Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Text Analytics: "Graphic Visualization in Education and a Scientometric Analysis Using R Tool to Explore the Impact and Trends in Classroom Learning."

Maran Chanthiran[1,*], Abu Bakar Ibrahim[1], Mohd Hishamuddin Abdul Rahman[1], Punithavili Mariappan[2], Dagmar Ruskova[3]

[1] Faculty of Computing and Meta-Technology, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, Malaysia
[2] Faculty of Sustainability Arts and Creative Industry, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, Malaysia
[3] Slovak University of Technology, Vazovova 2757/5 81107 Bratislava, Slovak Republic

ARTICLE INFO

Article history:
Received 22 June 2023
Received in revised form 3 September 2023
Accepted 21 October 2023
Available online 28 February 2024

Keywords:
Text Analytics; Graphic Visualization; Artificial Intelligence; Technology Aids

ABSTRACT

Text analytics can be applied in education to gain insights into student learning, teacher performance, and educational trends by analysing various forms of text-based data such as student essays, social media posts, and educational resources. While the need for teacher preparation and training is identified, specific solutions or effective strategies for equipping educators with the skills and knowledge to integrate graphic visualizations into their teaching practices might be underexplored. This Scientometrics study used PRISMA approach (Preferred Reporting Items for Systematic Review and Meta-Analysis) Using R tool. Scopus databases that were relevant to the research topic, and its standardized procedures ensured comprehensiveness and replicability. The study found 85 articles using the PRISMA approach from the Scopus database, with 98.82% being articles and 1.18% from conference proceedings. The number of articles published increased in 2022, with 33 articles, compared to 22 articles in 2020. The total number of cited papers was 70, with a total citation of 969. This indicates an increase in research related to graphic visualization in education due to technological advancements. The citation per cited paper was 119. Besides, the study identifies the top 10 countries that have conducted research in graphic visualization, with the United States leading with 19 studies followed by China with 12 and Spain with 8. The top three subject areas in the current research trends are Computer Science education with 78 publications, Engineering education with 33, and Social Science education with 14. Other fields related to language and linguistics are also being given special attention. These findings suggest that education systems and research in education are keeping up with global developments. There is potential for visualizations to be integrated with AI technologies to provide personalized learning experiences, while ensuring that visualizations are accessible to all students, including those with visual impairments. Studies have shown that using these approaches in education can enhance student learning and understanding of complex concepts.

* *Corresponding author.*
E-mail address: maranchanthiran@gmail.com

https://doi.org/10.37934/araset.40.2.112

1. Introduction

Text analytics, also known as text mining, is the process of analysing unstructured data such as written text to extract useful insights and knowledge. In education, text analytics can be used to analyse various forms of text-based data such as student essays, social media posts, and educational resources to gain insights into student learning, teacher performance, and educational trends. The importance of text analytics in education lies in its ability to provide data-driven insights that can inform decision-making, improve teaching and learning outcomes, and enhance educational research. For instance, text analytics can be used to identify patterns and trends in student writing that can help teachers identify areas where students need more support or differentiate instruction based on student needs. It can also be used to analyse educational resources such as textbooks and online materials to determine their effectiveness in promoting student learning.

According to [1], text analytics has the potential to transform education by providing real-time feedback and personalized learning experiences for students. The authors argue that the use of text analytics can help educators identify individual learning styles, tailor instructional strategies to meet the needs of different students, and track student progress more effectively. In addition, a study by [2] found that text analytics can be used to analyse online discussion forums to identify topics and themes that are of interest to students and to determine the effectiveness of online discussions in promoting student learning. Text analytics is a powerful tool that can help educators and researchers gain insights into student learning, teacher performance, and educational trends. Its importance in education is likely to grow as the amount of digital data generated by students and teachers continues to increase.

Technology that has enabled the widespread use of graphic visualization is the development of software tools such as Tableau and Power BI. These tools allow users to create interactive and dynamic visualizations of data, making it easier to explore and analyse complex datasets. In education, these tools can be used to visualize student performance data, demographic data, and other information to help educators make data-driven decisions [3].

Text analytics can be used to analyse student writing and provide feedback that can improve their writing skills. Using automated text analysis improved student writing skills by providing specific feedback that students could use to improve their writing [4]. Text analytics can also be used to analyse teacher performance, such as classroom observations and evaluations. By using text analytics to analyse teacher evaluations provided insights into the strengths and weaknesses of teachers, which could be used to improve teacher performance [6]. Text analysis of teacher feedback from online forums helped to identify areas where teachers needed additional support [5].

Technology that has enabled the use of graphic visualization is virtual reality (VR) and augmented reality (AR) technologies. These technologies allow users to immerse themselves in a virtual or augmented environment and interact with data in new and innovative ways. In education, VR and AR can be used to create immersive learning experiences, allowing students to explore complex concepts and ideas more engagingly and interactively [7].

Additionally, the use of technology has also enabled the development of new types of visualizations, such as network graphs, heat maps, and word clouds. These types of visualizations can provide new insights into data and information that may not be easily understood through traditional methods of visualization [5]. So, this review is to explore the use of graphic visualization and examine the trends and impact in education using Scientometric analysis.

Text analytics has become an increasingly popular tool in education, particularly in the area of learning analytics. Learning analytics involves collecting, analysing, and using data about learners and their contexts to understand and optimize learning and the environments in which it occurs. Text

analytics can be used to analyse a wide range of educational data, including text-based data such as student essays, discussion forum posts, and social media posts.

According to [6], text analytics has the potential to transform education by providing insights into student learning and engagement. The authors note that text analytics can be used to analyse patterns in student writing, identify gaps in learning, and track student progress over time. They also suggest that text analytics can be used to personalize learning by providing students with individualized feedback and recommendations based on their learning styles, interests, and needs.

The use of text analytics in higher education to support student success [7]. The authors found that text analytics can be used to identify at-risk students and provide targeted interventions, as well as to support faculty in developing more effective teaching strategies. These studies suggest that text analytics has the potential to transform education by providing new insights into student learning and engagement. By analysing large datasets of text-based data, text analytics can help educators to identify patterns and trends, as well as develop personalized learning experiences for individual students. As the field of learning analytics continues to grow, text analytics will likely become an increasingly important tool for educators and researchers alike.

The use of interactive visual aids, such as simulations and animations, improved students' understanding of physics concepts and helped to bridge the gap between abstract theories and concrete phenomena [8]. The authors concluded that the use of graphic visualization can enhance the quality of instruction and improve student performance. Data visualization techniques can be used to present complex data in a clear and understandable format, allowing researchers to identify patterns and trends. For instance, data visualization was used to analyse the effects of the COVID-19 pandemic on nursing education [9]. The authors used charts and graphs to illustrate the impact of the pandemic on nursing program enrolment and completion rates, as well as to identify the challenges faced by nursing students and educators. By presenting information in a visual and interactive format, graphic visualization can help to engage students and improve their understanding of complex concepts. Additionally, it can help researchers to identify patterns and trends in educational data, ultimately leading to more effective educational practices and policies.

A meta-analysis by [10] examined the impact of various teaching methods on students' learning outcomes. The authors found that the use of graphic organizers, which are visual aids that help students organize and understand information, had a positive effect on students' learning outcomes across multiple subjects and grade levels. Students who received instruction with graphic visualization had higher scores on their exams and performed better on programming assignments compared to those who received traditional instruction. On the other hand, the finding shows the use of graphic visualization can enhance students' problem-solving skills and improve their performance in programming tasks [11].

One of the most significant challenges with text-based data in education is the quality of the text itself [12]. Text quality can be affected by factors such as spelling errors, grammatical mistakes, and the use of informal language [13]. Text-based data can often be ambiguous, making it challenging to interpret the data accurately. Ambiguity can arise from factors such as multiple interpretations of words or phrases, sarcasm, and idiomatic expressions [14].

These studies suggest that the use of graphic visualization in classroom learning can have a positive impact on students' learning outcomes. By presenting information in a visual and simplified format, graphic visualization can help students to understand and remember complex concepts, improve their problem-solving skills, and enhance their performance on exams and assignments [15]. And in this study focus on text analytics and graphic visualization use in education. Research in this area can provide insights into how cognitive processes are influenced by visual learning [16]. This can lead to the design of visualizations that align with how the human brain processes and retains

information. Based on the literature below the research question will be answered in this review paper:

i. How far has the graphic visualization approach in education research progressed in the publication?
ii. What is the scientific productivity pattern in the graphic visualization approach in education field research?
iii. What is the main area of the graphic visualization approach in education research?
iv. What is the future direction of the graphic visualization approach in education?

2. Methodology

This section explains the selection of appropriate methods and procedures for data collection and analysis, as well as the development of a research framework and research questions.

2.1 Scientometric Analysis

Scientometrics is the quantitative study of science, technology, and innovation. It involves the analysis of bibliographic data, citation patterns, and other quantitative indicators to measure and evaluate the productivity, impact, and influence of scientific research [17]. The scientometric analysis is used in various fields, including research evaluation, science policy, and information science [18-20]. This study used Scientometric analysis typically involves the use of bibliographic databases, citation analysis tools, and other statistical methods to identify patterns and trends in scientific research.

2.2 PRISMA Approach (Preferred Reporting Items for Systematic Review and Meta-Analysis)

To address the research questions, this study utilized the PRISMA approach (Preferred Reporting Items for Systematic Review and Meta-Analysis) in combination with Scientometric analysis Using the R tool. The PRISMA approach as shown in Figure 1 facilitated the selection of articles from Scopus databases that were relevant to the research topic, and its standardized procedures ensured comprehensiveness and replicability. The inclusion criteria are characteristics that studies must possess to be considered for inclusion in the review [21,22]. In this study, the inclusion criteria required as below:

i. Publication type: the study focuses on research articles and conference proceedings.
ii. Period: The study was limited to articles published between 2019-2023
iii. Research field: The study focuses on graphic visualization in education
iv. Language: English

The exclusion criteria help to refine the analysis and ensure that the results are relevant and reliable. The exclusion criteria for this Scientometric study include:

i. Publications that are outside the scope of the research area or research question would be excluded. In this, a Scientometric analysis of research publications in the field of genetics would exclude publications on unrelated fields such as non-technology graphic visualization.

ii. Publications that are not written in English excluded.
iii. Publications that lack essential data such as the author's name, the publication date, the growth of research output, and other bibliometric information are excluded.
iv. Publications that are duplicated across multiple databases or sources are excluded.

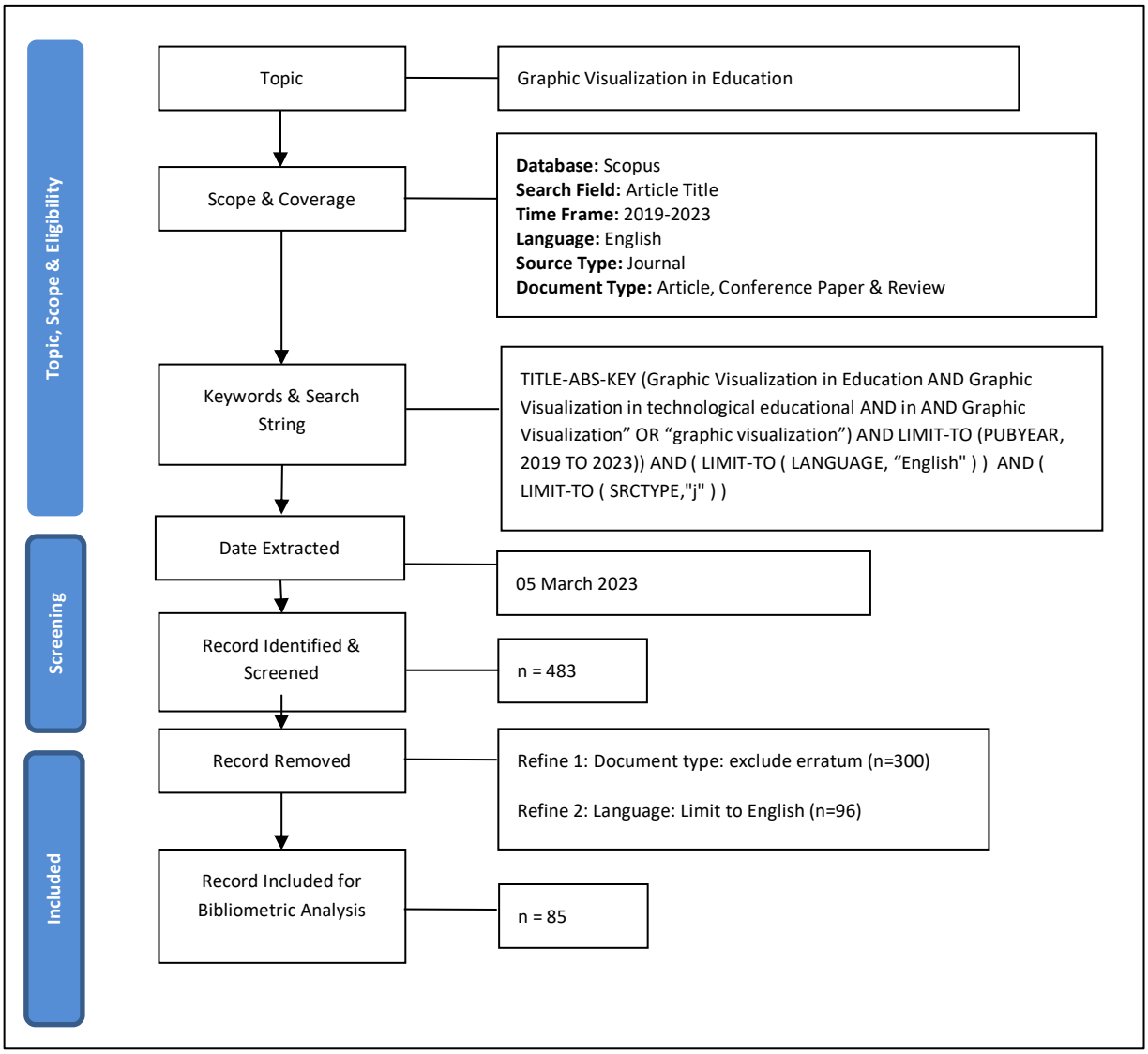


Fig. 1. PRISMA flowchart of data inclusion and exclusion [23]

3. Findings

3.1 Progressed in the Publication on Graphic Visualization Approach in Education

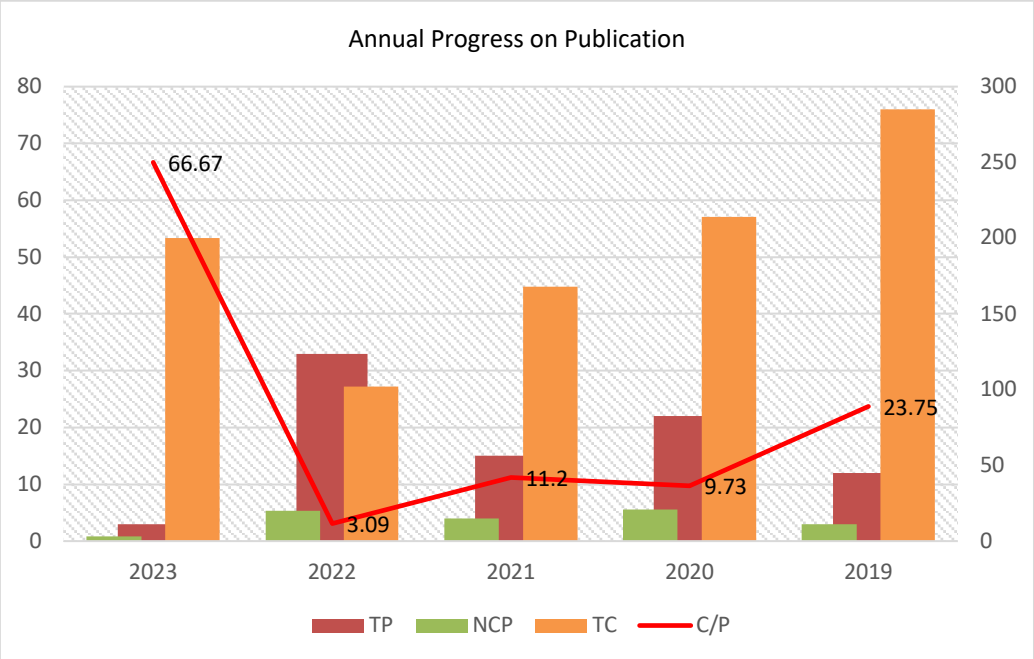
A total of 85 studies were found using the PRISMA approach from the Scopus database. The Scopus database was selected for this study because being indexed in Scopus is considered an indicator of journal quality and impact, as it meets certain criteria for scholarly publishing, such as peer review and editorial standards. The findings as shown in Table 1 mentioned that 98.82% of the studies are articles and 1.18% are from conference proceedings.

Table 1
Annual Progress on Publication of Graphic Visualization

Year	TP	%	NCP	TC	C/P	C/CP	h	g
2023	3	3.53%	3	200	66.67	66.67	0	0
2022	33	38.82%	20	102	3.09	5.10	5	9
2021	15	17.65%	15	168	11.20	11.20	7	12
2020	22	25.88%	21	214	9.73	10.19	9	13
2019	12	14.12%	11	285	23.75	25.91	6	11
Total	85	100.0%	70	969	114.4	119.1	27	45

*Total Publication (TP), Number of Cited Publication (NCP), Total Citation (TC), Citation Per Paper (C/P), Citation per Cited Paper (C/CP), Hirsch index (-h), G index (-g)

The results indicate as in Figure 2 that the number of articles published from 2019 to 2023 is 85, and the trend shows that 38.82% of them were published in 2022, which is 33 articles compared to other years. Furthermore, 22 articles were published in 2020, and the total number of cited papers (NCP) is 70, with a total citation (TC) of 969. This indicates an increase in publications and research related to graphic visualization in education, reflecting the growing importance of graphic visualization based on technological advancements. Meanwhile, the citation per cited paper (C/CP) shows a metric of 119.1, confirming the study's findings of an increase in research in the field of graphic visualization. Finally, Table 1 shows that there are 27 articles indexed in h and 45 indexed in g. Both the h-index and g-index have been widely used in the academic community as a way to evaluate the impact and productivity of researchers, although they are not without their limitations and criticisms.



*Total Publication (TP), Number of Cited Publication (NCP), Total Citation (TC), Citation Per Paper (C/P)
Fig. 2. Annual Progress on Publication of Graphic Visualization

3.2 Scientific Productivity Pattern in the Graphic Visualization Approach in the Education Field Research

The study findings as in Table 2 show the top 10 countries that have published and conducted research in the field of graphic visualization. Scientometric analysis indicates that the United States of America has conducted the most studies, with a total of 19 studies (22.35%) ranking highest. This is followed by China with 12 articles (14.12%) published, while Spain has published eight articles (9.41%).

Table 2
Top Ten Countries Productivity on Graphic Visualization

Country	TP	%
United States	19	22.35
China	12	14.12
Spain	8	9.41
United Kingdom	6	7.06
Canada	5	5.88
India	4	4.71
Taiwan	4	4.71
France	3	3.53
Germany	3	3.53
Malaysia	3	3.53

*Total Publication (TP)

This indicates in Figure 3 as that these countries are ensuring that their education system and research in education are keeping up with global developments.

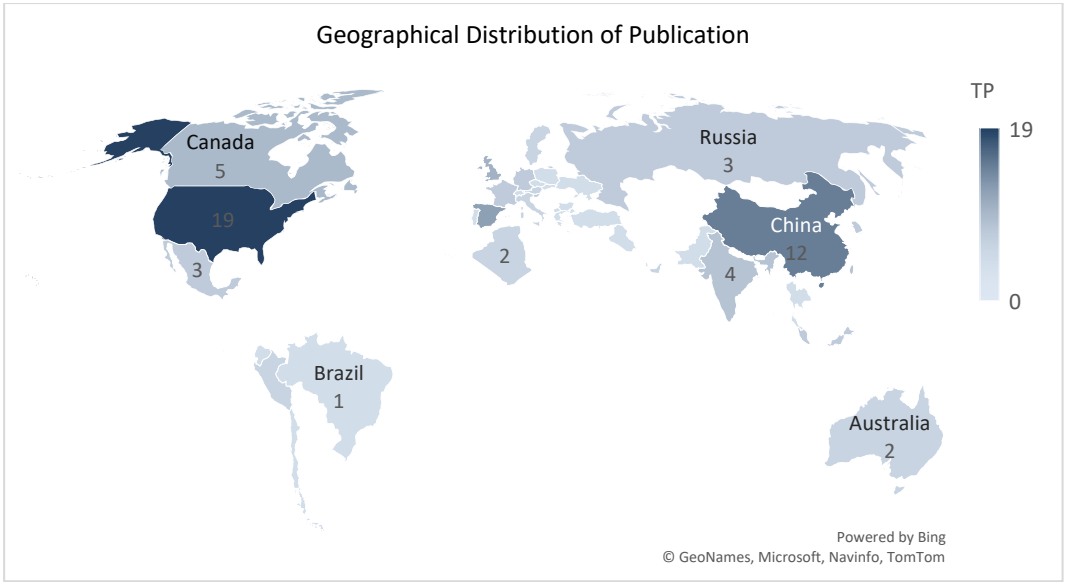


Fig. 3. Top Ten Countries Productivity on Graphic Visualization

3.3 The Main Area of the Graphic Visualization Approach in Education Research

Scientometric analysis as in Table 3 shows the top ten subject areas that are the main focus of the current research trends. Among them, Computer Science education is the largest field with a total of 78 publications (91.76%), followed by Engineering education with a total of 33 publications

(38.82%), and Social Science Education with 14 studies (16.47%). These research findings indicate that many other fields are being given special attention, particularly subjects or areas related to language and linguistics.

Table 3
Top Ten Subject Area on Graphic Visualization

Subject Area	TP	%
Computer Science	78	91.76
Engineering	33	38.82
Social Sciences	14	16.47
Mathematics	9	10.59
Materials Science	7	8.24
Medicine	7	8.24
Chemistry	4	4.71
Health Professions	4	4.71
Physics and Astronomy	4	4.71
Arts and Humanities	3	3.53

*Total Publication (TP)

3.4 The Future Direction of the Graphic Visualization Approach in Education

The future direction of this approach in education is likely to involve the integration of new technologies and tools to create more interactive and engaging visualizations [23]. One area of growth is in the use of augmented and virtual reality. These technologies allow students to explore and interact with visualizations in 3D space, which can enhance their understanding of complex concepts [24,25]. For example, a study by [26,27] found that using augmented reality visualizations helped students improve their understanding of anatomy. Another area of growth is in the use of data visualization [28]. With the increasing availability of data, there is a need for students to be able to analyse and interpret this information. Data visualization can help students understand patterns and trends in data more easily. A study by [29] found that using data visualizations in a statistics course improved students' ability to interpret and analyse data. Lastly, the use of graphic visualization in education is likely to become more personalized. As technology advances, it is becoming easier to create visualizations that are tailored to individual student's needs and learning styles. Besides, [30] found that using personalized visualizations helped students with different learning styles to understand chemistry concepts better. With the increasing use of artificial intelligence in education, there is potential for visualizations to be integrated with AI technologies to provide personalized learning experiences [31]. For example, visualizations could be used to help AI systems understand a student's learning style and adjust their approach accordingly. As education becomes more inclusive, it is important to ensure that visualizations are accessible to all students [32]. This could involve creating visualizations that are compatible with screen readers or designing visualizations with high contrast for students with visual impairments.

4. Discussion

The effective use of graphic visualization in the classroom requires careful consideration of various factors, such as accessibility, instructional design, and technological infrastructure. In this context, the use of text analytics and Scientometric analysis can help to explore the impact and trends of graphic visualization in classroom learning [33]. This article aims to provide an overview of the

current state of graphic visualization in education, review previous studies on its impact on classroom learning, discuss the challenges associated with its use, and propose future directions for research and development. Based on the Scientometric analysis There are several challenges associated with the use of graphic visualization in education. Some of these challenges include:

i. Limited access to technology: One of the main challenges in incorporating graphic visualization in education is the limited access to technology in many classrooms. According to a study by the National Center for Education Statistics, only 44% of schools in the United States have high-speed internet access in every classroom [15]. This can limit the ability of educators to effectively use graphic visualization tools in their teaching.
ii. Limited training and support: Another challenge is the lack of training and support for educators to effectively use graphic visualization tools in their teaching. Many teachers may not have the necessary skills or knowledge to use these tools effectively, or may not have access to professional development opportunities to improve their skills [16].
iii. Difficulty in interpreting visualizations: Another challenge is the difficulty that some students may have in interpreting visualizations. Research has shown that students may have difficulty interpreting certain types of visualizations, particularly if they are unfamiliar with the subject matter [17]. This can limit the effectiveness of using graphic visualization as a teaching tool.
iv. Limited accessibility: Another challenge is the limited accessibility of visualizations for students with disabilities. Many visualizations may not be accessible to students with visual or hearing impairments, or may not be compatible with assistive technologies [18].

Overall, while there are many potential benefits to using graphic visualization in education, these challenges need to be addressed to ensure that visualizations are used effectively and ethically in the classroom. The future direction of graphic visualization in education is an area of active research and development. Some potential areas of focus for future research include developing more accessible visualizations. As mentioned previously, one of the challenges associated with graphic visualization in education is limited accessibility for students with disabilities. There is a need to develop more accessible visualizations that are compatible with assistive technologies and can be used by all students [19].

In addition, Investigating the use of immersive technologies such as virtual reality and augmented reality have the potential to enhance the use of graphic visualization in education. Future research could investigate the use of these technologies in the classroom and their effectiveness in enhancing learning outcomes [20]. Exploring the use of data visualization tools such as Tableau and Power BI can be used to create interactive visualizations that allow students to explore data in a more engaging and meaningful way. Future research could investigate the effectiveness of these tools in enhancing learning outcomes in various subject areas [21].

5. Conclusion

The article focuses on the use of graphic visualization in education and its impact on classroom learning. It highlights the importance of careful consideration of factors like accessibility, instructional design, and technological infrastructure for the effective use of graphic visualization. The article proposes the use of text analytics and Scientometric analysis for exploring the impact and trends of graphic visualization in classroom learning. The article also discusses the challenges associated with its use and suggests future directions for research and development, specifically focusing on the use

of the R tool for data analysis and visualization. The research questions aim to explore the effectiveness of graphic visualization in classroom learning, the challenges associated with its use, and the potential benefits of using text analytics and Scientometric analysis to better understand its impact. The future of graphic visualization in technology education is expected to continue to evolve and improve with advancements in technology. One area of particular interest is the integration of virtual and augmented reality into education. According to [26], the global market for virtual and augmented reality in education is projected to reach $1.6 billion by 2023, with a compound annual growth rate of 42.9% from 2018 to 2023 [38]. This growth is expected to be driven by the increasing adoption of virtual and augmented reality technologies in the education sector. The future of graphic visualization in technology education is expected to be characterized by the increasing use of advanced technologies such as virtual and augmented reality, as well as data visualization tools to help students better understand complex concepts.

Acknowledgment
We appreciate the support from the Research Management and Innovation Centre (RMIC) and Faculty of Computing and Meta-Technology, UPSI in preparing the journal of this article. The authors would also like to thank each individual involved in this research.

References

[1] Chen, C., & Chen, H. "Educational Data Mining and Learning Analytics for 21st Century Learning." *Journal of Educational Technology Development and Exchange (JETDE),* 10(1), 1-14. (2017).
[2] Raghavan, K., Khandpur, R., Deshpande, A., Kambadur, P., & Lohani, S. "Analyzing online discussion forums in higher education using text analytics." *Education and Information Technologies,* 24(6), (2019): 3401-3417.
[3] Maier, H. R. "Technology in data analysis and visualization: An overview." *Hydrology and Earth System Sciences,* 24(8), (2020): 4257-4265.
[4] Kim, J., & Lee, W. "Virtual reality and augmented reality in education." *Journal of Educational Technology & Society,* 22(4), (2019): 1-15.
[5] Chen, X., & Paul, R. "Visual analytics: Past, present, and future." *ACM Transactions on Intelligent Systems and Technology (TIST)*, 9(5), (2018): 1-32.
[6] Aggarwal, S., Kulkarni, P., & Srivastava, S. "Leveraging Text Analytics in Education: Challenges and Opportunities. International Journal of Engineering Research and Technology, 14(3), (2021): 20-24.
[7] Vanek, J., Chen, B., Prajapati, A., Zhu, Z., & Suen, H. K. "Text analytics in higher education: opportunities and challenges." *Journal of Computing in Higher Education,* 33(1), (2021): 18-35.
[8] Zhang, M., Li, X., Liao, M., & Li, M. "The effect of interactive graphic visualization on students' performance and motivation in college physics courses." *Computers & Education,* 163, (2021): 104073.
[9] Kuziemsky, C. E., Kennelly, J., Maeder, A. J., & Lai, H. "Nursing education during COVID-19: A comprehensive scoping review." *Journal of Nursing Education and Practice,* 11(4), (2021): 52-61.
[10] Hattie, John, Deb Masters, and Kate Birch. *Visible learning into action: International case studies of impact*. Routledge, 2015. https://doi.org/10.4324/9781315722603
[11] Luo, Z., Liu, X., Shi, Y., & Xie, L. (2020). The impact of graphic visualization on students' understanding of statistics in a college course. Frontiers in Psychology, 11, 1274.
[12] Akpan, I. J., & Ntuen, C. A. "Enhancing students' learning outcomes through the use of graphic visualization in computer programming education." *Journal of Educational Computing Research,* 55(3), (2017): 364-388.
[13] Leydesdorff, L., & De Moya Anegón, F. "The evaluation of research by scientometric indicators. In F. Moed, W. Glänzel, & U. Schmoch (Eds.)." *Handbook of quantitative science and technology research* (pp. 19-52). Springer. (2010).
[14] Bormann, L., and L. Leydesdorff. "Scientometrics in a changing research landscape." *Science & society* 15, no. 12 (2014): 1228-1232. https://doi.org/10.15252/embr.201439608
[15] U.S. Department of Education. "Education and the internet: Trends and patterns in technology use by students and teachers." (2018). https://nces.ed.gov/pubs2018/2018066.pdf.
[16] Hershkovitz, A. & Forkosh-Baruch, A. "Are teachers ready to teach with technology? A survey of Israeli teachers' Technological Pedagogical Content Knowledge." *Journal of Educational Computing Research,* 54(5), (2016): 600-618.

[17] Bergner, Y. & Zeckzer, D. “From "seeing" to "understanding": The impact of graphic visualization on learning in science education.” *Journal of Educational Psychology,* 109(3), (2017): 281–297.
[18] Sonalake. “Barriers to accessing online content for people with disabilities.” (2019). https://sonalake.com/latest/barriers-to-accessing-online-content-for-people-with-disabilities/
[19] Eichelberger, A., Fu, S., Zhou, Q., & Liu, J. “Visualization for individuals with disabilities: A survey.” *Journal of Visual Languages & Computing,* 48, (2018): 47-57. https://doi.org/10.1016/j.jvlc.2018.08.002
[20] Ravindran, D., Manivannan, M., & Anand, S. “Virtual and augmented reality in education.” *In Virtual Reality* (pp. 167-182). Springer. (2020).
[21] Hurtubia Ramos, E., Strijk, T., & van der Kooij, K. “A systematic review of data visualization in education: current use and future opportunities.” *Education and Information Technologies,* (2021): 1-22.
[22] Moher, David, Alessandro Liberati, Jennifer Tetzlaff, Douglas G. Altman, and Prisma Group. "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement." *International journal of surgery* 8, no. 5 (2010): 336-341. https://doi.org/10.1016/j.ijsu.2010.02.007
[23] Page, Matthew J., Joanne E. McKenzie, Patrick M. Bossuyt, Isabelle Boutron, Tammy C. Hoffmann, Cynthia D. Mulrow, Larissa Shamseer *et al.,* "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews." *International journal of surgery* 88 (2021): 105906.
[24] Research and Markets. “Data Visualization Tools Market by Tool, Service, Deployment Mode, Organization Size, Vertical and Region - Global Forecast to 2026.” (2021). https://www.researchandmarkets.com/reports/5231048/data-visualization-tools-market-by-tool-service
[25] Wang, Y., Chen, G., & Yin, X. “Visualization-based approaches for learning and teaching in science education: a systematic review.” *Journal of Educational Technology Development and Exchange,* 12(1), (2019): 1-20.
[26] MarketsandMarkets. (2018). Virtual and Augmented Reality in Education Market by Component, Application, and Geography - Global Forecast to 2023. https://www.marketsandmarkets.com/Market-Reports/virtual-augmented-reality-education-market-151989995.html.
[27] Gómez-Varela, A. I., Ortega-González, R., Sánchez-Montañés, M., & Martín-Blas, T. “Augmented Reality and Anatomy Learning: A Systematic Review.” *Journal of Medical Systems,* 45(2), (2021): 1-12.
[28] Hsiao, H. C., Wang, Y. M., & Wang, C. Y. “Designing personalized visualization for enhancing chemistry learning.” *Interactive Learning Environments,* 28(6), (2020): 739-754.
[29] Mullen, R., Kerby, M., & Kaur, R. “Using data visualizations to improve students’ understanding of statistics.” *Journal of Statistics Education,* 28(2), (2020): 84-91.
[30] Smith, C. L., & Stoker, J. H. “The multimodal nature of learning: Opportunities and challenges for educators.” *Journal of Management Education,* 42(1), (2018): 5-11.
[31] Li, Y., Liu, X., & Li, S. “An intelligent graphic visualization approach to personalized e-learning system.” *IEEE Access,* 7, (2019): 123697-123705.
[32] Garcia-Sanjuan, F., Jurado-Navas, J. A., & Jiménez-Fernández, C. “Gamification and visualisation in education.” *Education Sciences,* 7(2), (2017): 50.
[33] Li, Y., Li, S., Wu, X., & Liu, X. “Personalized visualized knowledge assessment based on adaptive testing.” *Computers & Education,* 179, 104901. (2022).
[34] Püttmann, V., Klose, M., Prenzel, M., & Neuhaus, B. J. “Individualized feedback in biology education using an adaptive visual analytics dashboard.” *Journal of Biological Education,* 56(1), (2022): 47-65.
[35] Wu, Y., Chen, X., & Gao, F. “Multimodal learning analytics for analyzing visual and textual cues in multimedia learning.” *Journal of Educational Computing Research,* 56(1), (2022): 68-85.
[36] Wong, B. L., & Bergeron, B. P. “Interactive visualization in engineering education: A review of the state-of-the-art and recommendations for future research.” *IEEE Transactions on Education,* 61(1), (2018): 12-22.
[37] Chen, J., Xu, Y., & Yu, H. “Visualization in technology enhanced learning: A review.” *Journal of Educational Technology & Society,* 21(4), (2018): 146-160.
[38] Rahimi, M., van den Berg, J., & Veenstra, A. “The quality of text-based discussion forum contributions.” *Computers & Education,* 113, (2017): 84-93.
[39] Baker, Ryan SJd, Sidney K. D'Mello, Ma Mercedes T. Rodrigo, and Arthur C. Graesser. "Better to be frustrated than bored: The incidence, persistence, and impact of learners’ cognitive–affective states during interactions with three different computer-based learning environments." *International Journal of Human-Computer Studies* 68, no. 4 (2010): 223-241. https://doi.org/10.1016/j.ijhcs.2009.12.003
[40] Wagner, T., Hassanein, K., & Head, M. “Students’ perceptions of using automated feedback in a writing course.” *Computers & Education,* 87, (2015): 192-203.
[41] Kaplan, Andreas M., and Michael Haenlein. "Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster." *Business horizons* 59, no. 4 (2016): 441-450. https://doi.org/10.1016/j.bushor.2016.03.008

[42] Tunney, M. T., Ziegler, M., & Fletcher-Watson, S. "Teachers' online forum contributions as indicators of professional development and classroom practice." *Teaching and Teacher Education,* 68, (2017): 44-54.
[43] Zokhi, Aini Nurrasyidah Md. "Aplikasi Inovasi Q-Track Kit Dalam Proses Pengajaran dan Pembelajaran Bagi Modul Teoritikal: Innovative Application of Q-Track Kit in the Teaching and Learning Process for Theoretical Modules." *International Journal of Advanced Research in Future Ready Learning and Education* 27, no. 1 (2022): 20-29.
[44] Roslan, Nur Widad, Normaliza Abd Rahim, Nur Maisarah Roslan, and Siti Nur Aliaa Roslan. "Students' presupposition towards incooperating AI (Artifical Intelligence) technology in virtual and face-to-face classes." *International Journal of Advanced Research in Future Ready Learning and Education* 27, no. 1 (2022): 16-19.
[45] Jamaludin, Aaishah Radziah, Wan'Atikah Wan Ibrisam Fikry, Siti Zhafirah Zainal, Fatin Shaqira Abdul Hadi, Nawal Shaharuddin, and Nurul Izzati Abd Rahman. "The effectiveness of academic advising on student performance." *International Journal of Advanced Research in Future Ready Learning and Education* 25, no. 1 (2021): 20-29.