Research Paper

Metaphors as narrative tools in english for specific purposes: insights from biology students

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ABSTRACT

Metaphors play an essential role in shaping understanding and meaning representations, especially in the context of ESP where students encounter technical and domain-specific language. This study investigates the role of metaphors as narrative tools in scientific acquisition, focusing on university students pursuing a biology degree. This study builds on theoretical frameworks and insights from existing research to explore the effectiveness of conceptual metaphors in explaining and understanding domain-specific knowledge. To this aim, we investigate the comprehension of metaphorical language in first-year science and biology English reading texts using diagnostic assessments. The study involves a two-phase testing process: in the first phase, students are required to define and explain discipline-specific vocabulary and expressions. In the second phase, the same terms and expressions are presented in metaphorical contexts, such as "plasma membrane as a gatekeeper," "DNA as a recipe book." The results reveal significant improvements in student performance in the second test, where discipline-specific vocabulary is presented in metaphorical contexts. This suggests that metaphors not only facilitat the comprehension of technical terms but also help bridge the gap between language acquisition and technical mastery, enhancing the overall quality of their explanations.

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1. INTRODUCTION

Language can be highly technical and often abstract in specialised domains like science and technology. It is claimed that metaphors can become bridges between the familiar and the unfamiliar, helping learners navigate challenging conceptual notions. Non-native English speakers studying scientific disciplines must simultaneously master both disciplinary knowledge and a foreign language. In this study, we claim that metaphors can play abeneficial role in English teaching students pursuing a degree in a scientific discipline, particularly biology. Relatively little attention has been paid to the role of metaphors in literature on language acquisition. However, it has been claimed that metaphors and particularly conceptual metaphors are crucial in meaning representation [1]. More specifically, in fields such as English for Specific Purposes (ESP), students may use technical and domain-specific language, so metaphors can of great use [2]. Despite their importance, metaphors present unique challenges for language learners, and their full impact on comprehension in ESP contexts remains insufficiently explored. In this research, we present the findings of a pilot study that investigates how metaphors can function as narrative tools to enhance scientific concept acquisition among technical university students learning English for scientific purposes.

2. RELATED WORK

2.1. The Importance of Linguistic Competence in L2 Learning

Proficiency in English language acquisition (L2) has become increasingly essential in educational and professional contexts. The importance of linguistic competence in second language acquisition has been extensively studied over the past few decades [3], [4], [5], [6]. These studies have demonstrated that language acquisition is not a matter of memorizing complex vocabulary and grammatical rules, learners need to create links between complex and abstract notions in order to grasp specialized learning processes. In comparision with traditional teaching methodologies, recent research has revealed the importance of figurative language as a pratical teaching methodology. Science students in particular, can benefit from this competence, as they have to understand and make use of specialized vocabulary and discourse. Figurative language is also a source of motivation. According to [7], students can be more likely to engage if they regard course taught as stories and processes, and if they manage to grasp the link between what they receive in class and their future professional goals. Based on classroom observations, students show difficulties when reading complex scientific texts, therefore, innovative teaching approaches in scientific disciplines are needed.

According to [8], "student motivation in ESP contexts is often correlated with the perceived usefulness of the language skills being taught". This suggests that methods that relate language acquisition to disciplinary knowledge may be especially successful. Similarly, mastering metaphorical language is a crucial step towards developing advanced linguistic competence [9]. However, little is known about the precise function of metaphors in supporting language acquisition in technical disciplines. According to [10] when learning activities are closely related to ESP students' disciplinary interests, they tend to exhibit higher levels of intrinsic motivation. Therefore, new approaches are needed to raise students' motivation, in our case, we claim that metaphor-based teaching approaches can be valuable in terms of improving the retention and comprehension of language in scientific domains.

2.2. Metaphor in Specialised Disciplines

Metaphors are not simply figurative devices, they are essential cognitive tools that influence how we internalize difficult ideas. Studies in cognitive linguistics have shown that our conceptual system is essentially metaphorical, thus it compares abstract domains to more concrete and experiential ones. The viewpoint that "our conceptual system is fundamentally metaphorical in nature" [1] has significant implications for teaching English language in specialised contexts, where learning requires making meaningful connections to students' prior knowledge and abstract concepts are less common. When abstract ideas more approachable and easier to grasp, metaphors can become vehicle on cognitive bridges that link new ideas with previously acquired knowledge [11] as illustrated in Figure 1. This is particularly challenging in scientific discourse, where complex biological processes and structures for instance defy direct observation among students with little on no prior knowledge. It is claimed that when learners are aware of the metaphorical patterns, this may improve linguistic competence in certain disciplines, as explained in the findings by [12] that L2 learners who receive explicit instruction in metaphor usage in class are keener to engage and perform better in post assessments.

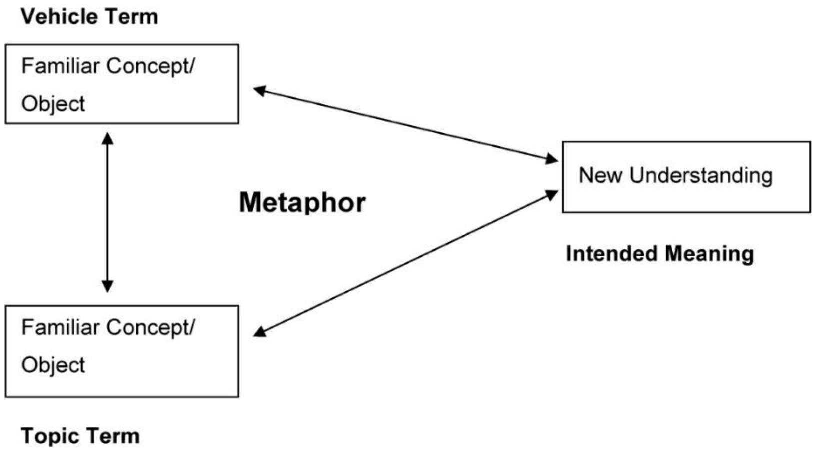

Figure 1. How Metaphors Work (Adapted from Lakoff and Johnson 1980)

This is highlighted in [13] by stating that "metaphor is a key cognitive and sociolinguistic mechanism building up the content and formal schemas involved in discourse interactions." Put differently, metaphors help in the development of the conceptual frameworks required for complex conversation. Consequently, using metaphors can lead to the building up of scientific narratives which link different concepts in the same storyline. As claimed by Paltridge and Starfield in [14], engagement in ESP contexts requires an awareness of genre-specific metaphor usage, meaning that learners need to be instructed on how to use metaphors in their answers and told that this may improve their linguistic proficiency. Additionally, since metaphor-based approaches are not common in L2 context, metaphors can be very difficult for L2 learners to understand. This is explained by the fact that learners don't necessarily have the cultural and conceptual background to correctly understand figurative expressions as noted by [15]. This is evidently the case in technical and scientific domains, where specialised metaphors may be ingrained in already difficult disciplinary discourse. On a similar vein, demotivation is a major problem in ESP contexts. Recent studies such as [16], point out that students frequently lose motivation when they are unable to relate technical vocabulary to conceptual frameworks. Therefore, we claim that if we manage to connect these frameworks, metaphor-based instruction may be able to help address this issue.

The challenge for educators and researchers, therefore, lies in understanding how metaphors function within specific disciplinary contexts and how their understanding can be facilitated for L2 learners. The literature on metaphors is continuing to grow and our understanding of metaphor has been broadened by the woks of linguists such as Musolff's [17], who examines the cross-cultural aspects of metaphor and points out that metaphorical ideas that seem universal may actually be interpreted differently depending on the cultural setting. This finding has significant consequences for ESP instruction in global settings; as teachers we need to be aware and conscious of possible cultural differences when we choose the metaphrs to be taught. Each culture can have its own set of metaphors and certain concrete concepts are embedded in foreign cultures, therefore meaningless when used without explanations. Susan and Creed [18] for instance, have examined how native and non-native speakers use metaphors and found out that L2 learners frequently use a smaller variety of metaphorical expressions, they also may find it difficult to identify metaphors that native speakers automatically process. These results imply that ESP students who come across specialised disciplinary texts may benefit most from explicit training in metaphor identification and interpretation.

2.3 Metaphors in ESP: Conceptual Bridges in Biology Discourse

In this study, we argue that metaphors in the English for biology learning context improve understanding by means of which students can map known ideas onto unknown ones, therefore enabling the cognitive processing of specialised knowledge. This mapping is crucial in ESP contexts where students may find it difficult to relate technical vocabulary to new conceptual frameworks. In [19], points out that ESP students often feel overrun by the amount of technical vocabulary they have to learn; he also suggests that methods that arrange this vocabulary within coherent conceptual frameworks may improve both understanding and motivation. The field of biology is rich in intricate processes and challenging technical structures. As a field of study, it offers a fertile ground for metaphorical expression. Additionally, the findings in [20] have indicated that students with little scientific background knowledge in life sciences show more involvement and better understanding when scientific ideas are conveyed via familiar narratives or stories, implying that learner-based strategies might be especially useful for students pursuing a scientific degree. One of the first metaphors used in biology education is CELLS AS FACTORIES as illustrated in Figure 2, this metaphorical framework projects the well-known idea of an industrial factory onto the tiny cellular structure. The nucleus in this conceptual mapping is the manager guiding the cell's activities; ribosomes are the workers building proteins on genetic structures and mitochondria are the power source producing the energy required for cellular activities. By creating links with the more familiar idea of a factory's organisational structure, this metaphorical mapping helps students to grasp the intricate interrelationships between cellular components. Another metaphor used in English for biology education is the BLUEPRINT metaphor used to describe DNA. This conceptualization views genetic material as an architectural blueprint which represents how all living are built, and genetic instructions are the equivalent of design specifications used by architecs. According to [21], this metaphor greatly improves learbers' recall of DNA structure and function when they study scientific English, indicating that it is especially beneficial for students without a strong disciplinary background.

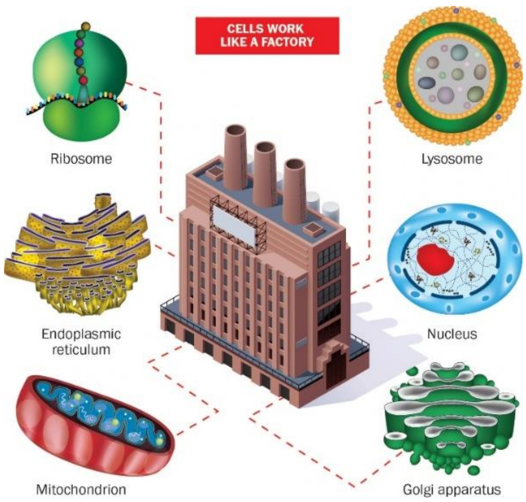

Figure 2. Cells Are Factories Metaphor (Adapted From the Washington Post 2017)

In addition to making difficult biological ideas easier to understand, these metaphorical frameworks also produce narrative structures that improve recall and promote in-depth comprehension. As stated earlier, metaphors help learners better understand specialised vocabulary by rendering abstract scientific processes into narratives with well-known elements, and it is this narrative aspect of metaphor which may be especially inspiring in ESP contexts. This is illustrated in [22], wenscientific processes are presented as narratives built around central metaphors, students exhibit higher levels of engagement and even better grades.

Nevertheless, teachers cannot use complex metaphors or conceptualisations, teachable metaphors should ideally be straightforward, tangible, and visual so that students can create distinct mental images. Baring in mind that L2 learners can have different backgrounds, the distinction between metaphor as a cognitive phenomenon and its linguistic realization should be made. We therefore highlight the necessity of choosing metaphors with cross-cultural accessibility since metaphors based on cultural allusions may cause non native students more confusion than clarity. As claimed in [23], students report higher levels of engagement when they believe they have successfully decoded disciplinary metaphors.

2.4 Metaphors as Narrative Tools in Biology Education

In scientific discourse, teacher may resort to various tools and approaches to make the learning experience more enjoyable. Narrative devices can be of great use, since learners like stories, therefore, metaphors can help build narratives illustrating different concepts. For instance, molecular mechanisms in biology and evolutionary processes take place across temporal and spatial scales, this is very challenging for L2 Lerners who lack the linguistic competence to grasp the advanced vocabulary used in these contexts. Scientific literacy means comprehending the stories that science tells about the natural world as stated by in [24]. Stories offer frameworks which render vocabulary into meaningful patterns, this is much easier than memorizing isolated words or expressions. Previous studies on metaphor-based teaching have introduced the ARMY metaphor to explain the immune system. Even though a bit simplistic but this metaphor represents while blood cells as soldiers in a battle against infections. These cells use antibodies as weapons and follow a military defence system. Students are reminded that this narrative is based on a story of conflict and defence, and when possible, the instructor defines scientific terminology in metaphorical terms. This approach can be applied to other abstract concepts in biology and science. Students without a strong background in biology environmental sciences can understand the concept thanks to this metaphorical framework, which simplifies a complicated atmospheric process into a straightforward story with obvious causal relationships. Such causal narratives centred on central metaphors have been demonstrated in [25] to greatly improve learners' understanding of climate change and global warming.

Another significant role of metaphors in scientific discourse is represented by visual storytelling. Scientific concepts are frequently too abstract to explain simle terms, they can be too small (like DNA), too large (like ecosystems), or too vague (like evolution) for L2 students to grasp. An example of the DNA metaphor which I have been using in my biology classes is the Helix metaphor, alos referred to as the ladder metaphor. This visual representation explains how molecules look like in an efficient way. Another example of a useful metaphor in biology is the BOMB metaphor to represent climate change, frequently used in the press to generate a narrative of imminent danger, therefore creating a scenario of conflict and solution. In addition to making the idea more emotionally compelling, this metaphorical framing presents the issue as interesting and compelling. According to [26], these conflict-based narratives improve students' comprehension of scientific texts by fostering an emotional attachment to otherwise abstract concepts. In ESP contexts, where student motivation is impacted by both cognitive and emotional engagement with disciplinary content, the affective aspect of metaphor may be especially significant. We claim that students who successfully understand metaphorical expressions may report higher levels of confidence and engagement with specialised texts. Additionally, we suggest a 4-step teaching methodology to integrate metaphors in biology classroom context as illustrated below.

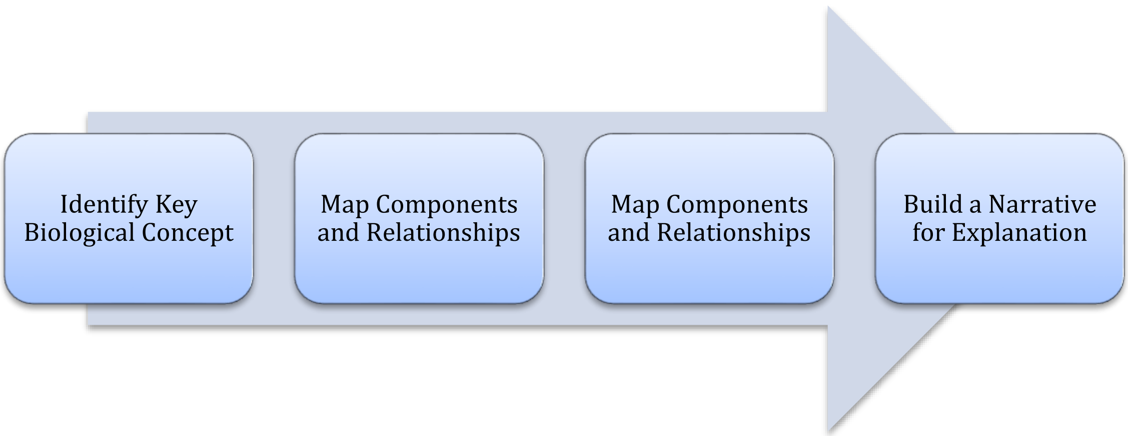

Figure 3. Metaphor Based Teaching Methodology

The procedure involves identifying the key concept (such as the immune system), choosing a metaphor based on familiar experiences or ideas. Figure 3, the following step is mapping the details of the biological concept onto the metaphor and finally, building a narrative around the metaphor to explain the cause-and-effect relation.

3. METHODOLOGY

In order to examine the effectiveness of metaphor-based instruction in improving learners' acquisition of specialised biological terminology, we have created and put into practice a comparative study in a French technical university. A total of 90 first-semester undergraduate biology students pursuing a bachelor's degree participated in the study. They were randomised to either the experimental group (n = 46) or the control group (n = 44). Recent research in ESP pedagogy, which highlights the value of empirical data in assessing creative teaching strategies, served as the basis for this methodological approach [10], [27].

The participants in this study are all native French speakers pursuing an English for biology course for their degree requirements. They represent a typical ESP context in which language acquisition is closely linked to professional objectives. As for the duration of the experiment, each participant received 12 in-class teaching hours during a four-week study period. This period of time was chosen because prior research indicates that in order to see significant improvements in vocabulary acquisition and conceptual understanding, interventions lasting at least four weeks are recommended [28]. To evaluate the cognitive efficacy of metaphors in language acquisition, the research design integrated conceptual, linguistic, and communicative elements.

The experimental group's students were taught technical biological vocabulary using metaphor-based teaching strategies that highlighted the narrative aspects of scientific ideas. This method of teaching started with straightforward metaphor-based explanations, introducing biological terms by relating them to metaphors from everyday life as can be seen in Table 1. For example, I have introduced the LOCK metaphor to explain how enzymes break down food. In this mapping, certain molecules represent the keys to the lock, and each lock has its own key.

Table 1. Metaphors Used With the Experimental Group

Metaphor	Source Domain	Target Domain	Conceptual Mapping
DNA is a Blueprint for Life	Architecture	Molecular Biology	DNA = blueprint, genes = design instructions, transcription = building process
The Cell is a Factory	Industry	Cell Biology	Nucleus = manager, mitochondria = power supply, ribosomes = workers, proteins = products
Enzyme-Substrate Interaction is a Lock and Key System	door	Molecular Biology	Enzyme = lock, substrate = key, specificity = correct key fitting into lock
Mutation is a Typo in the Genetic Code	Book/ writings	Molecular Biology	Mutation = typo, DNA sequence = text, incorrect nucleotide = misspelled word
The Nervous System is the Body's Electrical Wiring	Electrical wires	Neurobiology	Neurons = wires, electrical signals = currents, brain = control center
Blood Circulation is a Highway System	Traffic	Human Anatomy (Circulatory System)	Arteries = highways, blood = cars, heart = traffic control center
Plasma membrane as a gatekeeper/policeman	policeman	Cell membrane	Regulates entry and exit like a security system.

DNA as a recipe book	book	Genetic code	Contains instructions for making proteins.
PCR as a photocopier	Copier	DNA replication	Copies DNA segments like a machine.
Energy flow as a bank transaction	Money	Ecosystem energy flow	Transfers energy between organisms like money.
Hormones as emails	IT Comm	Endocrine system	Carry chemical signals throughout the body.

Following the initial instructions, I ask students to use metaphors in their answers whenever possible. A writing exercice is given at the end of each class where the experimental group has to write a brief essay to explain a medical or biological disease using metaphors. These assignments gave students the opportunity to use specialized vocabulary in context and to improve their understanding of the various processes and biological aspects taught. Eventually, these exerices were followed by an evaluation phase to assess students' understanding and usage of metaphors.

Students in the control group, on the other hand, received conventional instruction that focused on dictionary definitions and textbook explanations with a substantial amount of English to French translations, rather than the explicit use of metaphors, as is done in Standard English classes. Among their learning activities were textbook-based exercises, such as standard scientific article comprehension and matching exercises; lecture-based vocabulary explanations, where the instructor defined and explained biological terms taken from dictionaries; and traditional writing assignments that required describing biological processes without particular instructions on the use of metaphors. Participants from both groups were asked to take a post-instruction test after each lesson to evaluate their understanding and memory retention of biology-related vocabulary: The test included 15 covering biology concept explanation, multiple-choice, and yes or no questions. In keeping with the findings in [29] that vocabulary knowledge encompasses not only individual terms but also the networks of relationships between them, the assessment also featured items created specially to gauge students' comprehension of conceptual relationships.

4. RESULTS AND DISCUSSION

Significant benefits for the metaphor-based approach were found in the comparative analysis of student performance across a number of language acquisition and conceptual understanding dimensions. As can be seen in Table 2, students in the experimental group gave more detailed explanations of biological processes (61% vs. 39%), they were much more proficient in analogical reasoning (54% vs. 23%), and had higher rates of correct definitions (59% vs. 41% in the control group). Most significantly, students who received metaphor-based instruction demonstrated a significant decrease in conceptual misconceptions (19% versus 46% in the control group), indicating that metaphorical frameworks improved conceptual clarity in addition to terminology acquisition. In each aspect of evaluation, there were cases where some students from both groups were not able to answer correctly, this can be attributed to their already low proficiency in English.

Table 2. Performance Evaluation Test

Performance Aspect	Control Group	Experimental Group
Correct Definitions	42%	71%
Detailed Explanations	38%	69%
Use of Analogies	23%	55%
Misconceptions	46%	19%

Qualitative observations about the character of student explanations were added to these quantitative differences. Students in the experimental group generally incorporated terminology into logical explanatory frameworks, frequently expanding on the metaphors presented in class to produce unique explanations, whereas students in the control group tended to replicate dictionary definitions with little elaboration. As for terminology retention, the analysis reveals that students in the experimental group show a 21% improvement than the control group. This is proven through a post assessment test conducted after the experiment. Students also concluded that metaphor-based teaching was more motivational in class, despite the fact that it is was time consuming.

Numerous students specifically cited the narrative aspect of metaphors as improving their understanding of the subject matter, pointing out that metaphorical explanations turned abstract concepts into logical stories that were simpler to understand and retain. A number of students also discussed the affective aspect of metaphor-based learning, pointing out that by making abstract ideas more relatable, metaphorical explanations helped them feel less nervous about technical jargon when reading scientific articles. This finding is consistent with [30] study on language anxiety in academic settings, which indicates that instructional strategies that establish meaningful links between unfamiliar words and well-known ideas may lessen anxiety and boost motivation. Additionally, the promising results from this pilot study prompted us to revise the headings and course structure of the first-year biology coursebook by replacing the original titles with metaphorical ones as can be seen **Error! Reference source not found.** Table 3.

Table 3. Metaphor Based Table of Contents

Section	Title / Subsections	Section	Title / Subsections
Chapter 1	The Building Blocks 1.1 Cells are tiny factories 1.2 The nucleus is the CEO 1.3 The ribosomes are assembly lines 1.4 The mitochondria are power plants 1.5 The cell membrane is the security gate	Chapter 6	The Grand Ecosystem 6.1 Ecosystems are complex machines 6.2 Producers (plants) are energy generators 6.3 Consumers (animals) are energy users 6.4 Decomposers (fungi, bacteria) are recyclers
Chapter 2	The Master Blueprint 2.1 Genes are individual recipes 2.2 The RNA is the chef's assistant 2.3 The enzymes are the kitchen staff 2.4 Typos (mutation)	Chapter 7	The Story of Evolution 7.1 Evolution is a never-ending book 7.2 Natural selection is the editor 7.3 Genetic mutations are plot twists
Chapter 3	The Energy Network 3.1 Photosynthesis is a solar power plant 3.2 Chloroplasts are solar panels 3.3 Cellular respiration is an energy converter 3.4 The mitochondria act as batteries	Chapter 8	The Human Impact 8.1 Pollution is like clutter in a house 8.2 Deforestation is tearing down walls 8.3 Climate change is a rising thermostat
Chapter 4	The Defence System 4.1 White blood cells are soldiers 4.2 Antibodies are guided missiles 4.3 Vaccines are military training exercises 4.4 Enemy hands (infection)	Chapter 9	Biotechnology & Genomics 9.1 Biotechnology is a biological engineering lab 9.2 Genetic modification is DNA hacking 9.3 CRISPR is a pair of molecular scissors 9.4 Cell cultures are farms of cells
Chapter 5	The Great Highway System	Chapter 10	Neuroscience & Behaviour

	5.1 The circulatory system is a highway 5.1.1 The heart is the central hub 5.1.2 The arteries are highways 5.1.3 The veins are return routes 5.2 The nervous system is the internet		10.1 The brain is an ultra-powerful computer 10.2 Neurons are electronic circuits 10.3 Synapses are USB ports 10.4 Memory is a hard drive

In spite of these advantageous results, we have noted a number of difficulties with metaphor-based learning. At first, some experimental group students misinterpreted some metaphors, necessitating explanations from the teacher, therefore we highlight the significance of selecting metaphors carefully and clearly before engaging in a similar experiment. Another limitation to this study is the limited time allocated for English courses in IUT contexts, 90 minutes per week at best is not enough time to conduct large scale linguistic experiments. This raises useful issues for curriculum planning in ESP contexts where instructional time is usually limited. Nonetheless, the experimental group's better retention and conceptual comprehension indicate that this extra time commitment might have major long-term advantages.

5. CONCLUSION

The results of this study confirm that metaphors are effective learning tools in ESP context of biology students learning English. Using this teaching method, students improved their long-term retention comprehension of complex vocabulary. By converting abstract scientific concepts into relatable stories, the systematic incorporation of carefully chosen metaphors into science-related language instruction may significantly improve both linguistic and conceptual development. Metaphor-based teaching in biology disciplines helps establish meaningful connections between scientific vocabulary and conceptual representations of the processes taught. Additionally, the results of our study show that vocabulary retention improved among students, the experimental group were able to convert abstract notions into stories based on visual images. Lastly, motivation levels increased among the experimental group, they seem to show less signs of anxiety and cstate that the course are more approachable and interesting. It should be noted that the results of this study only apply to the context of Biology learners. Therefore, we recommend applying the metaphor-based teaching approach to other disciplines like chemistry, physics, and computer science. As for our case, we intend to conduct a similar longitudinal study next year with the same participants, as they advance through their academic and professional levels, this would be helpful in evaluating the long-term effects of metaphor-based instruction on language. Acquiring complex scientific vocabulary will always be challenging, and ESP instructors will need to develop more effective and engaging learning experiences. This study is an example of the narrative power of metaphors in ESP classrooms.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Sayf Mohamed	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

C	: **C**onceptualization	I	: **I**nvestigation	Vi	: **Vi**sualization
M	: **M**ethodology	R	: **R**esources	Su	: **Su**pervision
So	: **So**ftware	D	: **D**ata Curation	P	: **P**roject administration
Va	: **Va**lidation	O	: Writing - **O**riginal Draft	Fu	: **Fu**nding acquisition
Fo	: **Fo**rmal analysis	E	: Writing - Review & **E**diting		

Conflict of Interest Statement

Authors state no conflict of interest.

Informed Consent

The participants have consented to the use of their answers as long as their identities remain confidential.

Ethical Approval

Ethical approval for this study was obtained from the relevant review board at the university and the participating students. The research adhered to established ethical standards; participation was entirely voluntary and involved no risk to the participants.

Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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