in his discussion of parallax, or slips of the tongue. Common mistakes in speaking reveal a person's deepest motives or fears. Drawing on psychoanalysis, the unconscious expresses itself through language. It is true, that language, in his view, is a bridge to reality. In addition, the literature also argues that the way we describe events determines the meaning of the event and this meaning helps us continue to understand reality. Similar assumptions are implicit in much sociolinguistic research (e.g., Eckert 1999, Tannen 1994), narrative and discourse analysis, and communication research (Pennebaker et al., 2003).

Other studies have looked at the impact of teacher language style on students' academic self-efficacy. To create an effective learning environment, lecturers employ a variety of language styles. The language style conveyed in this case is the way they express themselves (Gunawan et al., 2019). Language style as a communication medium has a significant impact on a communication event. It should be simple to accept and comprehend so that the purpose of the speech act can be effectively carried out. The resulting speech may reflect the speaker's characteristics. The better a person's language style, the better the person's assessment of the person—the worse a person's language style, the worse the person's assessment. The psychological

impact can be in the form of self-motivation, self-efficacy, and the creation of good interpersonal relationships, and vice versa (Gunawan and Kadir, 2017). Experts are increasingly agreeing that cultural, linguistic, and social factors have an impact on learning. Language use, as previously stated, can affect self-efficacy. Students will be motivated to do something they want to achieve in terms of learning if they have self-confidence in their abilities. As previously stated, self-efficacy is a psychological state influenced by the use of language styles. The third source of self-efficacy formation is social or verbal persuasion. This social persuasion can include other people's verbal assessments of someone. As a result, the third source of self-efficacy is frequently referred to as verbal persuasion. A person who obtains verbal information about his or her ability to master a particular job or task tends to make greater efforts and be more diligent in completing a task. Positive persuasion can encourage and support someone and conversely, negative persuasion can weaken self-efficacy (Gunawan et al., 2019).

Application of technology in media to improve the way of language in delivering subjects in science

The application of technology in the media as an effort to grow students' language skills is a good and effective approach during the language learning and teaching process. Technology is an interesting thing in utilizing communicative, effective, and efficient learning experiences (Al Husaeni et al., 2022). Various technologies can be used to train language skills to support the science learning process. The application of technology in media provides greater flexibility and accessibility for students (Izzo, 2012). The role of technology also provides space for expression for students in improving listening skills, speaking skills, reading skills, and writing skills. The following are types of technology that are applied as learning media to foster language competence in delivering science teaching material.

- Language Learning Apps, there are many language learning apps available for smartphones and tablets that offer interactive lessons, vocabulary practice, and pronunciation practice (Heil et al., 2016).
- Language Exchange Platforms, online platforms, and applications such as Tandem, HelloTalk, and Speaky connect language learners with native speakers for language exchange (Kessler, 2021). Students can practice speaking and listening with native speakers via text, voice, or video chat.
- Virtual Reality (VR) and Augmented Reality (AR), VR and AR can provide an immersive language-learning experience (Blyth, 2018).
- Online Language Communities, online forums, discussion groups, or social media communities dedicated to language learning can expose students to native language use and cultural insight (Lomicka, 2020).
- Language Learning Websites, many websites, and platforms, such as BBC Languages, Duolingo, and Memrise (Bączkowska, 2021).
- Language Learning Games, gamification of language learning through educational games and quizzes can make the learning process more interesting and fun (Prathyusha, 2020).
- Podcasts and Audiobooks, listening to podcasts or audiobooks in the target language can help improve listening comprehension and pronunciation (Gündüz, 2006).
- Automatic Translation Tools such as Google Translate can help students translate texts from their native language to the target language and vice versa (Stapleton and Kin, 2019).

- E-books and E-readers, e-books in languages can help students improve their reading skills and expand their vocabulary (Korat et al., 2014). E-readers often offer built-in dictionaries for quick word lookups.
- Language Learning YouTube Channels, there are many YouTube channels dedicated to language teaching (Brünner, 2013; de Azevedo Fay and Matias, 2019).

Improving literacy and the effect of language

Improving literacy and language effects an effort to improve good communication skills, through training in understanding information or data, and direct practice in the community. Here are some ways to improve literacy and language effects:

- Read Regularly. One of the best ways to improve literacy is to read regularly (Teguh, 2020). Read a variety of materials, including books, magazines, news articles, and poetry. Don't just stick to one type of reading material. Diverse reading will expand vocabulary and understanding.
- Discussion and Debate. Engaging in discussions and debates with others can help in practicing speaking and listening skills, as well as increase understanding of various perspectives (Wagu and Riko, 2020).
- Write. Practice writing regularly by writing essays, personal journals, or even blogs. Writing can help organize thoughts better and improve written communication skills (Karlina, 2017).
- Analyze the Text. Learning to analyze texts critically includes the ability to identify arguments, analyze data, and evaluate evidence. This activity can help in better understanding the material read (Pratama, 2016).
- Take a language class. Consider taking a language course or a literacy course. This activity can provide guidance and feedback from an experienced instructor.
- Talk to Other People. Engage in conversations with other people, especially people who speak a different language or have a different cultural background. This will broaden understanding of language use in different contexts.
- Read about Topics of Interest. Reading about topics that interest you can help you sharpen your understanding of the specific language in that field. This also makes learning more fun.
- Watch films and listen to music in the language you are learning. Watching films, listening to music, or following television programs in the language being studied are fun ways to strengthen your understanding of the language (Sari and Lestari, 2019).

Barriers to language for special needs

Students with special needs require different treatment from other students (Maryanti et al., 2021; Rahmat, 2022). Language barriers for individuals with special needs can present significant challenges in many aspects of their lives. These barriers can hinder communication, access to education, and participation in society. Individuals with speech and language disorders may have difficulty articulating words clearly or understanding spoken language, making effective communication difficult (Prelock et al., 2008). People with writing and reading disabilities, such as dyslexia or cerebral palsy, may have difficulty spelling words correctly or understanding written text (Roitsch and Watson, 2019; Abidin et al., 2021). Special needs children who rely on sign language may face obstacles if they encounter people who do not understand or communicate in sign language.

Presenting information through pictures or symbols makes it easier for students with special needs to understand, so the use of visual aids or alternative communication methods is

something that must be done. People with language processing disorders may have difficulty understanding complex or long sentences, so information must be presented in a simplified manner (Booth et al., 2000). Individuals with a diagnosis of autism or Communication Spectrum Disorders may experience difficulties in social communication and may require special communication strategies tailored to their needs (Gittins et al., 2018).

Using an inclusive approach and considering alternative communication methods tailored to the needs of students with special needs is important. Ways to overcome language barriers in people with special needs may involve the use of communication aids, sign language interpreters, augmentative and alternative communication (AAC) devices, or other assistive technologies (Baxter et al., 2012). Additionally, increasing awareness and understanding of the needs of individuals with language barriers can help create a more inclusive environment for them. It is important to realize that communication is not limited to spoken or written language, and alternative methods can also be valid and effective.

New technology for improving language in education difficult subject

Language learning becomes easier with the help of technology. Current technological developments allow language learning to be more effective. For many years, educators and researchers have used technology to aid language learning and instruction. According to Merriam-Webster technology is defined as technical processes, methods, or knowledge used to complete a task. Based on this definition, we define technology in the context of this study as the use of technical processes, methods, or knowledge to complete a learning task or instructional goal. Because of recent technological advancements, educators now have more opportunities to use technology for education. Several researchers examined related studies to determine which technologies were used in language learning shown in Table 2 (Golonka et al., 2014).

Table 2. Reviewed technologies, their brief descriptions, and some affordances of each

Technologies	Brief Description	Example affordances for language study
Schoolhouse- or classroom-based technologies Course management system (CMS)	A server-based application that displays materials and services required for blended or distance learning (for example, syllabi, required readings, calendars, and so on). Teachers and students use a web browser to access a CMS over a network via a menu-driven interface.	● Allow course materials to be shared, allowing access to content at any time and from any location. ● Facilitate the organization of course content as well as teacher-student and student-student communication.
Interactive white board	A computer, a projector, and a display panel, which is a large freestanding or wall-mounted touch-sensitive screen, comprise an interactive display. The projector displays an image of the computer screen on the screen, which all students in the classroom can easily see.	● Encourage interactive activities and collaborative work among students and teachers. ● Improve motivation and attitudes toward learning. ● Incorporate authentic internet-based content into classroom lessons.

ePortfolio	A digital archive of a learner's student work that documents evidence of the learner's experiences, progress, achievements, and self-reflections.	● Encourage learner autonomy and self-assessment. ● Emphasize the learning process rather than the products of learning. ● Facilitate the development of self-assessment skills and the setting of learning goals.
Electronic dictionary	An electronic dictionary, either handheld or online	● Accelerate searches for lexical items so that looking up words does not significantly disrupt the reading process. ● Allow for different search preferences and learning styles. ● Encourage customized and elaborated input
Automatic speech recognition (ASR) and pronunciation program	A technology that allows a computer to recognize the words spoken into a microphone. ASR is frequently used as a component of speech pronunciation software, identifying specific parameters of the learner's output, such as prosody or specific sounds, and providing feedback on these aspects of performance.	● Compare the student's pronunciation to the target pronunciation and provide feedback. ● Allow the learner to work on his or her speaking ability at his or her own pace. ● Allow students to engage in simulated dialogue with a computerized agent.
Network-based social computing Virtual world	A virtual world is a program that allows students to move a character representation, or "avatar," through a 3-D graphical environment. A serious game is a virtual environment or traditional computer game in which users' activities are guided or limited by the program and they must complete a specific goal or set of goals.	● Provide virtual meeting rooms. ● Allow learners to navigate simulated environments, such as those modeled after target language locales and incorporating culturally relevant objects. ● Encourage role play by allowing students to take on the roles of various characters in a scenario.
Chat	A type of synchronous computer-mediated communication that can be text-based or audio-based.	● Maintain interaction logs that can be printed for review and used as an assessment tool (Tudini,

		2003). ● Allow students to communicate and collaborate with one another or with native speakers without regard for distance or location.
Social networking	Peer-to-peer communication and collaboration are possible through social networking sites such as Facebook and MySpace. Users establish their social networking presence by creating personal profile pages and then joining networks based on geography, interests, associations, or friendships.	● Support user networking as well as the ability to communicate with others who share similar interests. ● Allow interaction with native speakers and other target language students. ● Allow synchronous as well as asynchronous communication.
Blog	A web application that displays blog entries with time and date stamps and is visible to other web users.	● Support personal journaling or blogging, and allow feedback in the form of blog comments. ● Promote collaborative learning.

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

Metric results

Google scholar search results for language publications in science learning in 2019-2023. Metadata found 995 papers. The number of citations for all publications was 337,777. while the average number of citations per year is 84,319 and the average number of citations per article is 3.53 (see table 3). Google Scholar has indexed 254 language publications in science learning, with a G-index of 544. The H-index is a matrix used to assess the contribution and impact of scientific publications by researchers (Chapman et al., 2019). The number of citations for all articles published by a researcher can be used to calculate the H-index. The h-index in this study was 254, indicating that 54 papers had been cited at least 254 times.

Table 3. Result metrics publication on language in chemistry learning.

Publication years	2019-2023
Citation years	4
Papers	995
Citations	337277
Cites/year	84319.25
Cites/paper	338.97
Author/paper	3.53
h-index	254
g-index	544

hI, norm	148
hI, annual	37.00
hA-index	153

Publication trend

Figure 2. Shows the trend of publication of discussions in science learning from 2019-2023. The average number of publications per year during this period was 345 (2019), 334 (2020), 189 (2021), 75 (2022), and 48 (2023). Based on the data, publication trends are recorded according to each year. The highest number of publications occurred in 2019 and the lowest number of publications occurred in 2023. Many factors cause a decrease in the number of publications each year on the topic of language in science learning. The following are several factors that might cause, including:

- The focus of educational research could have shifted to other areas, such as technology in education, science learning, or educational policy. Although language education is critical, academic priorities can shift over time (Luke, 2003).
- Language education research can be both theoretical and applied. A shift toward more applied research that focuses on practical teaching methods and strategies may not always be visible in traditional academic publications, but it can have a significant impact in the classroom.
- Changes in educational policy at the national or regional levels may also have an impact on research direction (Aikens et al., 206). Researchers could look into the effects of policy changes versus specific language teaching methods.
- Extraordinary events, such as an economic crisis or a global pandemic, may have an impact on education and research systems (Srivastava and Agarwal, 2020). Resources may be diverted to address pressing issues, causing research projects to stall.
- Technology has had a significant impact on education, including language education. Rather than traditional teaching methods, researchers may concentrate on the impact of technology on language learning (Warschauer, 2002). The rise of open-access journals and online platforms, for example, can alter how and where research is published, making it difficult to track all ongoing research activity.

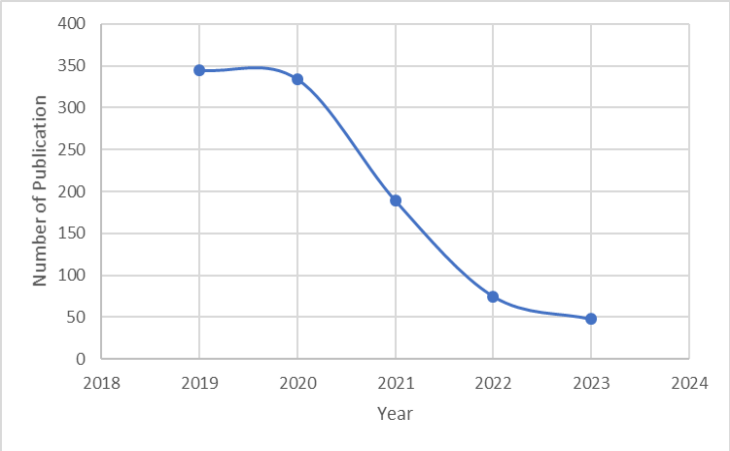

Figure 2. Annual publication report on language in chemistry research based on Google Scholar data

Article trend

Academic researchers highly uphold academic integrity by quoting the scientific work of previous research, becoming a basis for scientific development, creating new knowledge and research arguments becoming a solid foundation in the wider scientific literature (Jomaa and Bidin, 2017). In addition, citations have become the most popular method for measuring the impact of publication quality in a particular field. Connecting topics with authors, groups and even countries (Cao et al., 2016). Apart from the potential for bias due to the frequent occurrence of authors citing their own work, bibliometric analysis provides an overview of the overall quality as a tool for evaluating scientific journals (Agarwal et al., 2016; Roldan-Valadez et al., 2019). In this research, ten papers were presented with the highest number of citations in the field of language in science learning, reaching more than 4,207 citations, namely the article "BioBERT: a pre-trained biomedical language representation model for biomedical text mining." In addition, the tenth most cited article was entitled "Array programming with NumPy" (Lee et al., 2020) (see table 4).

Table 4. Top nine most cited articles

No	Cites	Title	Ref
1	2259	PubChem in 2021: new data content and improved web interfaces	(Kim et al., 2021)
2	2370	Simplifying graph convolutional networks	(Wu et al., 2019)
3	2458	Deep learning and process understanding for data-driven Earth system science.	(Reichstein et al., 2019)
4	3152	Transformers: State-of-the-art natural language processing. In Proceedings of the 2020 conference on empirical methods in natural language processing: system demonstrations	(Wolf et al., 2020)
5	4207	BioBERT: a pre-trained biomedical language representation model for biomedical text mining	(Lee et al., 2020)
6	5281	Neuroscience: exploring the brain, enhanced edition: exploring the brain	(Bear et al., 2020)
7	5428	A comprehensive survey on graph neural networks	(Wu et al., 2020)
8	6629	Bart: Denoising sequence-to-sequence pre-training for natural language generation, translation, and comprehension	(Lewis et al., 2019)
9	11329	Graph neural networks: A review of methods and applications	(Zhou et al., 2020)

Co-occurrences analysis

Co-occurrence analysis is used to see patterns in the number of events that frequently occur (Kim et al., 2020). Co-occurrence analysis in this research is used to see the frequency of words or terms that frequently appear in the language in science learning using bibliometric analysis and VOSviewer software. Every word or term that appears is marked with a node relationship. The research uses two types of visualization, namely network visualization (Figure 3) and overlay visualization (Figure 4).

Figure 3 shows a network visualization of the language field in science learning. The terms that appeared were limited to a minimum of 6 times. Thus, 128 terms were found. The 128 terms are grouped into 4 clusters.

Cluster 1, marked in red, is centered around the keyword “student” and shows a total link strength of 245 with 95 occurrences. This group includes various relationships with terms such as "language learning", "practice", "foreign language", and "education". Cluster 1 whose relationship shows that education provides a formal structure for language learning, including foreign language learning. Practice is the bridge between theoretical knowledge and practical language skills (Resch and Schrittesser, 2023). Regular and meaningful practice, often facilitated by education, is essential to mastering a foreign language. These elements are interconnected to form a symbiotic relationship that supports the acquisition of language and effective communication skills.

Cluster 2, highlighted in green, is centered around the main keyword 'machine' and shows a total link strength of 246 with 119 occurrences. Within this group, several related terms are found, including 'language processing', 'machine learning approaches', 'neural network', 'discovery', 'supervised learning', and 'unsupervised learning' whose connection is that language processing benefits significantly from machine learning approaches such as supervised learning and unsupervised learning. These techniques enable the discovery of meaningful patterns and insights in textual data, thereby improving our ability to process and understand language in a variety of applications (Torfi et al., 2020).

Cluster 3, depicted in blue, shows a total link strength of 320 with the occurrence of 113 terms. Important terms in this group include 'deep learning', 'language translation', and 'material science'. These terms are closely related to deep learning which serves as a foundational technology that has significantly improved language translation systems, making cross-language communication and collaboration more accessible. Additionally, deep learning techniques are applied in materials science to analyze and understand complex data sets, aiding the discovery and development of new materials (Akay and Hess, 2019). The intersection of these advances is driving global scientific collaboration and accelerating progress in both fields.

Cluster 4, depicted in yellow, shows a total link strength of 224 with the occurrence of 88 terms. Important terms in this group include 'natural language process', 'transfer learning', and 'language model'. These terms are closely related to language models which are the basis of natural language processing that provides the ability to understand and produce human language. Transfer learning improves this process by allowing pre-trained language models to be adapted, enabling faster development and improved performance in a variety of language processing applications.

Figure 4 depicts a cluster analysis using keyword terms to search for the most common research subjects. Overlay visualization is used to illustrate frequently occurring terms based on the year of publication. Notably, by 2020, terms such as 'learning process,' 'language model,' and 'large language model' (represented by yellow dots) had not been thoroughly researched.

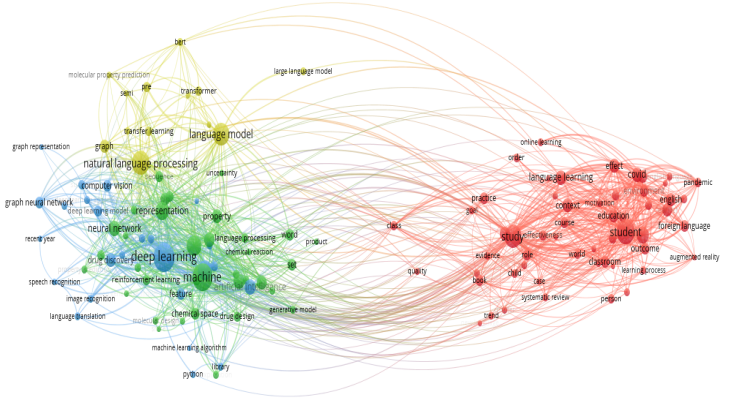

Figure 3. Network visualization from the language in chemistry learning subject

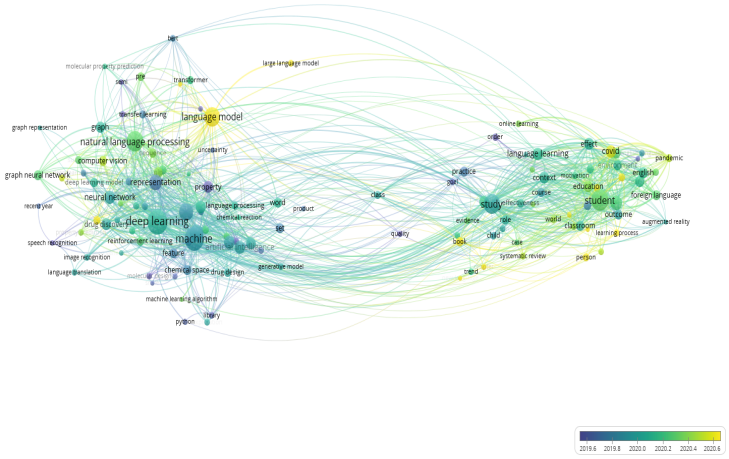

Figure 4. Overlay visualization from the language in chemistry learning subject

Conclusion

This research examines the evolution of language research in science learning which can improve the quality of teaching and learning in the field of science, as well as explaining several factors that influence the learning process and bibliometric analysis (from Google Scholar from 2022 to 2022). Language and student characteristics, motivation, teacher-student relationships, therapy, and psychological conditions can all be concluded to be closely interrelated. Language is another important factor that can enhance the learning experience. Language style should be adapted to the situation and psychological conditions of students. Thus, students can receive learning well. This article is used as material for readers to consider in understanding current conditions regarding the importance of language in science learning.

Declaration of conflicting interest

The author declares that there is no conflict of interest in this work.

Funding acknowledgements

The research received no external funding.

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