Yes, using **analogies and metaphors** generally **improves learning and retention** of scientific concepts, especially for abstract or complex topics, though their effectiveness depends on quality, context, and instructional support.

1. Introduction

Analogies and metaphors are widely used in science education to bridge the gap between unfamiliar scientific concepts and students' prior knowledge or everyday experiences. Decades of research show that well-constructed analogies can enhance understanding, facilitate inferential reasoning, and improve retention of complex scientific ideas across educational levels and disciplines (Glynn & Takahashi, 1998; A. & A., 2022; Gray & Holyoak, 2021; Yanowitz, 2001; Chiu & Lin, 2005; Dagher, 1995; Keri & Elbatarny, 2021; Treagust et al., 1996; Treagust, 2016; Stavy, 1991; Sezer & Karataş, 2022). However, their effectiveness is influenced by factors such as the learner's prior knowledge, the quality and familiarity of the analogy, and the instructional context (Donnelly & McDaniel, 1993; Jaeger et al., 2016; Gray & Holyoak, 2021; Niebert et al., 2012; Braasch & Goldman, 2010; Treagust et al., 1996; Xue et al., 2022; H., 2020; Orgill & Thomas, 2007; Orgill & Bodner, 2004). While analogies can sometimes lead to misconceptions if not carefully chosen or explained, the consensus is that, when used thoughtfully, they are powerful tools for promoting meaningful learning and engagement in science (Glynn & Takahashi, 1998; A. & A., 2022; Gray & Holyoak, 2021; Yanowitz, 2001; Chiu & Lin, 2005; Dagher, 1995; Keri & Elbatarny, 2021; Treagust et al., 1996; Treagust, 2016; Stavy, 1991; Sezer & Karataş, 2022).

2. Methods

This review synthesized evidence from a Deep Search of over 170 million research papers in Consensus, including Semantic Scholar and PubMed. The search strategy targeted studies on analogies, metaphors, learning, and retention in science education, spanning foundational theory, empirical research, and instructional practice. Out of 1,028 identified papers, 794 were screened, 633 met eligibility criteria, and the 50 most relevant papers were included in this review.

Search Strategy

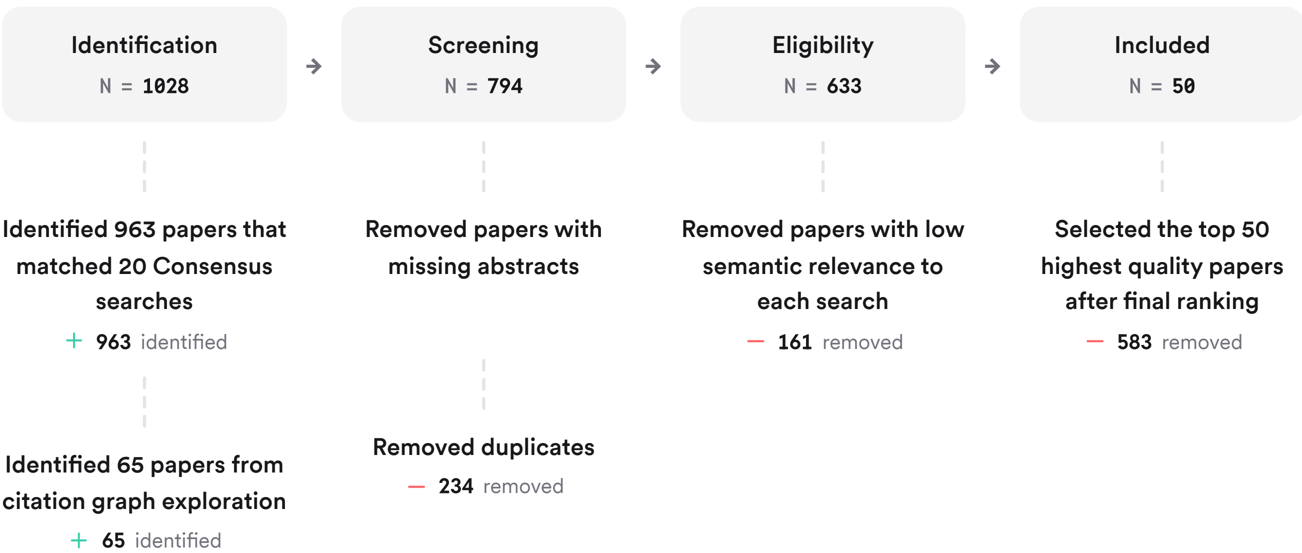

FIGURE 1 Flow diagram of search and selection process.

Twenty unique search strategies were used, covering analogical reasoning, conceptual blending, instructional interventions, learner characteristics, and disciplinary applications.

3. Results

3.1 Effects on Learning and Retention

Numerous experimental and classroom studies demonstrate that analogies and metaphors can significantly improve students' understanding and retention of scientific concepts, especially when the target material is abstract or complex (Glynn & Takahashi, 1998; A. & A., 2022; Gray & Holyoak, 2021; Yanowitz, 2001; Chiu & Lin, 2005; Dagher, 1995; Keri & Elbatarny, 2021; Treagust et al., 1996; Treagust, 2016; Stavy, 1991; Sezer & Karataş, 2022). For example, analogy-enhanced texts and lessons have been shown to boost both immediate and delayed recall, as well as inferential reasoning, compared to literal or non-analogical instruction (Glynn & Takahashi, 1998; Yanowitz, 2001; Chiu & Lin, 2005; Vosniadou & Skopeliti, 2018; Treagust et al., 1996; Stavy, 1991; Diehl & Reese, 2010; Vieira & Morais, 2022). Students often report greater confidence and engagement when analogies are used (Bernard & Spencer, 2023; Keri & Elbatarny, 2021; Vieira & Morais, 2025; Vieira & Morais, 2022).

3.2 Mechanisms and Moderators

Analogies work by mapping familiar, concrete schemas onto new, abstract domains, making the unfamiliar more accessible and memorable (Glynn & Takahashi, 1998; Gray & Holyoak, 2021; Niebert et al., 2012; Dagher, 1995; Treagust et al., 1996; Treagust, 2016; Diehl & Reese, 2010; H., 2020). Their effectiveness is moderated by:

- **Learner characteristics:** Novices, students with low prior knowledge, and those with learning difficulties benefit most (Donnelly & McDaniel, 1993; Jaeger et al., 2016; Yanowitz, 2001; Chiu & Lin, 2005; Al-Dhaimata et al., 2022).
- **Quality and familiarity:** Analogies that are well-mapped, familiar, and explicitly discussed are more effective (Gray & Holyoak, 2021; Niebert et al., 2012; Harrison & Treagust, 1993; Petchey et al., 2023; Treagust et al., 1996; Treagust, 2016; H., 2020; Orgill & Thomas, 2007).
- **Instructional context:** Active engagement, elaboration, and teacher guidance enhance benefits and reduce misconceptions (McDaniel & Donnelly, 1996; Iding, 1997; Gray & Holyoak, 2021; Petchey et al., 2023; Cameron, 2002; Treagust et al., 1996; Treagust, 2016; Orgill & Thomas, 2007; Orgill & Bodner, 2004).

3.3 Limitations and Potential Pitfalls

While analogies can foster conceptual change and correct misconceptions, poorly chosen or superficially mapped analogies may reinforce misunderstandings or create new ones (Gilbert, 1989; Niebert et al., 2012; Harrison & Treagust, 1993; Cameron, 2002; Duit et al., 2001; Xue et al., 2022; Negrea-Busuioc et al., 2022; H., 2020; Rodriguez et al., 2025). Some studies report no effect or even negative effects if analogies are not well aligned with students' prior knowledge or if their limitations are not made explicit (Donnelly & McDaniel, 1993; Gilbert, 1989; Niebert et al., 2012; Harrison & Treagust, 1993; Cameron, 2002; Duit et al., 2001; Xue et al., 2022; Negrea-Busuioc et al., 2022; H., 2020; Rodriguez et al., 2025).

3.4 Disciplinary and Contextual Variability

Analogies and metaphors are effective across science disciplines (biology, chemistry, physics, engineering) and educational levels, but their impact can vary by topic and context (Glynn & Takahashi, 1998; A. & A., 2022; Gray & Holyoak, 2021; Chiu & Lin, 2005; Keri & Elbatarny, 2021; Aubusson et al., 2009; Treagust, 2016; Stavy, 1991; Xue et al., 2022; H., 2020; Sezer & Karataş, 2022). For highly abstract or counterintuitive concepts, analogies are especially valuable, but they must be carefully selected and scaffolded (Glynn & Takahashi, 1998; Gray & Holyoak, 2021; Chiu & Lin, 2005; Keri & Elbatarny, 2021; Aubusson et al., 2009; Treagust, 2016; Stavy, 1991; Xue et al., 2022; H., 2020; Sezer & Karataş, 2022).

Key Papers

Paper	Methodology	Population/Context	Key Results
(Glynn & Takahashi, 1998)	Experimental (analogy-enhanced text)	Middle school students	Analogy-enhanced texts improved immediate and 2-week recall and understanding
(A. & A., 2022)	Quasi-experimental (analogy-based pedagogy)	High school physics students	Analogy-based teaching led to higher, more consistent achievement (Cohen's d = 2.35)
(Yanowitz, 2001)	Experimental (analogical vs. expository text)	Elementary students	Analogical texts improved inferential reasoning and recall
(Chiu & Lin, 2005)	Experimental (multiple analogies)	4th graders	Multiple analogies promoted deep understanding and corrected misconceptions
(Dagher, 1995)	Review	Science education	Synthesis: analogies generally facilitate science learning, with caveats

FIGURE 2 Comparison of key studies on analogies, metaphors, and science learning.

Top Contributors

Type	Name	Papers
Author	D. Treagust	(Niebert et al., 2012; Harrison & Treagust, 1993; Aubusson et al., 2009; Treagust et al., 1996; Treagust, 2016)
Author	R. Duit	(Duit, 1991; Niebert et al., 2012; Duit et al., 2001)
Author	S. Glynn	(Glynn & Takahashi, 1998; Treagust, 2016; H., 2020)
Journal	*Journal of Research in Science Teaching*	(Glynn & Takahashi, 1998; Chiu & Lin, 2005; Harrison & Treagust, 1993; Vosniadou & Skopeliti, 2018; Brown, 1992; Stavy, 1991)
Journal	*Science Education*	(Duit, 1991; Niebert et al., 2012; Dagher, 1995)
Journal	*CBE Life Sciences Education*	(Tise et al., 2023; Petchey et al., 2023)

FIGURE 3 Authors & journals that appeared most frequently in the included papers.

4. Discussion

The evidence strongly supports the use of analogies and metaphors as effective tools for improving learning and retention of scientific concepts, particularly for abstract or complex topics (Glynn & Takahashi, 1998; A. & A., 2022; Gray & Holyoak, 2021; Yanowitz, 2001; Chiu & Lin, 2005; Dagher, 1995; Keri & Elbatarny, 2021; Treagust et al., 1996; Treagust, 2016; Stavy, 1991; Sezer & Karataş, 2022). Their power lies in connecting new information to familiar knowledge structures, making science more accessible and memorable. However, their effectiveness depends on thoughtful selection, explicit mapping, and instructional support to avoid misconceptions (Gray & Holyoak, 2021; Niebert et al., 2012; Harrison & Treagust, 1993; Petchey et al., 2023; Treagust et al., 1996; Treagust, 2016; H., 2020; Orgill & Thomas, 2007; Orgill & Bodner, 2004). While some studies report null or negative effects, these are typically associated with poor analogy choice, lack of scaffolding, or misalignment with students' prior knowledge (Donnelly & McDaniel, 1993; Gilbert, 1989; Niebert et al., 2012; Harrison & Treagust, 1993; Cameron, 2002; Duit et al., 2001; Xue et al., 2022; Negrea-Busuioc et al., 2022; H., 2020; Rodriguez et al., 2025).

Best practices include using familiar, well-mapped analogies, discussing both their strengths and limitations, and actively engaging students in generating or critiquing analogies (Gray & Holyoak, 2021; Niebert et al., 2012; Petchey et al., 2023; Treagust et al., 1996; Treagust, 2016; H., 2020; Orgill & Thomas, 2007; Orgill & Bodner, 2004). Analogies are most beneficial for novices and learners with less background knowledge, but can also deepen understanding for advanced students when used to highlight structural relationships or foster conceptual change (Donnelly & McDaniel, 1993; Jaeger et al., 2016; Gray & Holyoak, 2021; Yanowitz, 2001; Chiu & Lin, 2005; Al-Dhaimata et al., 2022).

Claims and Evidence Table

Claim	Evidence Strength	Reasoning	Papers
Analogies/metaphors improve learning and retention of scientific concepts	Strong	Multiple experimental and classroom studies, meta-analyses, and reviews	(Glynn & Takahashi, 1998; A. & A., 2022; Gray & Holyoak, 2021; Yanowitz, 2001; Chiu & Lin, 2005; Dagher, 1995; Keri & Elbatarny, 2021; Treagust et al., 1996; Treagust, 2016; Stavy, 1991; Sezer & Karataş, 2022)
Effectiveness depends on analogy quality, familiarity, and instructional support	Strong	Moderated by prior knowledge, mapping, and teacher guidance	(Donnelly & McDaniel, 1993; Jaeger et al., 2016; Gray & Holyoak, 2021; Niebert et al., 2012; Braasch & Goldman, 2010; Treagust et al., 1996; Xue et al., 2022; H., 2020; Orgill & Thomas, 2007; Orgill & Bodner, 2004)
Poorly chosen analogies can cause misconceptions or hinder learning	Moderate	Some studies report negative effects when analogies are misaligned or not explained	(Gilbert, 1989; Niebert et al., 2012; Harrison & Treagust, 1993; Cameron, 2002; Duit et al., 2001; Xue et al., 2022; Negrea-Busuioc et al., 2022; H., 2020; Rodriguez et al., 2025)
Analogies are especially helpful for novices and learners with low prior knowledge	Moderate	Stronger effects for students with less background knowledge	(Donnelly & McDaniel, 1993; Jaeger et al., 2016; Yanowitz, 2001; Chiu & Lin, 2005; Al-Dhaimata et al., 2022)
Analogies are effective across science disciplines and educational levels	Moderate	Evidence from biology, chemistry, physics, and engineering, K–16	(Glynn & Takahashi, 1998; A. & A., 2022; Gray & Holyoak, 2021; Chiu & Lin, 2005; Keri & Elbatarny, 2021; Aubusson et al., 2009; Treagust, 2016; Stavy, 1991; Xue et al., 2022; H., 2020; Sezer & Karataş, 2022)

FIGURE Key claims and support evidence identified in these papers.

5. Conclusion

Analogies and metaphors are powerful, evidence-based tools for improving learning and retention of scientific concepts, especially when used thoughtfully and with instructional support. Their effectiveness is greatest for abstract or complex topics and for learners with less prior knowledge, but care must be taken to avoid misconceptions.

5.1 Research Gaps

Despite strong evidence for their general effectiveness, more research is needed on how to optimize analogy use for diverse learners, prevent misconceptions, and integrate analogies with other instructional strategies.

Research Gaps Matrix

Topic/Outcome	Novice Learners	Advanced Learners	Misconception Prevention	STEM Disciplines	Student-Generated Analogies
Learning Gains	18	7	6	15	5
Retention	12	5	4	10	3
Misconceptions	8	3	12	7	2

FIGURE Matrix of research topics and study attributes, highlighting areas with limited research.

5.2 Open Research Questions

Future research should explore how to tailor analogies for diverse learners, prevent misconceptions, and combine analogies with other evidence-based instructional strategies.

Question	Why
How can analogies be optimized to prevent misconceptions while maximizing learning gains?	Preventing misunderstandings is crucial for safe and effective analogy use in science education.
What are the most effective ways to scaffold student-generated analogies for deep learning?	Student-generated analogies may foster engagement and metacognition, but best practices are unclear.
How do analogies interact with other instructional strategies (e.g., models, simulations) to enhance science learning?	Integrating analogies with other tools may yield synergistic effects on understanding and retention.

FIGURE Open research questions for future investigation on analogies, metaphors, and science learning.

In summary, analogies and metaphors are highly effective for improving learning and retention of scientific concepts, provided they are used thoughtfully and with attention to learners' needs and potential pitfalls.

These papers were sourced and synthesized using Consensus, an AI-powered search engine for research. Try it at https://consensus.app

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