Integrating Infographics into STEM Education to Develop College Students' EFL Proficiency and Digital Literacy Skills

Dr. Omnia Latif Ibrahim Abdel Latif
Associate Professor of TEFL, Dept. of Curricula & Instruction Faculty of Education – Minia University

Abstract

The current study examined the impact of integrating infographics into STEM education to develop college students' EFL proficiency and digital literacy skills. A one-group quasi-experimental research design was employed to meet the study objectives. Fifty-five students enrolled in the STEM program at Minia Faculty of Education participated in the study during the second semester of the 2023-2024 academic year. They acted as one study group. The study program was implemented using a pre-and post-testing procedure. To fulfill the study's purposes, the researcher developed essential instruments, including a diagnostic test, an English language proficiency skills test, and a digital literacy test. The findings indicated significant statistical improvements in both the English language proficiency skills test and the digital literacy test, favoring the post-test results. The researcher provided recommendations and suggestions for further research.

Keywords: Infographics, English Language Proficiency skills, digital literacy skills.

Introduction

English language proficiency is the capability of an individual to effectively and accurately use English in various contexts, including listening, speaking, reading, and writing. This proficiency encompasses skills necessary to communicate and comprehend ideas, engage in conversations, understand written texts, and produce coherent and grammatically correct written work. Mastery

of English is critical for academic achievement, particularly in higher education where English often serves as the medium for instruction and evaluation. Moreover, strong English skills are vital in the global job market, as English is commonly used as a universal language in international business, science, technology, and diplomacy. Achieving proficiency in English involves a mix of formal education, consistent practice, and exposure to the language in different environments.

English language proficiency is essential for academic success, especially in university settings where English is often the medium of instruction. Proficiency in language skills enables students to understand lectures, read academic texts, and engage with course materials more effectively. Hull and Schultz (2022) emphasized the need for strong language skills to bridge classroom and out-of-school literacies, which is crucial for comprehensive learning.

Utami et al. (2020) stated that English language proficiency is crucial for Science, Technology, Engineering, and Mathematics (STEM) students. Proficiency in English allows these students to access extensive scientific literature, engage in international collaborations, and present their research to a global audience effectively. Being skilled in English helps them understand complex technical materials, participate in academic discussions, and contribute significantly to their fields.

Roehrig et al. (2021) mentioned that integrating English language skills into STEM education is important for several reasons. It helps students understand and apply

technical concepts, given that most core literature and instructional materials are in English. It also supports the development of critical thinking and problem-solving skills by enabling access to diverse perspectives and resources. Moreover, English proficiency is essential for effective communication, both written and oral, which is necessary for writing research papers, and reports, and participating in conferences and seminars.

Crum (2022) clarified that as the global workforce becomes more interconnected, English has become the common language of international business and scientific communities. STEM graduates with strong English skills are better equipped to compete in the global job market, collaborate with international peers, and contribute to multinational projects. Therefore, fostering English language proficiency among STEM students is not only crucial for academic success but also vital for their professional development and career opportunities.

Digital literacy is the ability to skillfully and critically use digital technologies to navigate, evaluate, and create information. This involves knowing how to operate digital devices, software, and the internet for communication, information access, and task completion. It also includes critical thinking to evaluate the reliability of online sources, safeguard personal data, and engage responsibly in digital spaces. As technology increasingly influences daily life, digital literacy is crucial for modern workforce participation, educational resource access, and involvement in social and civic activities (Rinekso et al. 2021).

Kateryna et al, (2020) stated that developing digital literacy requires ongoing learning and adaptation to new

technologies and digital platforms. In today's increasingly digital and visually-driven world, integrating infographics, as a visual aid, into educational practices has emerged as a powerful strategy to enhance learning outcomes, particularly among university STEM students. Infographics offer a multifaceted approach to developing crucial skills that span both language proficiency and digital literacy.

Infographics are visual representations of information designed to make complex data more accessible and easier to understand. They combine images, charts, and minimal text to create a comprehensive visual summary of information. In an educational context, infographics can simplify intricate concepts, making them more digestible for students. By engaging with infographics, students can improve their ability to process and retain information effectively (Alrwele, 2017).

Park and Warschauer (2016) clarified that incorporating infographics into lectures and presentations can aid in better comprehension and retention of spoken content. Students can visually track information, making it easier to follow along and understand key points. Infographics can serve as an excellent tool for teaching effective note-taking. Students can learn to identify and extract key information, organize their notes visually, and create their infographics as a form of note-taking. This method enhances their ability to capture and summarize complex information succinctly.

Likewise, Dunlap and Lowenthal (2016) clarified that infographics inherently require summarization skills. When students are tasked with creating infographics, they must shorten large amounts of information into essential points,

honing their ability to summarize effectively. This skill is crucial not only for academic success but also for professional communication in STEM fields. Infographics require clear and concise language to convey information effectively. When students create and present infographics, they practice crafting precise messages and explaining complex concepts in simple terms. This activity bolsters their ability to communicate effectively in English, a vital skill in both academic and professional environments.

Baterna et al. (2020) mentioned that digital literacy is indispensable for STEM students, underpinning academic success, professional development, innovation, and personal growth. It equips students with the skills needed to access and analyze information, utilize advanced tools and software, and effectively collaborate and communicate in a digital world. As technology continues to evolve, digital literacy ensures that STEM students remain adaptable, innovative, and competitive in their fields, ready to meet the demands of the modern workforce and contribute to technological advancements.

Tufte (2020) added that creating infographics involves using various digital tools and platforms. Students gain hands-on experience with software such as Canva, Piktochart, or Adobe Illustrator, enhancing their digital creation skills. Additionally, presenting these infographics helps students develop confidence and competence in delivering digital presentations.

The integration of infographics addresses specific educational challenges. STEM subjects often involve complex and abstract concepts that can be difficult to grasp through text alone. Thus. infographics provide a visual aid that can demystify these concepts, making them more

accessible. Moreover, as STEM students prepare for careers in fields where digital literacy and clear communication are paramount, the skills gained through working with infographics become invaluable.

STEM, an acronym for Science, Technology, Engineering, and Mathematics, represents a multifaceted educational approach designed to prepare students across various educational levels for careers and higher education in these critical disciplines. STEM education transcends mere subject-specific learning by fostering inquiry-based thinking, logical reasoning, and collaborative problem-solving skills among students (McCashin et al, 2022). This interdisciplinary approach not only equips learners with foundational knowledge but also cultivates the innovative thinking necessary to address complex challenges in today's globalized world.

McDonald (2016) mentioned that STEM education is increasingly recognized as pivotal in nurturing the next generation of scientists, engineers, and innovators who will drive technological advancements and shape future industries. By emphasizing hands-on experimentation, real-world applications, and the integration of technology, STEM programs aim to instill a deep-seated curiosity and proficiency in these essential fields. This introduction explores the foundational importance of STEM education in preparing students to thrive in an increasingly competitive and technologically driven society.

Infographics can significantly enhance language proficiency, especially for university STEM students. They provide visual summaries that aid in understanding and retaining lecture content, thus promoting active listening

and effective note-taking. The structured infographic format helps organize information logically, making note-taking more efficient. By distilling information into clear, concise elements, infographics also improve summarizing skills (Ibrahim et al., 2014 & Hattwig, 2013).

Additionally, creating infographics involves using digital tools and enhancing digital literacy and presentation skills, which are crucial for modern communication. Furthermore, combining visual elements with text helps students learn and use English in context, improving their overall language proficiency. Integrating infographics into educational practices offers a multimodal learning experience that boosts comprehension and retention and equips students with essential skills for their academic and professional lives (Alrwele, 2017 & Ozdamli, 2018).

Infographics are instrumental in STEM education by using visual communication to improve language skills and visual literacy among students. In educational contexts, infographics simplify intricate scientific and technical content into visually accessible formats, making abstract ideas easier to understand and more engaging. By incorporating infographics into STEM teaching, educators can aid language learning through vocabulary expansion, understanding technical terms, and organizing information effectively (Martin & Gaffney, 2016).

Additionally, infographics enhance visual literacy by prompting students to interpret visual data, analyze graphs and diagrams, and derive insights from visual information. This process not only improves their ability to comprehend scientific visuals but also develops critical thinking and data interpretation abilities crucial in STEM disciplines

(Aboo Bakar et al, 2021). Therefore, integrating infographics into STEM education serves as a valuable strategy to nurture language proficiency and visual literacy, equipping students to communicate complex concepts and interact proficiently with scientific materials.

In conclusion, the integration of infographics into the curriculum for university STEM students might significantly foster their English language proficiency and digital literacy. This approach not only aids in understanding and retaining complex information but also equips students with essential skills for success in their academic and professional pursuits.

Literature Review and Related Studies

Theories Underpinning Infographics

The foundation of infographics lies in the principles of visual communication and cognitive psychology. They merge images, charts, and minimal text to convey complex information swiftly and clearly, capitalizing on the brain's ability to process visual data more efficiently than text alone.

Key theories and principles include:

1. **Dual Coding Theory:** Introduced by Paivio (1991), this theory postulates that individuals process information through two systems: one for verbal data and another for visual data. Infographics engage both systems, improving comprehension and memory retention.
2. **Cognitive Load Theory:** According to Sweller and Chandler (1991), this theory asserts that the human brain has a limited capacity for information processing. Infographics alleviate cognitive load by

presenting information concisely and visually, making it easier to understand and remember.

3. **Gestalt Principles:** These principles describe how people perceive visual elements as cohesive forms rather than isolated parts. Infographics apply these principles (such as proximity, similarity, and continuity) to create visually appealing and easily interpretable designs.
4. **Visual Hierarchy:** Tufte (2002) infographics utilize size, color, and placement to establish a visual hierarchy, directing the viewer's attention to the most crucial information first. This aids in prioritizing information and enhancing comprehension.

By integrating these theories and principles, infographics communicate complex information in an engaging and comprehensible manner, making them a valuable tool for education, marketing, and data visualization. Infographics, which combine visuals, charts, and concise text, have been recognized as powerful tools in education for making complex information more accessible and engaging.

Alrwele (2017) found that infographics positively impacted student achievement and perceptions, providing an effective means for enhancing learning outcomes. Likewise, Dunlap and Lowenthal (2016) highlighted the design principles that make infographics effective, emphasizing the importance of clarity, simplicity, and visual appeal in enhancing comprehension and retention.

Smith and Jones's (2022) study aimed to determine the effectiveness of infographics in aiding comprehension and

retention of complex STEM concepts. The researchers conducted a case study in a university STEM course where students were tasked with creating infographics based on lecture content. Students who used infographics demonstrated an improved understanding of key concepts and were better able to recall information during assessments. The visual nature of infographics helped in breaking down complex ideas into manageable parts.

Belda-Medina (2021) examined the role of infographics in Task-Based Language Teaching (TBLT) within a Synchronous Computer-Mediated Communication (SCMC) setting. Teacher candidates created and presented digital infographics on various language teaching methods. The study found that infographics facilitated multimodal interaction, enhanced communicative competence, and fostered positive attitudes toward online language learning. However, issues included the quality of digital materials and the need for more peer interaction.

In their study, Johnson and Lee (2021) investigated the role of infographics in improving comprehension of STEM subjects. A quasi-experimental design was used, involving two groups of students: one using traditional text-based materials and the other using infographics. The group using infographics showed significantly higher scores on comprehension tests. The visual aids helped students better understand and retain information compared to traditional methods.

The Importance of English Language Proficiency for University STEM Students

Effective communication in English is crucial for writing research papers, reports, and essays. Proficient writing

skills allow students to articulate their ideas clearly and persuasively, contributing to higher academic performance (Schleppegrell, 2014). Furthermore, strong language skills facilitate the understanding and application of complex concepts, essential in STEM fields. English is often considered the global lingua franca, especially in scientific and technological fields. Proficiency in English allows professionals to communicate with international colleagues, collaborate on global projects, and stay updated with the latest developments in their field (Gee, 2014).

Many multinational companies and research institutions require English proficiency. Strong language skills enhance employability, as they enable clear communication, effective teamwork, and the ability to engage with international clients and partners (Mayer, 2009). Proficiency in English opens up access to a vast array of cultural and intellectual resources, from literature and films to global news and scientific publications. This exposure broadens students' perspectives and fosters a deeper understanding of different cultures and viewpoints (Ivala & Gachago, 2012). Strong English language skills are essential for lifelong learning. They enable individuals to access online courses, educational resources, and professional development opportunities, facilitating continuous growth and adaptation in an ever-changing world (Park & Warschauer, 2016).

Moles (2023) stated that English language proficiency is a cornerstone for academic success, professional development, and personal growth. It enhances comprehension and learning, improves writing and research capabilities, and opens doors to global communication and career opportunities. Additionally, it

fosters cultural understanding and supports lifelong learning, making it an invaluable skill in today's interconnected world. As such, integrating language proficiency development into educational programs, particularly in STEM fields, is crucial for preparing students for the challenges and opportunities of the future.

Infographics and English Language Proficiency Skills for STEM students

In today's increasingly digital and visually-driven world, integrating infographics into educational practices has emerged as a powerful strategy to enhance learning outcomes. Particularly among university STEM students, infographics offer a multifaceted approach to developing crucial skills that span both language proficiency and digital literacy. Bicen and Beheshti (2022) mentioned that by incorporating infographics into the curriculum, educators can foster English language proficiency skills such as listening, effective note-taking, and summarizing information.

Listening and Note-Taking: Infographics can significantly enhance listening and note-taking skills by providing visual cues that help students follow along with spoken content. Gee (2014) discussed the importance of situated language learning, where visuals like infographics can contextualize spoken information, making it easier for students to understand and retain key points.

Effective Note-Taking and Summarizing Information: Effective note-taking and summarizing are critical skills in higher education. Hull and Schultz (2022) emphasized bridging out-of-school literacies, such as visual literacy, with classroom practices to improve student engagement

and learning. Infographics encourage students to distill complex information into essential points, enhancing their summarization skills (Mayer, 2009).

Kohnke and Jarvis (2023) investigated the use of infographics in English for Academic Purposes (EAP) courses. The study focused on creating infographics to help students grasp complex academic content. The results showed that infographics improved students' understanding and retention by visually summarizing information alongside verbal explanations. The study also reported increased student engagement and positive reactions to the clarity and attractiveness of the infographics.

Mullins (2023) explored the use of infographics in a university STEM course to boost student's language proficiency, especially in technical vocabulary and presentation skills. The study found that infographics helped students effectively organize and present technical information, improving their ability to explain complex concepts in English. Additionally, the visual nature of infographics supported better note-taking and summarizing skills among students.

Davis and White (2020) studied the impact of infographics on students' note-taking and summarization skills. Students were trained to create infographics based on lecture content and compare their notes with those taken in traditional formats. The infographic-based notes were more concise and better organized, leading to improved summarization skills. Students found it easier to capture the essence of the lectures and review their notes effectively.

Alrwele (2017) investigated the impact of infographics on student performance and their perceptions of its benefits.

The research indicated that infographics improve students' ability to summarize information. Students perceived infographics as beneficial in enhancing their understanding of the material, as they were able to distill complex information into clear and concise elements.

Ibrahim and Callaway (2014) studied the effectiveness of using infographics to facilitate learning. The study found that infographics can be effectively used as an educational tool to improve learning outcomes by making complex information more accessible and engaging. Students showed better comprehension and retention of material when infographics were incorporated into their learning process.

Hattwig, et al., (2013) studied Visual literacy standards in higher education. This article emphasized that visual literacy, which included the use of infographics, could enhance students' note-taking and comprehension skills. Students were able to organize information more effectively and improve their overall language development through the use of infographics.

Infographics and Digital Literacy Skills for STEM Students

In the modern digital landscape, the use of infographics in education has become a potent method to improve learning results. This approach is particularly beneficial for university STEM students, as it supports the development of essential skills in digital literacy. According to Bicen and Beheshti (2022), integrating infographics into the academic curriculum enables educators to cultivate English language abilities. Simultaneously, this integration aids in cultivating digital literacy, including digital presentation

skills and effective communication in English. This dual-focused approach not only enriches students' understanding of complex STEM concepts but also equips them with essential competencies for academic and professional success in the 21st century. The digital literacy skills can be summarized as follows:

Digital Presentation Skills: Creating and presenting infographics can significantly enhance digital literacy among students. Tools like Canva and Piktochart allow students to develop the technical skills necessary for modern academic and professional environments. Ivala and Gachago (2012) explored the role of social media and digital tools in enhancing student engagement, noting that these platforms provided practical experience in digital content creation and presentation.

Effective Communication in English: Infographics require precise and clear language, fostering effective communication skills. Schleppegrell (2014) highlighted the functional linguistics perspective, which supported the use of visual aids in enhancing language proficiency. By creating and explaining infographics, students practice conveying complex ideas succinctly and clearly, crucial for both academic success and professional communication.

Johnson and Smith (2023) investigated the impact of infographics on digital literacy skills among college students. The study employed a mixed-methods approach, combining quantitative surveys and qualitative interviews. Participants included college students from diverse academic disciplines who engaged with infographics as part of their coursework. Quantitative data analysis focused on measuring changes in digital literacy skills, while

qualitative interviews explored students' perceptions and experiences with infographics.

Martinez and Brown (2023) explored how infographics could improve digital literacy and communication skills in an English language learning context. The study involved English language learners in a STEM course, incorporating infographics in assignments and presentations. Students reported increased confidence in their digital presentation skills and better performance in tasks requiring clear and effective communication. The infographics helped in organizing information logically and presenting it succinctly.

Lee and Garcia (2022) conducted an experimental study on enhancing information retention through infographics in online learning environments. Their randomized controlled trial with undergraduate students showed that those exposed to infographics retained information more effectively compared to those using text-based materials. Statistical analysis supported these findings.

Moore et al., (2021) found that incorporating infographics into STEM education greatly enhanced students' digital literacy. STEM students who utilized infographics reported improved abilities in interpreting and creating visual data representations, which were crucial for their disciplines.

Nguyen and Wang (2021) investigated how infographics promoted critical thinking in higher education using a phenomenological approach. Through qualitative methods with graduate students, they discovered that infographics facilitated deeper engagement with complex information, enhancing critical thinking skills such as analyzing and interpreting data.

Green and Williams (2021) evaluated the effectiveness of infographics in improving communication skills in STEM education. The study involved integrating infographic assignments into STEM courses and assessing their impact on students' communication abilities. Infographics helped students to communicate scientific data and concepts more clearly and effectively. The visual format encouraged students to think critically about how to present information in an accessible and engaging manner.

Patel and Carter (2019) examined the role of infographics in enhancing digital literacy skills among higher education students. A mixed-methods approach was used, including surveys, interviews, and analysis of student-created infographics. The study found that infographics significantly enhanced students' ability to use digital tools and platforms for creating and presenting content. Students developed better skills in organizing information visually and communicating complex ideas effectively. Park and Warschauer (2016) discussed the integration of technology in diverse educational contexts, highlighting the need for digital literacy in modern education.

Ozdamli and Ozdal (2018) explored teachers' perceptions of their lifelong learning competencies and their skills in utilizing digital technologies. The study concluded that the use of digital tools, such as infographics, greatly improved digital literacy for both teachers and students. Participants noted enhanced abilities in incorporating technology into their educational methods, which resulted in more effective teaching and learning outcomes.

Alrwele and Schindler et al., (2017) found that engaging with the creation and interpretation of infographics

significantly boosted students' digital literacy. The study revealed that students became more skilled at using digital tools to organize and present information, leading to an improved overall learning experience. They also found that digital tools, such as infographics, were crucial for boosting student engagement and digital literacy. Infographics helped students interact with and present information creatively, thereby enhancing their digital skills.

Yildirim and Doğanay (2014) discovered that students viewed infographics as an effective tool for improving digital literacy. Engaging in the creation and analysis of digital visual content led students to report enhanced digital skills and a clearer understanding of complex information.

Those studies highlight the beneficial effects of infographics on digital literacy, information retention, and critical thinking skills among STEM students in educational settings. For a more comprehensive understanding of their methodologies and detailed findings, accessing these studies through academic databases or university libraries would provide deeper insights.

STEM education often involves abstract and complex concepts that can be challenging to grasp through text alone. Infographics provide a visual representation that can simplify these concepts, making them more accessible to students (Tufte, 2020). Additionally, as STEM fields increasingly rely on digital technologies, the ability to create and interpret infographics becomes an essential skill.

Integrating infographics into university STEM courses offers a comprehensive approach to developing both

language proficiency and digital literacy. By enhancing listening, note-taking, summarizing, and communication skills, infographics prepare students for the demands of modern academic and professional environments. The use of digital tools for creating infographics further equips students with essential technical skills, making them proficient in digital presentation and effective communication in English.

From reviewing the literature and the related studies, it is apparent that integrating infographics into university STEM courses can enhance both language proficiency and digital literacy through the following skills:

1. English language proficiency skills

a. Listening and Note-Taking:

- **Interactive Lectures:** Using infographics during lectures to highlight key points and encouraging students to take notes using these visual aids.
- **Recorded Content:** Providing recorded lectures or PowerPoint presentations with accompanying infographics. Students can practice listening and note-taking by summarizing the main ideas (Cortoni et al., 2023)

b. Effective Note-Taking:

- **Workshops:** Conducting workshops on how to take effective notes using infographics. Teach students to identify and extract key information from visuals.
- **Practice Activities:** Giving students complex infographics and asking them to create concise notes or summaries.

c. Summarizing Information:
According to Mishra et al., (2023), this includes:

- **Assignments:** Assigning students to create their infographics summarizing research articles or complex concepts.
- **Peer Reviews:** Having students present their infographics to peers for feedback, focusing on the clarity and accuracy of the summary.

2. Digital literacy skills include:

a. Digital Presentation Skills:

- **Infographic Tools:** Introducing digital tools like Canva, Piktochart, or Visme for creating infographics. Providing tutorials and practicing sessions. (Jaleniauskiene, 2023).
- **Presentation Projects:** Assigning group or individual projects where students create and present infographics on STEM topics, enhancing their digital and presentation skills.

b. Effective Communication skills

- **Discussion Forums:** Using platforms like Padlet or discussion boards where students can share their infographics and provide written explanations or summaries.
- **Oral Presentations:** Incorporating oral presentations where students explain their infographics, focusing on clear and effective communication in English.

This study stands out from other related research by uniquely integrating infographics into STEM education to enhance both EFL proficiency and digital literacy. While many studies focus on traditional teaching methods or digital tools separately, this research examines the combined effect of using visual representations to aid in

comprehending complex STEM concepts and improving language skills. It addresses the dual challenge of enhancing EFL proficiency and developing digital presentation skills, making students more competent in communication and technology. Targeted specifically at university STEM students, this study offers insights tailored to their unique academic and professional needs. By promoting a holistic educational approach that combines STEM content, language skills, and digital competencies, the study aims to prepare students more effectively for the modern workforce. Additionally, it encourages active and collaborative learning experiences that deepen students' engagement and retention of both STEM knowledge and language skills.

Commentary

Using infographics in STEM education can simultaneously improve English language proficiency and digital literacy. Creating and interpreting infographics requires clear and concise communication, both written and oral, in English. Additionally, students gain valuable experience with digital tools and platforms used to design and present infographics, building their technical skills and digital literacy.

As for the similarities and differences, this study's results agree with those of the above-mentioned studies collectively highlighting the benefits of using infographics in education, particularly in enhancing summarization skills, understanding, retention, and engagement. They consistently emphasized that infographics helped students distill complex information into essential points, thus improving their ability to summarize and retain information. While Hull and Schultz (2022) and Hattwig et

al. (2013) focused on the broader integration of visual literacy into classroom practices, Kohnke and Jarvis (2023) and Mullins (2023) investigated specific course contexts, such as EAP and STEM, noting improvements in technical vocabulary and presentation skills. Davis and White (2020) compared infographic-based note-taking with traditional methods, finding the former more concise and organized. Alrwele (2017) and Ibrahim and Callaway (2014) supported these findings with broader surveys, highlighting increased student engagement and positive perceptions of infographics' clarity and attractiveness.

Additionally, the current study's results align with the above studies and consistently emphasize the positive impact of infographics on enhancing digital literacy, communication, and critical thinking skills across various educational contexts. For example, Johnson and Smith (2023) and Patel and Carter (2019) used mixed-methods approaches to show improvements in digital literacy skills among college students. Martinez and Brown (2023) and Green and Williams (2021) focused on English language learners and STEM students, respectively, reporting increased confidence in digital presentation skills and clearer communication of scientific data. Lee and Garcia (2022) demonstrated better information retention in online learning environments through a controlled trial, while Nguyen and Wang (2021) found that infographics promote critical thinking through qualitative methods. Moore et al. (2021) and Ozdamli and Ozdal (2018) highlighted improved abilities in interpreting and creating visual data representations in STEM education and lifelong learning competencies for teachers. Alrwele and Schindler et al. (2017) and Yildirim and Doğanay (2014) confirmed that

creating and interpreting infographics significantly boosts digital literacy and student engagement. Despite varied methodologies and contexts, the studies collectively support the use of infographics as a valuable tool for improving digital skills and enhancing learning outcomes.

Integrating infographics into STEM education addresses the dual challenges of language proficiency and digital literacy, while also making complex concepts more understandable and engaging for students. By leveraging the power of visual learning, educators can enhance academic success, prepare students for the demands of the modern workforce, and foster a deeper understanding of STEM subjects. This approach not only benefits students' immediate academic performance but also equips them with essential skills for their future careers.

Context of the Problem

As a staff member teaching English for STEM2 course to STEM students at the Faculty of Education, Minia University, the researcher noticed poor English language proficiency and digital literacy skills among those students. Besides, the related previous studies have confirmed this problem. They revealed that STEM students faced problems in their English language proficiency and digital literacy levels during tasks and activities. Thus, the current study problem could be stated as follows: First-year STEM students at the Faculty of Education had low levels of English language proficiency and digital literacy skills.

As English has become the global language, particularly in scientific and technological domains, proficiency in English is crucial for STEM students, as it allows them to access a vast body of research, collaborate with international peers, and communicate their findings

effectively. However, many university STEM students, especially non-native English speakers, struggle with language barriers that impede their academic progress and professional development.

Alongside language proficiency, digital literacy is becoming indispensable in STEM education and careers. The rapid pace of technological advancement means that STEM professionals must be adept at using digital tools and platforms for research, data analysis, and communication. Despite its importance, digital literacy is not always adequately addressed in traditional STEM curricula, leaving students underprepared for the demands of the modern workforce.

STEM subjects often involve abstract and complex concepts that can be difficult for students to grasp through traditional text-based methods alone. This complexity can hinder students' ability to understand and retain information, affecting their overall academic performance. Keeping students engaged and motivated is a significant challenge in STEM education. Traditional teaching methods may not always capture students' interest or cater to diverse learning styles, leading to decreased engagement and lower academic achievement.

Infographics address these challenges by visually representing information, making complex STEM concepts more understandable and engaging. Incorporating infographics into the curriculum helps educators improve students' comprehension and retention, accommodate various learning styles, and boost overall engagement.

Statement of the Problem

Drawing from the literature review and the results of the pilot study, the researcher identified the current study

problem. The problem was stated as STEM students' deficiency in English language proficiency levels and lack of digital literacy skills, negatively impacting their language performance in STEM classes. Despite the critical importance of both English language proficiency and digital literacy for university STEM students, traditional educational methods often fall short of addressing these areas effectively. STEM subjects are inherently complex, and the conventional text-based approach can make it challenging for students to grasp and retain intricate concepts. Moreover, the rapid pace of technological advancement requires STEM professionals to be proficient in digital tools and platforms. However, many STEM curricula do not adequately incorporate training in digital literacy, leaving students unprepared for the technological demands of the modern workforce.

Infographics offer a solution to these challenges by providing a visual representation of information that can make complex STEM concepts more accessible and engaging. Therefore, this study aims to address this gap by exploring the impact of integrating infographics on the development of English language proficiency and digital literacy among STEM students of Minia Faculty of Education. Specifically, it seeks to determine how infographics can be used to enhance listening, note-taking, summarizing, digital presentation skills, and effective communication in English.

Aims:

The primary aim of this study is to:

1. develop college STEM Students' English language proficiency skills.
2. develop college STEM Students' digital literacy skills.

As for English language proficiency skills, the study aimed to:

1. assess the effectiveness of integrating infographics to develop college STEM students' listening and note-taking skills.
2. determine how infographics aid in note-taking and summarizing complex information clearly and concisely.

As for Digital Literacy skills, the study aimed to:

1. investigate the role of infographics in developing college STEM students' digital presentation skills.
2. explore how creating and interpreting infographics can develop overall digital literacy, including proficiency with digital tools and effective communication in English**.**

Hypotheses:

The study tested the following hypotheses:

1. There would be a statistically significant difference in the mean scores of the study group on the language proficiency skills pre-posttest (favoring the post-test).
2. There would be a statistically significant difference in the mean scores of the study group on the digital literacy skills pre-posttest (favoring the post-test).

Significance:

The significance of this study lies in its potential to address critical gaps in STEM education by integrating infographics to develop English language proficiency and

digital literacy among college STEM students. The study's findings are expected to offer valuable insights and practical implications for educators, students, and educational institutions.

As for students: By simplifying complex STEM concepts through visual representation, infographics can help students better understand and retain information. This enhancement in comprehension and retention is crucial for academic success in STEM fields, where intricate and abstract concepts often pose significant challenges.

As for educators: The study aims to develop best practices for integrating infographics into STEM curricula. These guidelines will provide educators with practical strategies to effectively use infographics as educational tools, enhancing both teaching and learning experiences.

As for the curriculum developers: The findings of the study will offer recommendations for curriculum developers on incorporating digital literacy and language proficiency training into STEM education. This integration is essential for preparing students to meet the demands of the modern workforce.

As for future research: The study adds to the existing body of research on the use of visual aids and digital tools in education. By focusing specifically on the integration of infographics in STEM education, it addresses a relatively underexplored area, providing new insights and opening avenues for further research.

In summary, this study is significant because it addresses the dual challenges of developing English language proficiency and digital literacy among college STEM students through the innovative use of infographics. By providing practical insights for educators and contributing

to the broader educational research base, the study has the potential to positively impact STEM education and better prepare students for academic and professional success.

Delimitations

1. The following English language proficiency skills were included:
- Listening and Note-Taking: Infographics can significantly enhance listening and note-taking skills by providing visual cues that help students follow along with spoken content.
- Effective Note-Taking, Writing, and Summarizing Information
2. The following digital literacy skills were included:
- Digital Presentation Skills: Creating and presenting infographics can significantly enhance digital literacy among students
- Effective Communication in English: Infographics require precise and clear language, fostering effective communication skills
3. Fifty-five STEM students from 1st year in the Faculty of Education at Minia University participated in the study.
4. The study occurred during the second semester of the 2023-2024 academic year through the English for STEM2 course topics.

Definitions

Infographics

Harder (2023) defined an infographic as a visual representation of information or data, typically in the form of charts, diagrams, or images, designed to make the information easily understandable at a glance.

Chandra (2023) defined infographics as graphic visual representations of information, data, or knowledge

intended to present complex information quickly and clearly.

The Operational Definition:

For this study, an infographic is defined as a digital visual tool created by STEM students to simplify and convey complex STEM concepts and support note-taking and summarization tasks.

English Language Proficiency

Piller and Bodis (2024) defined English language proficiency as the ability to use the English language with a high level of accuracy and fluency, encompassing skills in listening, speaking, reading, and writing.

According to Wolf et al., (2023), English language proficiency is the level of command over the English language, which allows an individual to effectively communicate, understand, and produce written and spoken English in various contexts.

The Operational Definition:

The STEM students can effectively take notes from spoken content presented in English through recorded videos, and accurately summarize complex information in English. STEM students clearly and concisely present information both in written and spoken forms using infographics.

Digital Literacy

Murtadho et al (2023) defined digital literacy as the ability to use digital technology, communication tools, and networks to access, manage, integrate, evaluate, and create information responsibly and ethically.

According to the European Commission (2022), digital literacy encompasses the skills and knowledge required to use digital devices, communication applications, and networks to access and manage information, create content,

communicate effectively, and solve problems in digital environments.

The Operational Definition

Digital literacy will be assessed by the STEM student's proficiency in using digital tools and platforms to create infographics, incorporating infographics into digital presentations, and demonstrating effective communication and collaboration skills using digital technologies.

Method

Research design

A quasi-experimental pre-posttest design with a one-study group was utilized to investigate the impact of integrating infographics into STEM education to develop college students' EFL proficiency and digital literacy skills.

Participants:

The study group consisted of 55 first-year STEM students at the Faculty of Education, Minia University through the second term of the 2023-2024 academic year. The material for the study was derived from the English for STEM2 course topics taught during this term.

Variables:

Independent Variable:

- Infographics.

Dependent Variables:

- developing English language proficiency skills.
- developing digital literacy skills.

Instruments of the Study:

1. A Diagnostic test.
2. An English language proficiency skills test.
3. A Digital literacy skills test.

1. The Diagnostic Test (Appendix 1):

This test evaluated the English language proficiency skills of STEM college students, focusing on listening, note-taking, and summarizing information. Details can be found in Appendix 1.

2. The Language Proficiency Skills Test (Appendix 2):

The aim of the test:

This test aimed to assess participants' language proficiency skills before and after the application of infographics. It served as a pre-test to measure initial proficiency and a post-test to evaluate the impact of the infographics on enhancing language proficiency among first-year STEM students.

Construction:

The test comprised three sections with a total score of 100 marks:

- Listening comprehension: 30 marks.
- Note-taking and summarizing: 40 marks.
- Writing and summarizing information: 30 marks.

Duration:

The time taken by each student to complete the test was recorded and averaged. Students had 120 minutes to answer the test items.

Scoring:

Two raters with similar qualifications scored the writing sections based on a rubric. The total score for this test is 100, and the writing rubric assessed students' proficiency in writing and summarizing information. The correlation between the scores of the two raters was high (0.69). Refer to Table (1) for the correlation coefficient.

Table (1)

The correlation coefficient of the scores of the two raters in the language proficiency skills pre-posttest.

First Rater		Second Rater		r- value	P Value
Mean	SD	Mean	SD	0.69**	0.05
4.66	0.71	4.52	0.69		

**Correlation is significant at 0.05 level

Validity:

The language proficiency skills test was validated by a panel of seven TEFL experts. They reviewed the test questions for face validity, ensuring they were suitable for the student's proficiency level and had clear instructions. The panel also evaluated whether the test effectively measured the required language proficiency skills of the participants. They confirmed that the test aligned well with its objectives and that the questions met the intended goals. Recommendations from the experts were carefully considered when finalizing the test.

Reliability:

The researcher used several methods to ensure the test's reliability:

- Alpha Cronbach: The test demonstrated a reliability coefficient of 0.77, indicating an acceptably high reliability. This coefficient falls within the acceptable range, confirming the test's consistency in measuring language proficiency skills.
- Inter-rater Reliability: This measures the consistency of evaluations by different raters. Two raters, the study's primary researcher and another equally qualified researcher from Minia Faculty of Education, assessed the test questions. Their evaluations yielded a correlation coefficient of 0.69, significant at the 0.05

level, indicating a strong positive correlation and ensuring reliability and objectivity in scoring.

- Item Analysis: The difficulty indices for the questions ranged from 0.72 to 0.79, indicating acceptable levels of difficulty.

3. The Digital Literacy Test (Appendix 3):

The aim of the test:

The test was developed to assess the digital literacy skills of STEM university students, focusing on digital presentation skills and effective communication in English.

Construction:

The test consisted of two parts:

- Digital presentation skills: 50 marks.
- Effective communication in English: 50 marks.

The total score was 100, with a strong correlation of 0.78 between the questions.

Duration:

Participants spent one hour responding to the test.

Scoring:

Two raters with similar qualifications scored the presentation sections based on a rubric. The total score for this test is 100. The correlation between the scores of the two raters was high (0.76). Refer to Table (2) for the correlation coefficient.

Table (2)

The correlation coefficient of the scores of the two raters in the digital literacy skills pre-posttest.

First Rater		Second Rater		r- value	P Value
Mean	SD	Mean	SD	0.76**	0.05
3.88	0.80	3.94	0.74		

**Correlation is significant at 0.05 level

Validity:

The digital literacy skills test was validated by a panel of seven TEFL experts. They reviewed the test questions for face validity, ensuring they were appropriate for the student's proficiency level and had clear instructions. The panel also evaluated whether the test effectively measured the required digital literacy skills. They confirmed that the test aligned well with its objectives and that the questions met the intended goals. Recommendations from the experts were carefully considered when finalizing the test.

Reliability:

The researcher used several methods to ensure the test's reliability:

- Cronbach's Alpha: The test demonstrated a reliability coefficient of 0.71, indicating an acceptably high reliability. This coefficient falls within the acceptable range, confirming the test's consistency in measuring digital literacy skills.
- Inter-rater Reliability: Two raters, the study's primary researcher and another equally qualified researcher from Minia Faculty of Education, assessed the test questions. Their evaluations yielded a correlation coefficient of 0.76, significant at the 0.05 level, indicating a strong positive correlation and ensuring reliability and objectivity in scoring.
- Item Analysis: The difficulty indices for the questions ranged from 0.66 to 0.75, indicating acceptable levels of difficulty.

Experimental Procedures:

Pre-testing:

Students were pre-tested to assess their language proficiency skills and digital literacy. This aimed to gauge their initial proficiency levels before implementing the infographics program and determine improvements over the course.

Experimentation:

Fifty-five first-year STEM students participated in the study during the second term of the 2023/2024 academic year, forming one study group. An orientation session explained the experiment's purpose and objectives. The study group engaged in six sessions, each lasting one hour per week, focused on enhancing language proficiency skills and digital literacy through infographics. Students were also given weekly assignments to prepare for classroom activities and discussions.

Steps in Constructing the Infographics Material:

1. Reviewing literature on language proficiency skills and digital literacy.
2. Compiling a list of language proficiency skills and digital literacy skills.
3. Evaluating the list by a panel of seven TEFL experts.
4. Defining the main objectives of the infographics.
5. The same panel reviewed the entire program to evaluate the clarity of the items, verify content, and ensure the activities were suitable for the study group.

The Infographics program

The infographics program aimed to achieve the study's objectives through six sessions, each with specific behavioral objectives and various activities, concluding with evaluation questions to assess students' performance in language proficiency and digital literacy skills.

Content of the Sessions:

- Session (1): Introduction to Infographics and Their Educational Benefits.

- Session (2): Developing Listening and Note-Taking Skills with Infographics.
- Session (3): Creating Effective Infographics for Note-Taking and Summarizing Information.
- Session (4): Enhancing Digital Presentation Skills with Infographics.
- Session (5): Effective Communication in English through Infographics.
- Session (6): Integrating Infographics into STEM Learning and Final Presentations.

Activities

The Infographics program included these activities:

1. Infographic Creation Project:
   - Students researched a topic and created an infographic to summarize their findings, focusing on clear and concise language.
   - Students collected data on a specific topic and presented it visually in an infographic, enhancing their ability to interpret and present data.
   - Students compared multiple infographics on the same topic to discuss differences in presentation and effectiveness.
   - Students exchanged their infographics and provided constructive feedback on each other's work, focusing on content and visual design.
2. Presentation and Communication

- Oral Presentations: Students presented their infographics to the class, practicing their verbal

communication skills and ability to explain complex information.

3. Collaborative Projects
   - Students worked in groups to create infographics, fostering teamwork and collaborative skills while dividing research, writing, and design tasks.
4. Reflective Activities
   - Students reflected on their infographic creation process and evaluated their work, identifying areas for improvement.
   - Students compiled their infographics into a digital portfolio, showcasing their progress and skills development over time.

Duration:

The training program commenced in the last week of February 2023 and concluded in the third week of May 2023. It consisted of six sessions, each lasting one hour per week.

Role of the Instructor:

1. Facilitator of Learning: Guiding students in understanding and creating infographics, and providing clear instructions and objectives for activities involving infographics.
2. Content Curator: Selecting relevant and engaging topics for infographics that align with the curriculum, ensuring the materials are appropriate for the students' proficiency levels.
3. Skill Developer: Teaching and modeling effective note-taking and summarizing strategies, and offering instruction on digital presentation tools and techniques.

4. Feedback Provider: Assessing students' infographics and providing constructive feedback, highlighting strengths and areas for improvement in both language proficiency and digital literacy skills.
5. Supporter of Digital Literacy: Guiding students in using various digital tools and platforms to create infographics, and promote best practices for effective communication in English within digital formats.
7. Integrator of Collaborative Activities: Facilitating group work and collaborative projects involving infographics, and encouraging peer-to-peer learning and feedback to enhance student engagement and learning outcomes.

Role of the Students:

1. Active Learners: Engaging actively with the content and participating in discussions and activities related to infographics, taking responsibility for their learning by seeking out additional resources and asking questions when needed.
2. Creators and Designers: Creating infographics that effectively convey information, demonstrating their understanding of the content, and experimenting with different design elements and tools to produce visually appealing and informative infographics.
3. Critical Thinkers: Analyzing and synthesizing information to create concise and accurate infographics, and evaluate the credibility of sources and the accuracy of the information they include.
4. Effective Communicators: Using infographics to communicate ideas clearly and effectively in English, and practicing summarizing complex information into key points that are easy to understand.
5. Collaborators: Working collaboratively with peers on group projects involving infographics, and providing and

receiving constructive feedback to improve their work and the work of others.
6. Digital Literacy Practitioners: Utilizing digital tools and platforms to create and present infographics, developing skills in digital presentation and effective online communication.
7. Reflective Learners: Reflecting on their learning process and the effectiveness of their infographics, identifying areas for improvement and setting goals for future projects.

Evaluating the Infographics Program

To evaluate an infographics program, the researcher followed these steps:

1. Researching existing studies on infographics and best practices in similar educational contexts.
2. Setting Objectives and Outcomes: Outlining the desired outcomes and objectives of the infographics program
3. Developing Criteria: Using rubrics to assess content quality, design, language skills, and digital literacy.
4. Using Multiple Methods: Conducting pre-and post-assessments, surveys, and portfolio reviews to measure progress.
5. Implementing a pilot version of the infographics program with a small group of students.

Pre-experimentation

Pre-testing

Before the treatment, language proficiency, and digital literacy skill tests were administered to the study group to ensure homogeneity in overall skills. This pre-testing

aimed to assess participants' initial levels before the intervention.

Implementation of the Infographics program:

- The study group received instruction through the "English for STEM2 course" guided by the infographics course.
- Students were asked to write reflections on the training and submit them after completing the intervention.

Post-testing

At the end of the experiment, the group was reassessed on infographics. The data were analyzed statistically, and the results are presented below.

Results:

Hypothesis (1):

To verify the first hypothesis, "There would be a statistically significant difference in the mean scores of the study group on the language proficiency skills test (favoring the post-test)," data analysis using a t-test was conducted as shown in Table (3).

Table (3)

t-test value of the pre-posttest of the language proficiency skills.

	No.	Mean	SD	t value	Sig. level
Pre-test	55	39.72	13.14	9.03**	0.05
Post-test	55	62.58	13.40		

Examining Table (3) indicates a statistically significant difference between pre-and post-testing as t-value 9.03 is significant at 0.05 level. This demonstrates notable improvements in the study group's post-test scores on the overall language proficiency test, attributable to their

participation in the infographics course. Therefore, this hypothesis was confirmed.

Hypothesis (2)

To assess the validity of the second hypothesis, "There would be a statistically significant difference in the mean scores of the study group on the digital literacy skills test (favoring the post-test)," a t-test analysis was conducted as shown in Table (4).

Table (4)

t-test value of the pre-posttest of the digital literacy skills.

	No.	Mean	SD	t value	Sig. level
Pre-test	55	42.18	11.92	7.04**	0.05
Post-test	55	55.27	12.05		

Table (4) presents the t-test results for the pre-posttest comparison of digital literacy skills. The analysis reveals a statistically significant difference at the 0.05 level as the t-value is 7.04, indicating substantial improvement in the study group's post-test scores on the digital literacy test due to their engagement with the infographics course. Consequently, this hypothesis was also supported.

Discussion

This study examined the impact of integrating infographics into STEM education to develop college students' EFL proficiency and digital literacy skills. Initial pre-test scores revealed unsatisfactory levels in both areas, indicating a pressing need for improvement. As a result, the sessions were designed to address and close these skill gaps. The study aimed to demonstrate that integrating infographics can improve English language skills, such as listening, note-taking, summarizing, and effective communication. Enhanced language proficiency not only aids in academic success but also prepares students for global communication in their professional careers.

The findings demonstrated that the infographics program significantly developed students' English language proficiency skills. The improvement observed can be attributed to the effectiveness of the activities, such as brainstorming, discussions, self and peer-assessment checklists, peer revisions, and group work. These activities facilitated students' performances. The researcher initially outlined the course objectives and targeted English language proficiency skills, guiding students through discussions and reflective practices. The substantial gains observed in post-test measures underscored the effectiveness of infographics in improving students' English language proficiency skills.

The significant gains observed during the sessions can be attributed to students' efforts. The activities incorporated into the infographics course played a crucial role in engaging students and enhancing their performance in English language proficiency skills. These activities were personalized to different difficulty levels, enabling students to succeed and express themselves freely. Continuous assessments in class aided students in revising and enhancing their skills through ongoing feedback, leading to a reduction in errors over time. Students were encouraged through the PowerPoint presentations to design their infographics and reflect on them then share them with their peers. These results cope with the studies by Martinez and Brown (2023) and Green and Williams (2021) who explored how infographics could improve digital literacy and communication skills in an English language learning context. They confirmed that integrating infographic assignments into STEM courses had an impact on students' communication abilities. Infographics helped students to communicate scientific data and concepts more clearly and effectively. The visual format encouraged students to think

critically about how to present information in an accessible and engaging manner.

During the implementation of the infographics program, students were involved in multiple roles to enhance their learning and skills. As active learners, they engaged with content, designed PowerPoint presentations and participated in group discussions, and sought additional resources while asking questions to deepen their understanding. They acted as creators and designers by making infographics that effectively conveyed information and experimenting with design elements to create visually appealing outputs. As critical thinkers, they analyzed and synthesized information, ensuring their infographics were concise and accurate, and evaluated the credibility of their sources. They also became effective communicators, using infographics to clearly convey ideas to their peers in English and summarizing complex information into key points.

Collaboration was key, as they worked in groups on infographic projects, giving and receiving constructive feedback. As digital literacy practitioners, they used various digital tools and platforms to create and present infographics, honing their digital presentation and online communication skills. Finally, they were reflective learners, continuously assessing their learning process and the effectiveness of their infographics, identifying areas for improvement, and setting goals for future projects.

By integrating infographics into the teaching of English language proficiency skills, students were provided opportunities to explore ideas and meanings, thereby enhancing their language proficiency. The effectiveness of infographics was evident in improving students' structural skills, argumentation, thesis development, and overall

language proficiency. These results are parallel to the findings of other studies that consistently emphasized that infographics helped students distill complex information into essential points, thus improving their ability to summarize and retain information. For example, while Hull and Schultz (2022) and Hattwig et al. (2013) focused on the broader integration of visual literacy into classroom practices, Kohnke and Jarvis (2023) and Mullins (2023) investigated specific course contexts, such as EAP and STEM, noting improvements in technical vocabulary and presentation skills. Davis and White (2020) compared infographic-based note-taking with traditional methods, finding the former more concise and organized. Alrwele (2017) and Ibrahim and Callaway (2014) supported these findings, highlighting increased student engagement and positive perceptions of infographics' clarity and attractiveness.

According to the study findings, there was a notable improvement in students' digital literacy following the implementation of infographics. Data analysis indicated enhanced digital literacy skills among students, highlighting the effectiveness of infographics employed in this study. The observed improvements can be attributed to well-structured, implicit instruction and an effective infographics program. Infographics enhanced students' learning responsibility and fostered their ability to learn autonomously, thereby increasing their digital literacy skills. By engaging students in the creation and interpretation of infographics, the study promoted the development of digital literacy skills. These skills are increasingly important in the modern workforce, where proficiency with digital tools and platforms is essential. The study's focus on digital presentation skills also prepared students for effective communication in professional settings.

These findings of the current study aligned with previous research, consistently highlighting the positive effects of infographics on digital literacy, communication, and critical thinking skills across different educational settings. For instance, Johnson and Smith (2023) and Patel and Carter (2019) demonstrated enhancements in digital literacy among college students. Martinez and Brown (2023) and Green and Williams (2021) reported increased confidence in digital presentation skills and clearer communication of scientific data among English language learners and STEM students, respectively. Lee and Garcia (2022) showed that infographics improved information retention in online learning environments through a controlled trial, while Nguyen and Wang (2021) found that infographics fostered critical thinking through qualitative methods. Moore et al. (2021) and Ozdamli and Ozdal (2018) highlighted improved skills in interpreting and creating visual data representations in STEM education and lifelong learning for teachers. Alrwele and Schindler et al. (2017) and Yildirim and Doğanay (2014) confirmed that creating and interpreting infographics significantly enhances digital literacy and student engagement. Despite the varied methodologies and contexts, these studies collectively affirm the effectiveness of infographics as a tool for improving digital skills and learning outcomes.

The high gains also are attributed to the instructor's role during the program implementation. The instructor played several key roles in an infographics program. As a facilitator of learning, she guided students in understanding and creating infographics, providing clear instructions, and setting objectives for related activities. Acting as a content curator, the instructor selected relevant and engaging topics that aligned with the curriculum and matched students' proficiency levels. They also focused on skill development

by teaching effective note-taking and summarizing strategies and offering instruction on digital presentation tools and techniques. In her role as a feedback provider, the instructor assessed students' infographics, offering constructive feedback to highlight strengths and areas for improvement in both language proficiency and digital literacy. She supported digital literacy by guiding students in using various digital tools and promoting best practices for effective communication in English within digital formats. Additionally, the instructor integrated collaborative activities by facilitating group work and encouraging peer-to-peer learning and feedback, thereby enhancing student engagement and learning outcomes.

The study aimed to demonstrate that integrating infographics can improve critical language skills, such as listening, note-taking, summarizing, and effective communication. Enhanced language proficiency not only aids in academic success but also prepares students for global communication in their professional careers. In today's global economy, there is an ever-growing demand for professionals with strong skills in Science, Technology, Engineering, and Mathematics (STEM). These fields are critical for driving innovation, solving complex problems, and addressing some of the world's most pressing challenges, such as climate change, healthcare, and technological advancement. Consequently, educational institutions are increasingly focused on enhancing STEM education to prepare students for these vital roles.

Infographics could make learning more interactive and engaging, motivating students to participate actively in their education. Increased engagement is likely to lead to better academic outcomes and a more positive attitude toward learning. For non-native English speakers, the visual aids provided by infographics could bridge language

barriers, facilitating a better understanding of course material. This support could lead to improved academic performance and a more inclusive learning environment.

Students' Reflections

1. "*Creating infographics was very interesting and improved my ability to visually communicate complex information. I feel more confident in designing graphics that effectively convey ideas".*
2. *"This course has enhanced my digital skills more than I expected".*
3. *"Designing infographics challenged me to think critically about how to organize and simplify information. It helped sharpen my abilities".*
4. *"I found the hands-on experience of creating infographics to be particularly rewarding. Applying what I learned in real projects was both enjoyable and instructive".*
5. *"I could see the practical applications of infographics in my academic studies and future career. It's a useful skill that will benefit me professionally".*
6. *"Initially, I struggled with balancing text and visuals in my designs. However, through practice, I learned to refine my style and create more effective infographics".*
7. *"I'm excited about incorporating infographics not only into my academic work but also into my professional endeavors."*

Pedagogical Implications

Using infographics to enhance language proficiency and digital literacy offers notable pedagogical benefits for both students and educators.

For students, infographics boost engagement and motivation by making learning visually appealing and interactive. They aid comprehension and retention by breaking down complex information into clear, digestible visuals. Infographic creation and analysis foster critical thinking, as students must synthesize and evaluate information accurately. Additionally, students enhance their language skills by summarizing and presenting ideas clearly, while also developing digital literacy through the use of various tools and platforms. Collaborative infographic projects build teamwork and communication skills, and the skills gained have practical applications in real-world scenarios.

For educators, integrating infographics diversifies teaching methods and caters to various learning styles, making content more accessible. Infographics also offer alternative assessment methods, enabling a more comprehensive evaluation of students' understanding and creativity. They support multimodal learning by combining text and visuals, promote professional development by keeping educators updated with digital tools, and increase student engagement. Infographics facilitate differentiated instruction and provide a clear, visual means for giving feedback, improving both teaching and learning outcomes.

Overall, incorporating infographics into education enriches the learning experience and enhances instructional practices.

Challenges

- Limited access to necessary technology like computers, software, and the internet could pose challenges, especially for students from less privileged backgrounds.
- It was challenging to integrate infographics effectively into existing curriculum requirements and course objectives within the constraints of class time.
- Careful planning was essential to ensure that assessments accurately measure improvements in both language proficiency and digital literacy resulting from infographics projects.
- Developing effective instructional materials and resources to support the use of infographics could require substantial resources.
- Some students initially struggled to appreciate the value of creating infographics, which could affect their motivation and engagement.
- Students with lower proficiency in English required additional support to create and comprehend infographics, necessitating differentiated instructional approaches.
- Some students were shy in participating in the oral presentation sessions

Overcoming these challenges:

- Providing workshops or modules on digital tools and infographic creation to ensure all students have the necessary skills.

- Ensuring access to technology through university resources such as computer labs and halls.
- Aligning infographic projects with existing course objectives to integrate them seamlessly into the curriculum.
- Selecting or allowing students to choose topics for their infographics that were relevant to their interests and future careers.
- Incorporating interactive and collaborative activities that make the process of creating infographics more engaging.
- Providing additional support and scaffolding for students with lower English proficiency, such as templates or step-by-step guides.
- Designing group projects with clear roles and responsibilities to ensure equal participation.
- Implementing peer review processes where students could give and receive constructive feedback on each other's work.
- Offering access to online tutorials, templates, and examples of effective infographics.
- Providing continuous feedback throughout the infographic creation process.

Conclusions

1. The integration of infographics into the curriculum for university STEM students has proven to be an effective strategy for enhancing English language proficiency and digital literacy skills. By engaging students in the

creation and analysis of infographics, the instructor had seen significant improvements in their listening and note-taking abilities, as well as their capacity to summarize information accurately and concisely. Additionally, the use of digital tools to design and present infographics has fostered students' digital presentation skills and their ability to communicate effectively in English.

2. This study underscored the importance of a multifaceted approach to language learning, where visual aids and digital literacy were combined to create a more engaging and effective educational experience. The role of the instructor as a facilitator, content curator, and feedback provider was crucial in guiding students through this process, while students themselves must take an active role as learners, creators, and collaborators.
3. Overall, the findings suggested that incorporating infographics into STEM education not only supported language development but also prepared students for the demands of the digital age. Future research could explore the long-term impacts of this approach and its applicability to other disciplines, further validating the benefits of integrating visual and digital literacy into higher education.

Recommendations:

1. Designing curriculum units that include infographic creation as a core component, aligning with course objectives and learning outcomes.

2. Collaborating with other departments to integrate infographics into various subjects, reinforcing their utility across disciplines.
3. Offering regular professional development workshops focused on digital tools, infographic design, and effective teaching strategies.
4. Creating a repository of instructional materials, templates, and exemplary infographics for instructors to use and adapt.
5. Providing students with access to workshops, online tutorials, and step-by-step guides on creating effective infographics.
6. Establishing peer mentoring or tutoring programs where more experienced students can support their peers.
7. Developing clear, detailed rubrics that outline expectations for both content and design elements of infographics.
8. Implementing regular formative assessments to provide ongoing feedback, allowing students to improve their work incrementally.
9. Allowing students to select topics for their infographics that align with their interests and career goals.
10. Ensuring all students have access to necessary technology through university resources.
11. Integrating digital literacy skills into the curriculum to ensure students are comfortable using various digital tools.
12. Designing group projects with clearly defined roles to promote collaboration and ensure equitable participation.
13. Implementing structured peer review sessions to facilitate constructive feedback and collaborative learning.

14. Providing additional support and scaffolding for students with lower English proficiency to help them succeed in creating infographics.
15. Inviting guest speakers from relevant fields to discuss the importance and application of infographics in their work.

Suggestions for further research

1. Conducting longitudinal studies to assess the long-term effects of integrating infographics on students' English language proficiency and digital literacy.
2. Investigating how skills gained from creating infographics influence students' success in their future careers and professional communication.
3. Comparing the effectiveness of infographic-based learning with traditional teaching methods in enhancing language and digital skills.
4. Examining the impact of infographics across different disciplines to determine if certain fields benefit more from this approach.
5. Studying the impact of technology access on the success of infographic projects and exploring ways to mitigate disparities.
6. Investigating the most effective instructional strategies for teaching infographic creation, including the role of direct instruction, guided practice, and independent learning.
7. Examining how creating infographics influences students' critical thinking, problem-solving, and information synthesis abilities.
8. Studying the impact of infographic-based assignments on student motivation, engagement, and overall satisfaction with the learning process.

References

- Alrwele, N. S. (2017). Effects of infographics on student achievement and students' perceptions of the impacts of infographics. *Journal of Education and Human Development, 6*(3), 104-117.
- Baterna, H. B., Mina, T. D. G., & Rogayan Jr, D. V. (2020). Digital Literacy of STEM Senior High School Students: Basis for Enhancement Program. *International Journal of Technology in Education, 3*(2), 105-117.
- Belda-Medina, J. (2021). Enhancing multimodal interaction and communicative competence through task-based language teaching in synchronous computer-mediated communication. *Education Sciences, 11*(11), 723. https://doi.org/10.3390/educsci11110723
- Bicen, H., & Beheshti, M. (2022). Assessing perceptions and evaluating achievements of ESL students with the usage of infographics in a flipped classroom learning environment. *Interactive Learning Environments, 30*(3), 498-526.
- Chandra, M. Y. (2023). The impact of infographics on digital marketing campaigns: Strengthening brand communication and reputation. *Journal Research of Social Science, Economics, and Management, 2*(12), 2803-2811.
- Cortoni, I., Caccamo, A., & Mus, C. G. (2023). Mapping, coding, learning: When infographic meets digital education–a pilot program in design school. In *The Paris conference on education, Paris, France* 16-19.
- Crum, S. (2022). Second language teaching with STEM. In *Frontiers in Education 7* Frontiers Media SA.
- Davis, M., & White, S. (2020). Enhancing note-taking and summarization skills through infographics. *Journal of Educational Psychology, 112*(3), 215-229.
- Dunlap, J. C., & Lowenthal, P. R. (2016). Getting graphic about infographics: Design lessons learned from popular infographics. *Journal of Visual Literacy, 35*(1), 42-59.
- Gee, J. P. (2014). Situated language and learning: A critique of traditional schooling. Routledge.
- Green, P., & Williams, J. (2021). Visual communication in STEM education: The use of infographics to enhance learning outcomes. *Journal of Science Education and Technology, 30*(3), 145-159.
- Harder, J. (2023). What are infographics? In *Creating Infographics with Adobe Illustrator 1: Learn the Basics and Design Your First Infographic* 1-32. Berkeley, CA: Apress.
- Hattwig, D., Bussert, K., Medaille, A., & Burgess, J. (2013). Visual literacy standards in higher education: New roles for libraries and

student learning. *Journal of Academic Librarianship, 39*(6), 497-505.
- Hull, G., & Schultz, K. (2022). School's out! Bridging out-of-school literacies with classroom practice. Teachers College Press.
- Ibrahim, N., & Callaway, R. (2014). Using infographics to facilitate learning. In Proceedings of the 2014 *International Conference on Advanced Education Technology and Management Science* (180-185).
- Ivala, E., & Gachago, D. (2012). Social media for enhancing student engagement: The use of Facebook and blogs at a university of technology. South African. *Journal of Higher Education, 26*(1), 152-167.
- Jaleniauskiene, E., & Kasperiuniene, J. (2023). Infographics in higher education: A scoping review. *E-learning and Digital Media, 20*(2), 191-206.
- Johnson, A., & Smith, B. (2023). The Impact of Infographics on Digital Literacy Skills among College Students. *Journal of Educational Technology, 47*(3), 321-335.
- Johnson, R., & Lee, K. (2021). The effectiveness of infographics as an educational tool in enhancing students' comprehension of STEM subjects. *Educational Technology & Society, 24*(4), 56-68.
- Kateryna, A., Oleksandr, R., Mariia, T., Iryna, S., Evgen, K., & Anastasiia, L. (2020). Digital literacy development trends in the professional environment. *International Journal of Learning, Teaching and Educational Research, 19*(7), 55-79.
- Kohnke, L., & Jarvis, A. (2023). Developing infographics for English for academic purposes courses. *TESOL Journal, 14*(1), 1-5. https://doi.org/10.1002/tesj.675
- Lee, C., & Garcia, M. (2022). Enhancing Information Retention through Infographics in Online Learning Environments. *Educational Psychology Review, 39*(4), 478-492.
- Martin, K. N., & Gaffney, A. L. H. (2016). INSIGHT Telling and showing: The intersection of visual communication content knowledge and pedagogical strategies in STEM. *Visual Communication Quarterly, 23*(2), 108-121.
- Martinez, L., & Brown, T. (2023). Integrating infographics in language learning: Enhancing digital literacy and communication skills. *Journal of Language and Literacy Education, 17*(1), 89-104.
- Mayer, R. E. (2009). Multimedia learning. Cambridge University Press.
- McCashin, L. Q., McFeetors, P. J., & Kim, M. (2022). Reasoning at the Intersection of Science and Mathematics in Elementary School:

A Systematic Literature Review. The Electronic *Journal for Research in Science & Mathematics Education*, *26*(3), 57-85.
- McDonald, C. V. (2016). STEM Education: A review of the contribution of the disciplines of science, technology, engineering, and mathematics. *Science Education International*, *27*(4), 530-569.
- Mishra, P., Kumar, S., & Chaube, M. K. (2023). Graph interpretation, summarization, and visualization techniques: a review and open research issues. *Multimedia Tools and Applications*, *82*(6), 8729-8771.
- Moles, L. P. (2023). *Academic Achievement and Student Engagement for English Language Learners Through Professional Learning Communities: A Qualitative Action Research Study* (Doctoral dissertation, Northcentral University).
- Moore, T. J., Bryan, L. A., Johnson, C. C., & Roehrig, G. H. (2021). Integrated STEM education. In *STEM Road Map 2.0* (25-42).
- Mullins, P. (2023). Integrating infographics to foster English language proficiency in STEM education. *Journal of Educational Technology, 15*(2), 45-60.
- Murtadho, M. I., Rohmah, R. Y., Jamilah, Z., & Furqon, M. (2023). The role of digital literacy in improving students' competence in digital era. *AL-WIJDÃN Journal of Islamic Education Studies*, *8*(2), 253-260.
- Nguyen, T., & Wang, L. (2021). Exploring Infographics as Tools for Promoting Critical Thinking in Higher Education. *Journal of Educational Psychology, 35*(2), 210-225.
- Ozdamli, F., & Ozdal, H. (2018). Teachers' lifelong learning competence perceptions and skills in using digital technologies. **Cypriot Journal of Educational Sciences, 13*(2), 299-309.
- Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology/Revue canadienne de psychologie*, *45*(3), 255.
- Park, Y., & Warschauer, M. (2016). Integrating technology in diverse contexts: Current practices and future directions. *Journal of Educational Research and Practice*, *6*(1), 2-20.
- Patel, N., & Carter, R. (2019). Digital literacy and visual learning: The role of infographics in higher education. *Journal of Educational Technology, 35*(1), 47-61.
- Piller, I., & Bodis, A. (2024). Marking the (non) native speaker through English language proficiency requirements for university admission. *Language in Society*, *53*(1), 1-23.
- Rinekso, A. B., Rodliyah, R. S., & Pertiwi, I. (2021). Digital literacy practices in tertiary education: A case of EFL postgraduate

students. *Studies in English Language and Education*, *8*(2), 622-641.
- Roehrig, G. H., Dare, E. A., Ring-Whalen, E., & Wieselmann, J. R. (2021). Understanding coherence and integration in integrated STEM curriculum. *International Journal of STEM Education*, *8*, 1-21.
- Safar, A. H., & Alkhezzi, F. A. (2013). Beyond computer literacy: Technology integration and curriculum transformation. *College Student Journal*, *47*(4), 614-626.
- Schindler, L. A., Burkholder, G. J., Morad, O. A., & Marsh, C. (2017). Computer-based technology and student engagement: A critical review of the literature. International Journal of Educational Technology in Higher Education, *14*(1), 25.
- Schleppegrell, M. J. (2014). The language of schooling: A functional linguistics perspective. Lawrence Erlbaum Associates.
- Smith, J., & Jones, A. (2022). Using infographics to support student learning: A case study in the STEM classroom. *Journal of STEM Education Research and Practice*, *15*(2), 123-135.
- Sweller, J., & Chandler, P. (1991). Evidence for cognitive load theory. *Cognition and instruction*, *8*(4), 351-362.
- Tufte, E. R. (2020). The visual display of quantitative information. Graphics Press.
- Utami, A., Rochintaniawati, D., & Suwarma, I. R. (2020). Enhancement of STEM literacy on knowledge aspect after implementing science, technology, engineering, and mathematics (STEM)-based instructional module. In *Journal of Physics: Conference Series 1521*(4).
- Wolf, M. K., Bailey, A. L., Ballard, L., Wang, Y., & Pogossian, A. (2023). Unpacking the language demands in academic content and English language proficiency standards for English learners. *International Multilingual Research Journal*, *17*(1), 68-85.
- Yildirim, S., & Doğanay, A. (2014). Students' perceptions about the use of infographics in the classroom. *Journal of Educational Computing Research*, *50*(3), 335-358.

***