Board 178: Educational Infographics, A Review Paper

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Educational Infographics, A Review Paper

Abstract

This paper endeavors to inspire educators and instructional designers to more fully embrace infographics, leveraging their unique capabilities to enrich the teaching and learning landscape and prepare students for an increasingly visual world. To inspire, this review seeks to offer a coherent framework for understanding and utilizing infographics in educational contexts. We will be providing this framework through the core themes of visual literacy skills, the diverse array of educational infographics, and strategic methodologies for their effective integration into curricula.

This review paper centers on the transformative potential of educational infographics in teaching and learning, with a particular emphasis on their application within engineering education. By dissecting various types, formats, and thematic deployments of infographics, we aim to showcase how these visual tools can significantly enhance the educational experience. A detailed exploration of visual literacy underscores the necessity for instructors and students alike to harness the full potential of infographics not only as pedagogical aids but also as a medium for fostering comprehensive learning.

We advocate for a dual approach that involves both the creation and use of infographics by educators, alongside teaching students to craft their own, thereby promoting an interactive and immersive learning environment. Critical to our discourse in advocating for infographic is empirical evidence demonstrating the superior efficacy of infographics in education when compared to traditional teaching methods. Through a synthesis of comparative studies, student testimonials, and specific case studies within the realm of engineering education, we conclude that infographics serve as a powerful catalyst for enhancing comprehension, engagement, and retention of knowledge.

Keywords: Visual Literacy, Educational Infographics, Cognitive Tools, Teacher Education, Engineering Education.

Introduction

In the digital era, the dynamics of how individuals' access and process information have shifted dramatically. No longer are libraries the primary starting point for inquiries; instead, the ubiquity of internet access and advancements in mobile communication technology have made online platforms, through search engines and web pages, the mainstay for acquiring up-to-date information [1][2]. This evolution reflects the emergence of "digital citizens" who prioritize concise, visually appealing information formats over traditional text-heavy content, marking a significant shift in information presentation to suit the preferences of modern learners.

Against this backdrop, the importance of supporting improvement of visual literacy skills in education has never been more pronounced. This paper advocates for the strategic integration of infographics as an essential tool to enhance learning outcomes. Infographics, by virtue of their ability to simplify complex information into engaging, visually stimulating formats, emerge as a critical asset in the educator's toolkit, offering novel ways to enrich the learning experience [2]. Driven by the significance of visual literacy and the pedagogical potential of infographics, this paper aims to highlight how these visual tools can significantly improve visual literacy, comprehension, engagement, and information retention among students. The discussion that follows will delve into the educational affordances of infographics, underscore their value as cognitive tools, and outline future directions for research and application in teaching methodologies.

Infographics as a Solution

Today's technology is revolutionizing communication and education. The field of education is heading towards technological advancement during an era of globalization. Teaching and learning in education are challenged by combining technology, pedagogy, and content knowledge [1]. There is a growing need for technology to improve studying and training at higher education institutions as the instructional strategy in the classroom quickly shifts from instructor-centered to student-centered [3]. In education, technological integration involves self-directed teaching and learning, interactive software, online assessments, communication, and publication. Education technology trends are largely responsible for integrating technology in educational settings [2].

There is a saying that “a picture can speak a thousand words”. People often scan the headlines and graphics to find the headlines or graphics that catch their attention [1]. Important information can be easily overlooked or thrown away when checking and scanning the headlines. Infographics provide a potential solution to this issue since information is presented in the form of graphics and images [2], so difficult facts can be easily understood instantly and that knowledge acquired is preserved. Infographics leverage the natural tendency of the human eye to recognize patterns and trends. In visualizations, data or information is analyzed visually by the observer to make conclusions more quickly and clearly.

Evaluating the Effectiveness of Educational Infographics

The integration of infographics into educational practices necessitates a methodical approach to evaluating their impact. This evaluation is pivotal for understanding how infographics influence learning outcomes, student engagement, comprehension, and information retention. To facilitate this understanding, we propose a set of metrics and methods that educators and researchers can utilize to assess the effectiveness of infographics in teaching and learning environments.

Pre- and Post-Tests: Employ pre- and post-assessment tests to measure the knowledge students acquire when infographics are utilized. Comparing the test scores offers a direct measure of learning enhancement attributable to infographic use.

Qualitative Feedback: Implement surveys or conduct interviews to gather students' perceptions on how infographics have influenced their learning experience. This feedback can provide insights into the subjective value of infographics in enhancing understanding.

Engagement

Time on Task: Monitor the duration students engage with infographics versus traditional texts. Increased time spent with infographics may indicate higher engagement levels.

Participation Rates: Observe and document changes in classroom interaction levels, including questions, discussions, and overall participation when infographics are introduced. A surge in these activities suggests a rise in student engagement.

Comprehension

Concept Mapping: After a learning session with infographics, instruct students to create concept maps. The depth and accuracy of these maps can serve as indicators of the students' understanding of the material.

Critical Thinking Tasks: Assess students' application, analysis, and evaluation of the information presented in infographics. Assign tasks that challenge students to solve problems or engage in critical thinking, thereby gauging their comprehension.

Retention

Follow-up Tests: Conduct tests several weeks after the initial instruction to evaluate how much information students retain over time. This long-term retention is crucial for determining the lasting impact of infographics.

Longitudinal Studies: Engage in studies over extended periods to compare the retention rates of students taught with infographics against those taught with traditional methods. Such studies can elucidate the enduring benefits of infographic-based learning.

Implementing and Interpreting Evaluation Metrics

To effectively implement these metrics, educators should adopt standardized data collection and analysis techniques. This standardization ensures the reliability and validity of the evaluation outcomes. Furthermore, interpreting the data requires an understanding of statistical significance and the ability to discern meaningful differences in learning outcomes, engagement, comprehension, and retention rates.

Continuous Improvement Based on Evaluation

The ultimate goal of evaluating educational infographics is not solely to affirm their effectiveness but also to identify areas for improvement. Continuous refinement of infographic design and instructional strategies, informed by empirical evidence, is essential. This iterative process

underscores the commitment to enhancing educational practices and maximizing the benefits of infographics for learners.

In conclusion, the systematic evaluation of educational infographics is fundamental to substantiating their value in academic settings. By adopting the recommended metrics and methods, educators and researchers can critically assess and continually enhance the utility of infographics as powerful educational tools.

Practical Application of Infographics in Engineering Education

Creating and Utilizing Infographics

Educator Use of Infographics. Educators can significantly enhance the delivery of complex engineering concepts to students through the use of infographics. Creating custom infographics allows educators to tailor content to the specific learning outcomes of their courses, ensuring that complex information is presented in a clear, engaging, and visually appealing manner.

A wealth of software to support the development of custom infographics with minimal graphic design experience exists. Alternatively, educators can utilize pre-made infographics available through academic databases, industry publications, or educational platforms. These resources can serve as effective teaching aids to introduce new topics, summarize key concepts, or review course material. However, it is essential for educators to critically evaluate the accuracy, relevance, and source of pre-made infographics to ensure they meet educational standards and objectives.

Student Creation of Infographics. Incorporating infographic creation into coursework or assignments encourages students to engage deeply with engineering topics by synthesizing information and conceptualizing it visually. This process not only enhances their understanding and retention of complex concepts but also develops their skills in visual communication, a valuable competency in the professional engineering field. Educators should provide guidance on design principles, data visualization techniques, and ethical considerations in information representation to support students in creating effective and responsible infographics.

Availability and Ethical Use

Availability of Engineering-Related Infographics. While the availability of high-quality, educational infographics on engineering topics is growing, it varies widely by discipline and subject matter. Educators may find a wealth of resources in certain areas, while others may require the creation of custom infographics. Engaging with professional societies, academic journals, and educational technology platforms can provide access to relevant and reliable infographic materials.

Discerning and Ethical Use. It is imperative for educators to exercise discernment in selecting infographics, whether pre-made or when guiding students in their creation. This includes verifying the accuracy of the information presented, ensuring that sources are cited correctly, and that the infographics are used in a way that respects copyright and intellectual property laws. Additionally, educators should instill in students the importance of ethical considerations in visual representation, including avoiding misleading visualizations and ensuring inclusivity and accessibility in their designs.

Infographics hold significant potential in engineering education to enhance learning, engagement, and comprehension of complex subjects. By adopting a thoughtful approach to the creation, selection, and use of infographics, educators can provide students with a richer, more engaging learning experience. Moreover, by teaching students to create their own infographics, educators are equipping them with essential skills for effective communication and critical thinking in their future professional endeavors.

Methodology for Evaluating the Effectiveness of Infographics

Evaluating the impact of infographics on learning outcomes, engagement, and retention involves adopting a multi-faceted approach that encompasses both quantitative and qualitative metrics:

1. **Learning Outcomes:** Pre- and post-tests can be utilized to quantitatively measure the knowledge gained before and after the integration of infographics into teaching. Improvement in test scores can indicate the effectiveness of infographics in enhancing understanding of the subject matter.
2. **Engagement:** Engagement can be assessed through classroom observations and analytics provided by digital learning platforms. Metrics such as time spent on tasks involving infographics, participation in discussions about the content of infographics, and the number of student-created infographics submitted can serve as indicators of engagement.
3. **Retention:** Long-term retention of information can be measured through follow-up assessments weeks or months after the initial exposure to the infographic-based material. Comparisons between retention rates for content taught with and without infographics can reveal the effectiveness of infographics in sustaining knowledge over time.
4. **Qualitative Feedback:** Surveys and interviews with students can provide valuable insights into their perceptions of the usefulness, clarity, and engagement of infographics as learning

tools. This feedback can highlight strengths and areas for improvement in the use of infographics in education.

5. **Case Studies:** Documenting specific instances of infographic integration across various subjects and grade levels can offer concrete examples of best practices and innovative approaches. These case studies can serve as a resource for educators looking to implement infographics in their own teaching.

Technical and Ethical Considerations in Infographic Design and Use

Infographic Creation Tools and Principles. In the digital age, a myriad of tools and software have emerged to facilitate the creation of infographics, making this powerful medium accessible to educators and students alike. Popular platforms like Canva, Piktochart, and Adobe Spark offer user-friendly interfaces and robust design features that empower users to craft visually compelling infographics without the need for advanced graphic design skills. While these tools provide the means to create, it's the principles of effective infographic design clarity, accuracy, and relevance that ensure the message is communicated effectively. Clarity in design avoids unnecessary complexity, ensuring the target message is easily discernible. Accuracy involves the diligent representation of facts and data, underpinning the infographic's credibility. Relevance ensures the content is aligned with the audience's interests and needs, enhancing engagement and comprehension.

Ethical Use of Infographics. Beyond the technicalities of creation, the ethical use of infographics is paramount. As visually engaging tools, infographics have the potential to simplify complex information, but they also carry the risk of oversimplification or misrepresentation. Educators and students must be critical consumers of infographics, questioning the sources of information and the reliability of the data presented. Ethical considerations extend to the creation process as well, where respect for intellectual property, transparency in sourcing, and accuracy in representation are essential. Misinformation can easily be propagated through compelling visuals, making it crucial for creators to verify the data and present it in a way that is not misleading. Moreover, inclusivity and accessibility should guide the design process, ensuring infographics are usable and understandable by diverse audiences, including those with visual impairments.

Visual Literacy Skills

From a wider perspective, visuals are common as they emerge from emerging communication tools and societal changes (2); hence, learners can use images to their advantage in both daily life and academic settings. The ability to comprehend and read pictures, absorb information visually, and approach thought processes visually benefit learners with visual proficiency abilities. Because of this, teaching students' visual literacy, which means the capacity to decode, understand and

create graphic images or messages, is of utmost importance, especially for those who plan the information, like instructors.

Visual literacy has been defined in several ways in the literature. These definitions originated from several fields, and those fields helped provide the groundwork for visual literacy. Hortin [8] defined visual literacy in 1980 as the capacity to use and comprehend visuals and to study and think conceptually. In 1973, Case Gant coined the term “visual literacy” to describe a collection of skills that enable individuals to understand, produce, and read graphical representations in personal communication. Yenawine [9] provided a succinct definition of visual literacy in 1997, stating that it is the capacity to interpret imagery.

In 2006 [10], visual literacy was expressed by Johnson as competence to understand and see the messages that are conveyed through the portrayals. Johnson further extended this demonstration of visual literacy by saying that it can generate, utilize and modify images and visual cues. In 2008 [11], Metros gave another report on visual literacy. He states that it can take the essence of the visual messages and compose and encode meaningful visual communications. From different perspectives, visual literacy is defined by scholars. Yet, in these definitions, similarities exist, including learning and thinking with images, from the graphical images making meaning to communications using the photos. For the core visual literacy skills, these commonalities are those that both teachers and learners should have.

Education professionals hold an essential role in education related to visual literacy through their development of course materials. While not typically considered a learning outcome, achievement of competency in visual literacy is important. They enrich their lessons with visuals and promote learners' visual literacy skill development. To do this, educators should follow the results of graphic usage and the emerging visualization tools and methods they should make themselves aware of. So, infographics are a great tool for instructional design and enhance cognitive learning.

Learning and Teaching Activities

To enhance students' learning experience, infographics are significant learning tools of teaching that are adaptable to any set of learning. [12]

Learning Activities

Some of the benefits of learning using the infographic tool include:

a) The improvable comprehension of concepts, ideas, and information [13]
b) The enhancement in the ability of critical thinking and development in the organization of ideas [14]

c) The improvement in the recall of information and retention [15]

The content is typically presented in a concise manner using infographics. To improve the students' engagement with the material and increase the chance of interaction, the educators can also design various learning activities, such as unit summaries and warm-up sessions, thanks to the excellent presentation style. Additionally, giving students an infographic assignment can help them develop their visual communication skills, which include learning, thinking, and expressing oneself visually, as well as more fundamental learning competencies like teamwork and information management. These student-created infographics can be seen as technological and aesthetic manifestations of the student's knowledge and ideas.

By allowing students to highlight their more advanced achievements, infographics can be utilized as a replacement for traditional assessment methods. Another potential application for infographics in education is to aid in kids' moral and social growth. In character education, infographics offer different techniques to create new opportunities to disclose the students' attitudes and emotions and internalize ethical principles since they simultaneously address the verbal and visual learning styles. The spatial contiguity principle and CTML (cognitive theory of multimedia learning), which Mayer established in 2009, can be used to explain the value of infographics as a visual learning tool [16].

Studies on meaningful learning and how people learn have led to the development of CTML. According to CTML, verbal and visual inputs are processed through two channels with a limited amount of processing power that is qualitatively distinct. Meaningful learning only happens when the right cognitive process integrates, organizes, and chooses the information. To aid learners in creating stronger semantic connections, the spatial contiguity principle advises that the instructional designers offer the pictures and related words close together. The spatial contiguity concept and CTML should be followed for the infographic to be efficient and successful.

Educator Training

Infographics' adaptability, compactness, and informativeness provide various usability alternatives for instructional practice. First of all, the majority of programs for training educators provide at least one course in visual literacy, computer literacy, or both [17]. Therefore, organizations may use infographics to spread the word about the content rather than creating a distinct brand course for the infographics. To thoroughly cover the infographics, it's crucial to imply relevance [18]. For instance, the Council of Higher Education in Turkey decides the framework programs for teacher education institutes. In programs discussed, all pre-service teachers must pass "Computer I and II" courses to assist teacher candidates in acquiring knowledge and computer literacy [19].

The course curriculum for IMD (instructional material design) needs to be broadened to include infographics, even if it is offered. IMD needs to be recognized as essential training for educators.

However, some schools that train instructors classify it as music education [20]. In Turkey, it would be desirable to revise the IMD curriculum focusing on infographics and make it mandatory for all programs that prepare instructors. It is identified that in a unit, infographics are not represented as a mere unit only, but they are further encompassed with the projects and assignments in the following units [21]. Infographics in assessments can further be expanded to promote the deeper transfer of skills to the other courses. For instance, pre-service science teachers may be required to embody infographics in their microteaching activities. Another course-based approach would be to devise specific courses on infographics and, after fulfilling prerequisites, encourage all the teachers to take them. So, in this way, both the senior and future candidates in the program of study can benefit from advancements, regardless of their college entrance term [22]. To achieve a wider application of infographics, the institutes of teacher education partner with the neighborhood schools to provide additional training opportunities and workshops for teachers currently employed.

Infographics

Infographics provide visual representations of ideas, information, and complex concepts, including information and data visualization, to educate a targeted audience. Alternatively, the term "infographic" (as coinage for the "information graphic") refers to a new type of data visualization that has greatly increased in popularity for communicating information both digitally and in print due to its usefulness. An infographic is a form of visual that, through the design, discloses facts and allows organizations and individuals to communicate with their audience succinctly, according to Smiciklas' definition from 2012. In a definition published in 2004 [17], Haynes and Newsom focused on the uses and purposes of infographics, saying: “Infographics are the graphic visual representation of knowledge, information, and data. These graphics clearly and quickly present the complex information in journalism, education, maps, signs and technical writing.”

The infographic's main components are graphics, words, and design elements. An infographic is a composition of pictures ranging from abstract to naturalistic, textual information varying in length and geographical means such as zoom boxes, movement lines, highlighting devices, and arrows.
The primary intent of infographics is to convey a notion as a single structure with graphics and words of a minimum number. In 2010 [24], Hagen and Golombisky used “minimum space” and "maximum information" to describe infographics. With the phrase “minimum time”, this demonstration can be extended because the infographics are interpreted and read by the people faster than the separate graphics and text [24]. In 2007 [25], Fichter and Wisniewski predefined that the infographic functions are to express, communicate, instruct and illuminate multifaceted notions. They added the minimum time aspect of infographics by indicating that the infographics are easy and fast to comprehend. In 2012 [26], Ghode considered the property of minimum time as a requirement since the new media users want to utilize more information quickly.

As a result of their similar objectives, infographics and data visualization are commonly used interchangeably. Unprocessed data, like statistics, are visually represented through data visualization. Infographics, on the other hand, use a range of text and graphical elements simultaneously in a presentation that is similar to a tale to illustrate a specific topic. The introduction, main theme or takeaway, and eventual resolution are all depicted in the infographics. While data visualization in a tale only provides current, accurate information. Infographics, which communicate a message through design elements, visuals, and words, give a comprehensive report. In contrast, a data visualization technique converts statistical data into a visual form. Moreover, infographics are a full-featured medium for product storytelling, while data visualization is applied to produce infographics.

The main objective of using information graphics, according to Holmqvist, Holmberg, and Holsanova in 2009 [27], is to simplify and illustrate complex issues so that readers can quickly comprehend and conceptualize the various aspects of a complex structure, effects, and causes of action, as well as the multiple stages of a process. In 2014 [28], Johnson and Lamb split this fundamental objective into five particular purposes:

1. Helpfully, the organization of ideas
2. Visually showing the complex relationships
3. Effectively comparing the information
4. By using analogies to give the data context, such as by using themes related to how data becomes information
5. Rather than just using words, they narrate a story to communicate the information excitedly.

According to Krum in 2013 [29], the goals of infographics can be categorized into three types: persuasion, entertainment, and information. These goals are comparable to those of public speaking.

Infographics begin with introductions, much like public speeches, to give the reader a context for the material that will be addressed. The purpose is to let the reader know that studying infographics takes time. The infographics conclude with recommendations for further action so that readers can reflect on the knowledge they have gained and take appropriate action. According to a 2012 study [30], retention, knowledge, and appeal are the three main infographic goals. Depending on how the infographic is to be used, the relative importance of these goals change (marketing, scientific, editorial, or academic).

In the literature, all the definitions of infographics indicate that an infographic must portray a story, process, or idea and demonstrate multifaceted evidence with an eye-catching design. That is why it is suitable that any topic should be provided visually as an infographic, giving a message and

telling a story. Similar evidence is presented by infographics, which can be presented conventionally with words alone or images. So, again, a question arises: if conventional materials and infographics deliver the same content, why are infographics needed? In 2012 [31], according to Krauss, the visual representation of the ideas and data engaged additional elements of the brain. Therefore, individuals can see an issue or a problem from multiple insights through infographics.

Smiciklas [23] investigated the time needed to evaluate the text and visuals. Infographics, according to Smiciklas, enable students to process text and images together rather than individually. Ghode [26] observed that the natural qualities of infographics appeal to learners' preferences and inspire them to pursue further study. Wartenberg and Holmqvist [32] used an eye-tracking approach to study and analyze the role of regional design components in newspaper reading. They discovered that, compared to other types of readers, information graphics lengthen the total amount of time spent reading a newspaper since infographics may catch learners' attention immediately and keep them interested longer than any other media type.

Infographics improve message and information understanding. The information in the graphical component of well-designed infographics needs to be reconsidered, and only more verbal information is provided. The visual search is eliminated by this approach, which also facilitates the visual and verbal information integration. Consequently, the unnecessary loads are reduced on the resources of restricted working memory. That is why well-designed infographics support learners' thinking and holistic understanding of the content.

Discussion

Infographics have gained significant attention in various fields, including education, due to their potential instructional affordances. While existing studies have focused on the design components and types of information presented in infographics, there is a call for future research to delve deeper into the pedagogical advantages of infographics [33]. It is suggested that a good categorization of infographics for educational purposes should emphasize processes such as comparisons and taxonomies, as well as cognitive abilities, rather than just individual design components [33]. In the realm of healthcare, tailored infographics have been used to help Hispanic family caregivers of persons with dementia better understand health status and disabilities, facilitating effective health management [34, 35]. Moreover, in the context of improving sleep hygiene in athletes, including ultra-marathon swimmers, resources like infographics have been recommended to engage individuals in adopting better practices [36]. Studies have also highlighted the role of infographics in enhancing education. For instance, infographics have been proposed as a tool to improve the effectiveness of education, emphasizing clarity and the visualization of complex information [37]. Additionally, infographics have been increasingly utilized in clinical pharmacy practice, education, and research, showcasing their importance in conveying medical information visually [38]. Furthermore, the use of infographics in educational settings has been explored in various contexts, such as the development of students' visual literacy and the enhancement of speaking skills in foreign language classes [39]. The integration of infographics in teaching practices has been shown to engage students in active learning, aiding in aligning prior knowledge, making corrections, and forming new connections between topics [33]. In conclusion, while infographics hold promise in enhancing educational practices by presenting information visually and engaging learners, further research is needed to establish a solid theoretical framework and practical evidence for their instructional affordances. By focusing on the pedagogical advantages, cognitive processes, and educational categorizations of infographics, future studies can better leverage the potential of infographics in educational settings.

Conclusion and Future Direction

Educational infographics have been recognized for their transformative impact on learning environments, particularly in enhancing comprehension, engagement, and retention [40]. Research indicates that infographics play a crucial role in improving student achievement by fostering active involvement in the learning process and promoting permanent learning and high remembering rates [40]. Furthermore, the use of infographics has been found to positively influence students' interaction and perception, indicating a strong impact on educational outcomes [41]. While the existing evidence underscores the benefits of educational infographics, there is a call for the development of a comprehensive framework to guide the creation, evaluation, and optimization of infographics in education [37]. This framework should prioritize accessibility, inclusivity, and adaptability to cater to the evolving landscape of digital education. By integrating infographics strategically into teaching practices, educators can transcend

traditional methodologies and create a more engaging and effective learning environment [37]. Infographics serve as a dynamic and impactful tool that aligns with modern pedagogical approaches, catering to the preferences of digital natives and offering visually compelling and interactive ways to present information [37]. They have been shown to deepen understanding, improve retention, and engage learners of all ages and backgrounds [40]. Through the strategic use of infographics, educators can leverage visual literacy to enhance the educational experience and promote a deeper understanding of complex concepts in various fields, including engineering education [37]. In conclusion, educational infographics represent a valuable resource for educators seeking to enhance student learning outcomes. By harnessing the power of infographics and incorporating them thoughtfully into educational practices, educators can create a more engaging and effective learning environment that resonates with learners across diverse settings and disciplines.

References

[1] Noori, N., & Anderson, P. K. (2013). Globalization, governance, and the diffusion of the American model of education: Accreditation agencies and American-style universities in the Middle East. International Journal of Politics, Culture, and Society, 26(2), 159-172.

[2] Refae, G. A. E., & Belarbi, A. K. (2017). University governance and educational AAU model: an organizational culture approach. Global Business and Economics Review, 19(2), 239-249.

[3] Anyanwu, S. U., & Iwuamadi, F. N. (2015). Student-centered teaching and learning in higher education: Transition from theory to practice in Nigeria. *International Journal of Education and Research*, *3*(8), 349-358.

[4] Bowen, W. G., & Tobin, E. M. (2017). Locus of authority: The evolution of faculty roles in the governance of higher education. Princeton University Press.

[5] Remache, A., & Belarbi, A. (2019). Adapting ICT in higher education in the developing world: influencing dynamics. International Journal of Economic Policy in Emerging Economies, 12(3), 264-284.

[6] Iskander, R., Pettaway, L., Waller, L., & Waller, S. (2016). An analysis of higher education leadership in the United Arab Emirates. Mediterranean Journal of Social Sciences, 7(1), 444.

[7] Dobbins, M., & Knill, C. (2017). Higher education governance in France, Germany, and Italy: Change and variation in the impact of transnational soft governance. Policy and Society, 36(1), 67-88.

[8] Hortin, J., A. (1980). Visual literacy and visual thinking. Retrieved from ERIC database (ED214522). International Society for Technology in Education (2008). ISTE standards for teachers.

[9] Yenawine, P. (1997). Thoughts on visual literacy. In J. Flood, S., B. Heath, & D. Lapp (Eds.), Handbook of Research on Teaching Literacy through the Communicative and Visual Arts. New York, NY: MacMillan Library Reference.

[10] Johnson, L. (2006). The sea change before us. EDUCAUSE Review, 41(2), 72–73.

[11] Metros, S., E. (2008). The educator's role in preparing visually literate learners. Theory Into Practice, 47(2), 102–109.
[12] Alyahya, D. M. (2019). Infographics as a learning tool in higher education: The design process and perception of an instructional designer. International Journal of Learning, Teaching and Educational Research, 18(1), 1-15.
[13] Goldman, S. R., & Scardamalia, M. (2013). Managing, understanding, applying, and creating knowledge in the information age: Next-generation challenges and opportunities. Cognition and Instruction, 31(2), 255-269.
[14] Kopzhassarova, U., Akbayeva, G., Eskazinova, Z., Belgibayeva, G., & Tazhikeyeva, A. (2016). Enhancement of Students' Independent Learning through Their Critical Thinking Skills Development. International Journal of Environmental and Science Education, 11(18), 11585-11592.
[15] Ryan, E., & Poole, C. (2019). Impact of virtual learning environment on students' satisfaction, engagement, recall, and retention. Journal of medical imaging and radiation sciences, 50(3), 408-415.
[16] Mayer, R., E. (2009). Multimedia learning (2nd ed.). New York, NY: Cambridge University Press.
[17] İslamoğlu, H., Ay, O., İlic, U., Mercimek, B., Dönmez, P., Kuzu, A., & Odabaşı, F. (2015). Infographics a new competency area for teacher candidates.
[18] Ru, G., & Ming, Z. Y. (2014, September). Infographics applied in design education. In *2014 IEEE Workshop on Advanced Research and Technology in Industry Applications (WARTIA)* (pp. 984-986). IEEE.
[19] Ozdamli, F., & Ozdal, H. (2018). Developing an instructional design for the design of infographics and the evaluation of infographic usage in teaching based on teacher and student opinions. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(4), 1197-1219.
[20] Alford, K. (2019). The rise of infographics: Why teachers and teacher educators should take heed. *Teaching/Writing: The Journal of Writing Teacher Education*, *7*(1), 7.
[21] Kardgar, A., Mentzer, N., Laux, D., Chesley, A., & Whittinghill, D. M. (2017, June). Developing Strategies for Instruction and Assessment of Infographics for First-Year Technology Students. In *2017 ASEE Annual Conference & Exposition*.
[22] Kibar, P. N., & Akkoyunlu, B. (2014, October). A new approach to equip students with visual literacy skills: Use of infographics in education. In *European Conference on Information Literacy* (pp. 456-465). Springer, Cham.
[23] Smiciklas, M. (2012). The power of infographics: Using pictures to communicate and connect with your audiences. Indianapolis, IN: Pearson Education, Inc.
[24] Golombisky, K., & Hagen, R. (2010). White space is not your enemy: A beginner's guide to communicating visually through graphic, web & multimedia design. Burlington, MA: Focal Press.
[25] Wisniewski, J., & Fichter, D. (2007). Saying it visually. Online, 31(6), 57–60.

[26] Ghode, R. (2012). Infographics in news presentation: A study of its effective use in Times of India and Indian Express the two leading newspapers in India. Journal of Business Management & Social Sciences Research, 1(1), 35–43. Retrieved November 5, 2014, from http://borjournals.com/a/index.php/jbmssr/article/view/122
[27] Holsanova, J., Holmberg, N., & Holmqvist, K. (2009). Reading information graphics: The role of spatial contiguity and dual attentional guidance. Applied Cognitive Psychology, 23(9), 1215–1226.
[28] Lamb, A., & Johnson, L. (2014). Infographics part 1: Invitations to inquiry. Teacher Librarian, 41(4), 54–58.
[29] Krum, R. (2013). Cool infographics: Effective communication with data visualization and design. Indianapolis, IN: John Wiley & Sons, Inc.
[30] Lankow, J., Ritchie, J., & Crooks, R. (2012). Infographics: The power of visual storytelling. Hoboken, NJ: John Wiley & Sons, Inc.
[31] Krauss, J. (2012). Infographics: More than words can say. Learning & Leading with Technology, (February), 10–14.
[32] Holmqvist, K., & Wartenberg, C. (2005). The role of local design factors for newspaper reading behaviour: An eye-tracking perspective. Lund University Cognitive Studies 127. Retrieved October 26, 2014 from: http://www.lucs.lu.se/LUCS/127/LUCS.127.pdf
[33] Т. Ю. Быстрова, "Infographics as a Tool for Improving Effectiveness of Education," Kne Social Sciences, 2020.
[34] L. G. Huettel, M. Gustafson, J. C. Nadeau, D. E. Schaad, M. M. Barger, and L. Linnenbrink-Garcia, "A Grand Challenge-Based Framework for Contextual Learning in Engineering: Impact on Student Outcomes and Motivation."
[35] A. Arcia, N. Suero-Tejeda, N. Spiegel-Gotsch, J. A. Luchsinger, M. Mittelman, and S. Bakken, "Helping Hispanic Family Caregivers of Persons With Dementia "Get the Picture" About Health Status Through Tailored Infographics," The Gerontologist, 2019.
[36] I. C. Dunican, E. L. Perry, G. Maisey, E. Nesci, and S. Roberts, "Sleep Hygiene Education for Improving Sleep in Ultra-Marathon Swimmers: Guidance for Coaches and Swimmers," International Journal of Sports Science & Coaching, 2023.
[37] B. Barlow, A. Webb, and A. Barlow, "Maximizing the Visual Translation of Medical Information: A Narrative Review of the Role of Infographics in Clinical Pharmacy Practice, Education, and Research," Journal of the American College of Clinical Pharmacy, 2021.
[38] О. Лілік, and K. Y. Sirenko, "Features of the Formation of Students' Visual Literacy of Higher Education by the Means of the Course «ukrainian Language for Professional Directions»," Scientific Herald of Sivershchyna Series Education Social and Behavioural Sciences, 2023.
[39] Y. M. Orekhova, "Use of Infographics for the Development Of Cadets' Speaking Skills at Foreign Language Classes," Vestnik of North-Ossetian State University, 2021.
[40] N. S. Alrwele, "Effects of Infographics on Student Achievement and Students' Perceptions of the Impacts of Infographics," Jehd, 2017.

[41] D. Alqudah, A. Bidin, and H. Mohd Azizul Hakim Bin, “The Impact of Educational Infographic on Students’ Interaction and Perception in Jordanian Higher Education: Experimental Study,” International Journal of Instruction, 2019.