The Testing Effect and Its Application in Web Copy to Improve Learning

1. Introduction

The **testing effect** refers to the robust phenomenon where actively retrieving information through testing leads to better long-term retention than simply restudying the same material. This effect has been demonstrated across a wide range of content, learner populations, and settings, including digital and web-based environments (Yang et al., 2021; Adesope et al., 2017; Roediger & Karpicke, 2006; Szpunar et al., 2013; Johnson & Mayer, 2009; Rowland, 2014; McDermott, 2020; Roediger & Karpicke, 2018; Rivers, 2020). Recent research has extended the testing effect to online learning and web copy, showing that incorporating quizzes, practice questions, or retrieval prompts into digital content can significantly enhance learning outcomes, attention, and knowledge transfer (Yang et al., 2018; McDaniel et al., 2012; Ahn, 2024; Szpunar et al., 2013; Johnson & Mayer, 2009; Parong & Green, 2023; Belardi et al., 2020). However, the effectiveness of the testing effect can depend on factors such as material complexity, feedback, test format, and cognitive load (Gog & Sweller, 2015; Leahy et al., 2015; Macaluso & Fraundorf, 2025). This review synthesizes the evidence for the testing effect and its practical application in web copy to improve learning.

2. Methods

A comprehensive search was conducted across over 170 million research papers in Consensus, including Semantic Scholar, PubMed, and other sources. The search strategy involved 20 targeted queries grouped into 8 thematic clusters, focusing on the testing effect, retrieval practice, digital/web learning, mechanisms, boundary conditions, and application in web copy. In total, 1,035 papers were identified, 773 were screened, 538 were deemed eligible, and the top 50 most relevant papers were included in this review.

Search Strategy

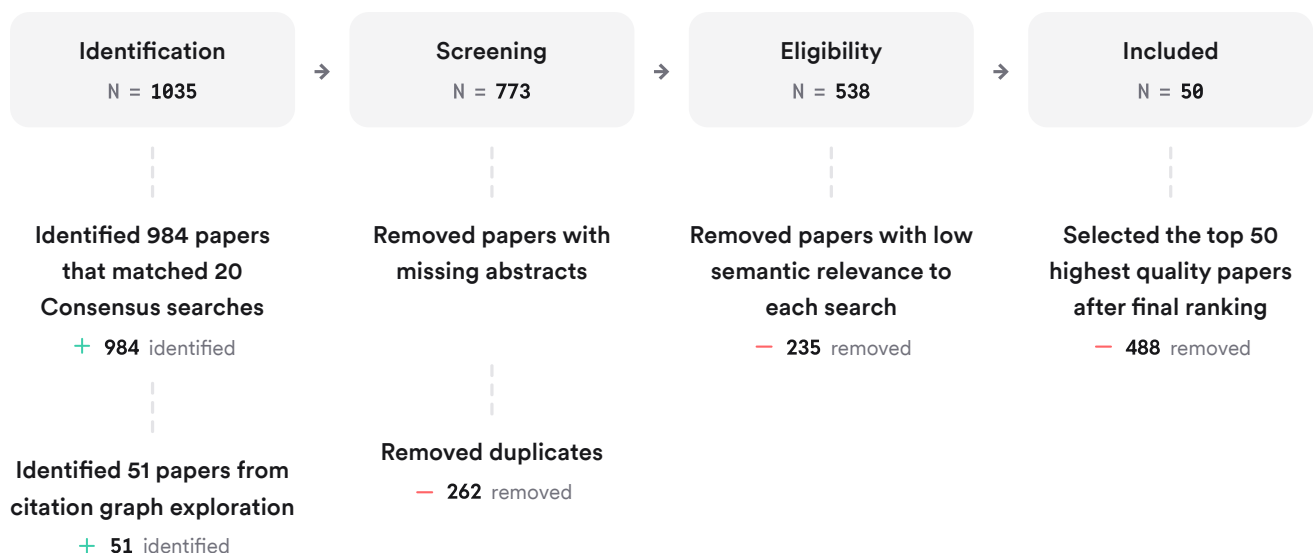| Identification N = 1035		Screening N = 773		Eligibility N = 538		Included N = 50
Identified 984 papers that matched 20 Consensus searches		Removed papers with missing abstracts		Removed papers with low semantic relevance to each search		Selected the top 50 highest quality papers after final ranking
+ 984 identified				— 235 removed		— 488 removed
Identified 51 papers from citation graph exploration		Removed duplicates				
+ 51 identified		— 262 removed				

FIGURE 1   Flow diagram of the literature search and selection process.

Eight unique search groups targeted foundational theories, mechanisms, digital/web applications, critiques, and interdisciplinary perspectives on the testing effect.

3. Results

3.1. What is the Testing Effect?

The testing effect is the finding that taking practice tests or engaging in retrieval practice leads to better long-term retention than restudying the same material (Yang et al., 2021; Adesope et al., 2017; Roediger & Karpicke, 2006; Rowland, 2014; McDermott, 2020; Roediger & Karpicke, 2018; Rivers, 2020). This effect is robust across various formats (e.g., multiple choice, short answer, free recall) and content types, and is supported by both cognitive and neurocognitive research (Broek et al., 2016; Rickard & Pan, 2017; Carpenter, 2009; Pyc & Rawson, 2010; Racsmány et al., 2018).

3.2. Mechanisms Underlying the Testing Effect

Several mechanisms explain the testing effect:

- **Effortful retrieval** strengthens memory traces and enhances semantic elaboration (Carpenter, 2009; Rowland, 2014; Pyc & Rawson, 2010).
- **Feedback** during or after testing further boosts retention (Adesope et al., 2017; Belardi et al., 2020; Macaluso & Fraundorf, 2025).
- **Metacognitive benefits**: Testing improves learners' ability to monitor and regulate their own learning (Barenberg & Dutke, 2018; Fernandez & Jamet, 2017; Rivers, 2020).
- **Reduction of mind-wandering**: Interpolated tests in online content help maintain attention and engagement (Yang et al., 2018; Szpunar et al., 2013).

3.3. The Testing Effect in Digital and Web-Based Learning

Numerous studies show that the testing effect translates well to digital environments:

- **Online quizzes and retrieval prompts** embedded in web copy or e-learning modules improve retention and exam performance compared to passive reading or restudy (McDaniel et al., 2012; Ahn, 2024; Szpunar et al., 2013; Johnson & Mayer, 2009; Parong & Green, 2023; Belardi et al., 2020).
- **Interpolated testing** (quizzes between content segments) in online lectures reduces mind-wandering and increases learning (Yang et al., 2018; Szpunar et al., 2013).
- **Web applications** that incorporate testing, spacing, and feedback principles yield significant learning gains (Belardi et al., 2020).

3.4. Boundary Conditions and Limitations

- The testing effect is **less robust for highly complex or abstract material** and may disappear with high element interactivity (McCarter et al., 2025; Gog & Sweller, 2015; Leahy et al., 2015).
- **Feedback** is critical; without it, the benefits of testing may be reduced, especially for learners with less background knowledge (Macaluso & Fraundorf, 2025).
- The effect is **independent of cognitive ability** and benefits a wide range of learners (Yang et al., 2020; Smith-Peirce & Butler, 2025; Jonsson et al., 2020).

Key Papers

Paper	Methodology	Context	Key Results
(Yang et al., 2021)	Meta-analysis (222 studies)	Classroom & digital	Testing (quizzing) robustly enhances retention and achievement
(Szpunar et al., 2013)	Experimental (online lectures)	Web-based	Interpolated tests reduce mind-wandering and improve learning
(McDaniel et al., 2012)	Experimental (web class)	Online quizzes	Online quizzing enhances exam performance over rereading
(Adesope et al., 2017)	Meta-analysis	Practice tests	Practice tests outperform restudy for learning
(Belardi et al., 2020)	Experimental (web app)	Vocabulary learning	Testing, spacing, and feedback in web apps boost learning by 29%

FIGURE 2   Comparison of key studies on the testing effect and its application in web copy.

Top Contributors

Type	Name	Papers
Author	Chunliang Yang	(Yang et al., 2018; Yang et al., 2019; Yang et al., 2021; Yang et al., 2020; Don et al., 2022)
Author	D. Shanks	(Yang et al., 2018; Yang et al., 2019; Yang et al., 2021; Yang et al., 2020; Don et al., 2022)
Author	Steven C. Pan	(Pan & Rickard, 2018; Pan & Sana, 2021)
Journal	*Psychological Bulletin*	(Yang et al., 2021; Chan et al., 2018; Pan & Rickard, 2018)
Journal	*Journal of Educational Psychology*	(Yang et al., 2019; Johnson & Mayer, 2009; Jonsson et al., 2020; Lee & Ahn, 2017)
Journal	*NPJ Science of Learning*	(Yang et al., 2018; Latimier et al., 2019)

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

4. Discussion

The testing effect is one of the most robust and well-replicated findings in cognitive science, with strong evidence supporting its use in both traditional and digital learning environments (Yang et al., 2021; Adesope et al., 2017; Roediger & Karpicke, 2006; Szpunar et al., 2013; Johnson & Mayer, 2009; Rowland, 2014; McDermott, 2020; Roediger & Karpicke, 2018; Rivers, 2020). Embedding quizzes, retrieval prompts, or practice tests in web copy can significantly improve information retention, attention, and transfer of learning (Yang et al., 2018; McDaniel et al., 2012; Ahn, 2024; Szpunar et al., 2013; Johnson & Mayer, 2009; Parong & Green, 2023; Belardi et al., 2020). The mechanisms include effortful retrieval, feedback, metacognitive monitoring, and reduced mind-wandering. However, the effect is less pronounced for highly complex or abstract material, and the presence of feedback is crucial for maximizing benefits (McCarter et al., 2025; Gog & Sweller, 2015; Leahy et al., 2015; Macaluso & Fraundorf, 2025). The testing effect benefits learners across ability levels and is effective in self-regulated and unsupervised online settings (Yang et al., 2020; Smith-Peirce & Butler, 2025; Fernandez & Jamet, 2017; Jonsson et al., 2020).

Claims and Evidence Table

Claim	Evidence Strength	Reasoning	Papers
The testing effect improves long-term retention more than restudy	Strong	Meta-analyses and large-scale studies show robust, generalizable effects	(Yang et al., 2021; Adesope et al., 2017; Roediger & Karpicke, 2006; Rowland, 2014; McDermott, 2020; Roediger & Karpicke, 2018; Rivers, 2020)
The testing effect applies to web copy and digital learning	Strong	Experimental and field studies confirm benefits in online and web-based settings	(Yang et al., 2018; McDaniel et al., 2012; Ahn, 2024; Szpunar et al., 2013; Johnson & Mayer, 2009; Parong & Green, 2023; Belardi et al., 2020)
Feedback enhances the benefits of testing	Strong	Feedback during/after testing further boosts retention, especially for novices	(Adesope et al., 2017; Belardi et al., 2020; Macaluso & Fraundorf, 2025)
The effect is less robust for highly complex/abstract material	Moderate	Some studies show diminished or absent effects with high element interactivity	(McCarter et al., 2025; Gog & Sweller, 2015; Leahy et al., 2015)
The testing effect is independent of cognitive ability	Moderate	Benefits observed across ability levels and backgrounds	(Yang et al., 2020; Smith-Peirce & Butler, 2025; Jonsson et al., 2020)
Testing improves metacognitive monitoring and self-regulation	Moderate	Testing helps learners better assess and regulate their learning	(Barenberg & Dutke, 2018; Fernandez & Jamet, 2017; Rivers, 2020)

FIGURE   Key claims and support evidence identified in these papers.

5. Conclusion

The testing effect is a powerful, evidence-based strategy for improving learning and retention, and it can be effectively applied in web copy and digital content through embedded quizzes, retrieval prompts, and practice tests. Its success depends on thoughtful implementation, especially for complex material and with appropriate feedback.

5.1. Research Gaps

While the testing effect is well-established, more research is needed on optimizing its use for complex content, in diverse digital formats, and for long-term retention in real-world web environments.

Research Gaps Matrix

Topic/Attribute	Simple Content	Complex Content	With Feedback	Without Feedback	Web/Digital
Testing effect robust	15	5	12	4	14
Transfer to new domains	10	3	8	2	9
Metacognitive benefits	8	2	7	1	6
Individual differences	7	2	6	1	5

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

5.2. Open Research Questions

Future research should address the following questions to further optimize the use of the testing effect in web copy and digital learning.

Question	Why
How can the testing effect be maximized for complex or abstract web content?	Complex material often shows weaker effects; optimizing strategies could broaden impact.
What is the optimal frequency and format of retrieval prompts in web copy for different learner populations?	Tailoring testing to user needs may enhance learning outcomes and engagement.
How does the testing effect interact with multimedia and interactive elements in web-based learning?	Understanding these interactions can inform best practices for digital instructional design.

FIGURE   Open research questions for future investigation on the testing effect in web copy.

In summary, the testing effect is a highly effective, evidence-based approach for improving learning in web copy and digital content, but its implementation should be tailored to content complexity, feedback, and learner needs for maximum benefit.

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

References

Yang, C., Potts, R., & Shanks, D. (2018). Enhancing learning and retrieval of new information: a review of the forward testing effect. *NPJ Science of Learning*, 3. **https://doi.org/10.1038/s41539-018-0024-y**

Yang, C., Chew, S., Sun, B., & Shanks, D. (2019). The forward effects of testing transfer to different domains of learning.. *Journal of Educational Psychology*. https://doi.org/10.1037/EDU0000320

Yang, C., Luo, L., Vadillo, M., Yu, R., & Shanks, D. (2021). Testing (quizzing) boosts classroom learning: A systematic and meta-analytic review.. *Psychological bulletin*. https://doi.org/10.1037/bul0000309

McDaniel, M., Wildman, K., & Anderson, J. (2012). Using quizzes to enhance summative-assessment performance in a web-based class: An experimental study. *Journal of applied research in memory and cognition*, 1, 18-26. https://doi.org/10.1016/J.JARMAC.2011.10.001

Broek, G., Takashima, A., Wiklund-Hörnqvist, C., Wirebring, L., Segers, E., Verhoeven, L., & Nyberg, L. (2016). Neurocognitive mechanisms of the "testing effect": A review. *Trends in Neuroscience and Education*, 5, 52-66. https://doi.org/10.1016/j.tine.2016.05.001

Yang, C., Zhao, W., Luo, L., Sun, B., Potts, R., & Shanks, D. (2021). Testing potential mechanisms underlying test-potentiated new learning.. *Journal of experimental psychology. Learning, memory, and cognition*. https://doi.org/10.1037/xlm0001021

Chan, J., Meissner, C., & Davis, S. (2018). Retrieval Potentiates New Learning: A Theoretical and Meta-Analytic Review. *Psychological Bulletin*, 144, 1111–1146. https://doi.org/10.1037/bul0000166

Rickard, T., & Pan, S. (2017). A dual memory theory of the testing effect. *Psychonomic Bulletin & Review*, 25, 847 - 869. https://doi.org/10.3758/s13423-017-1298-4

Ahn, D. (2024). Using interpolated testing to improve online learning of community college and university students. **. https://doi.org/10.31274/td-20240617-185

Adesope, O., Trevisan, D., & Sundararajan, N. (2017). Rethinking the Use of Tests: A Meta-Analysis of Practice Testing. *Review of Educational Research*, 87, 659 - 701. https://doi.org/10.3102/0034654316689306

Pan, S., & Rickard, T. (2018). Transfer of Test-Enhanced Learning: Meta-Analytic Review and Synthesis. *Psychological Bulletin*, 144, 710–756. https://doi.org/10.1037/bul0000151

Latimier, A., Riegert, A., Peyre, H., Ly, S., Casati, R., & Ramus, F. (2019). Does pre-testing promote better retention than post-testing?. *NPJ Science of Learning*, 4. https://doi.org/10.1038/s41539-019-0053-1

McCarter, A., Huber, D., & Cowell, R. (2025). No evidence of a visual testing effect for novel, meaningless objects.. *Journal of experimental psychology. Learning, memory, and cognition*. https://doi.org/10.1037/xlm0001430

Gog, T., & Sweller, J. (2015). Not New, but Nearly Forgotten: the Testing Effect Decreases or even Disappears as the Complexity of Learning Materials Increases. *Educational Psychology Review*, 27, 247-264. https://doi.org/10.1007/S10648-015-9310-X

Roediger, H., & Karpicke, J. (2006). Test-Enhanced Learning Taking Memory Tests Improves Long-Term Retention. *Psychological Science*, 17, 249-255. https://doi.org/10.1111/J.1467-9280.2006.01693.X

Barenberg, J., & Dutke, S. (2018). Testing and metacognition: retrieval practise effects on metacognitive monitoring in learning from text. *Memory*, 27, 269 - 279. https://doi.org/10.1080/09658211.2018.1506481

Yang, C., Sun, B., Potts, R., Yu, R., Luo, L., & Shanks, D. (2020). Do working memory capacity and test anxiety modulate the beneficial effects of testing on new learning?. *Journal of experimental psychology. Applied*. https://doi.org/10.1037/xap0000278

Don, H., Yang, C., Boustani, S., & Shanks, D. (2022). Do partial and distributed tests enhance new learning?. *Journal of experimental psychology. Applied*. https://doi.org/10.1037/xap0000440

Carpenter, S. (2009). Cue strength as a moderator of the testing effect: the benefits of elaborative retrieval.. *Journal of experimental psychology. Learning, memory, and cognition*, 35 6, 1563-9. https://doi.org/10.1037/a0017021

Szpunar, K., Khan, N., & Schacter, D. (2013). Interpolated memory tests reduce mind wandering and improve learning of online lectures. *Proceedings of the National Academy of Sciences*, 110, 6313 - 6317. https://doi.org/10.1073/pnas.1221764110

Johnson, C., & Mayer, R. (2009). A Testing Effect with Multimedia Learning. *Journal of Educational Psychology*, 101, 621-629. https://doi.org/10.1037/A0015183

Smith-Peirce, R., & Butler, A. (2025). A scoping review of research on individual differences in the testing effect paradigm. *Learning and Individual Differences*. https://doi.org/10.1016/j.lindif.2024.102602

Rowland, C. (2014). The effect of testing versus restudy on retention: a meta-analytic review of the testing effect.. *Psychological bulletin*, 140 6, 1432-63. https://doi.org/10.1037/a0037559

Parong, J., & Green, S. (2023). The forward testing effect after a 1-day delay across dissimilar video lessons. *Applied Cognitive Psychology*. https://doi.org/10.1002/acp.4101

Fernandez, J., & Jamet, E. (2017). Extending the testing effect to self-regulated learning. *Metacognition and Learning*, 12, 131-156. https://doi.org/10.1007/S11409-016-9163-9

Pan, S., & Sana, F. (2021). Pretesting versus posttesting: Comparing the pedagogical benefits of errorful generation and retrieval practice.. *Journal of experimental psychology. Applied*. https://doi.org/10.1037/xap0000345

McDermott, K. (2020). Practicing Retrieval Facilitates Learning.. *Annual review of psychology*. https://doi.org/10.1146/annurev-psych-010419-051019

Jonsson, B., Wiklund-Hörnqvist, C., Stenlund, T., Andersson, M., & Nyberg, L. (2020). A learning method for all: The testing effect is independent of cognitive ability.. *Journal of Educational Psychology*. https://doi.org/10.1037/EDU0000627

Lee, H., & Ahn, D. (2017). Testing Prepares Students to Learn Better: The Forward Effect of Testing in Category Learning. *Journal of Educational Psychology*, 110, 203–217. https://doi.org/10.1037/edu0000211

Roediger, H., & Karpicke, J. (2018). Reflections on the Resurgence of Interest in the Testing Effect. *Perspectives on Psychological Science*, 13, 236 - 241. https://doi.org/10.1177/1745691617718873

Pyc, M., & Rawson, K. (2010). Why Testing Improves Memory: Mediator Effectiveness Hypothesis. *Science*, 330, 335 - 335. https://doi.org/10.1126/science.1191465

Rivers, M. (2020). Metacognition About Practice Testing: a Review of Learners' Beliefs, Monitoring, and Control of Test-Enhanced Learning. *Educational Psychology Review*, 33, 823 - 862. https://doi.org/10.1007/s10648-020-09578-2

Racsmány, M., Szőllősi, Á., & Bencze, D. (2018). Retrieval Practice Makes Procedure From Remembering: An Automatization Account of the Testing Effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 44, 157–166. https://doi.org/10.1037/xlm0000423

Belardi, A., Pedrett, S., Rothen, N., & Reber, T. (2020). Spacing, Feedback, and Testing Boost Vocabulary Learning in a Web Application. *Frontiers in Psychology*, 12. https://doi.org/10.3389/fpsyg.2021.757262

Leahy, W., Hanham, J., & Sweller, J. (2015). High Element Interactivity Information During Problem Solving may Lead to Failure to Obtain the Testing Effect. *Educational Psychology Review*, 27, 291-304. https://doi.org/10.1007/S10648-015-9296-4

Macaluso, J., & Fraundorf, S. (2025). Do differences in topic knowledge matter? An experimental investigation into topic knowledge as a possible moderator of the testing effect. *Memory*, 33, 566 - 587. https://doi.org/10.1080/09658211.2025.2500538