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Picture This: Studying the Effectiveness of Illustrated Instructions

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Abstract:	Background: Research on multi-media instruction suggests that illustrations aid learning over straight text. Providing students with illustrated instructions may increase comprehension and retention of material. Objective: We tested if students would remember material better if it was presented as an infographic where content was supplemented with illustrations versus reading the same content without illustrations. Method: We randomly assigned students (N = 114) to either a text-based or to an illustrated instruction condition where they learned about three types of study techniques (retrieval practice, spaced practice, and interleaving). After a brief distraction task, all students took a quiz on the material presented. Results: A multivariate analysis of variance showed a significant main effect for condition. Students in the illustrated instruction condition scored higher on the quiz than those who were assigned to the text-based condition. Conclusion: Presenting complex material as an infographic with illustrations may aid learning. Teaching Implications: Teachers and textbook authors should consider the use of illustrated instructions to convey difficult material especially bottleneck concepts.

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Abstract

Background: Research on multi-media instruction suggests that illustrations aid learning over straight text. Providing students with illustrated instructions may increase comprehension and retention of material.

Objective: We tested if students would remember material better if it was presented as an infographic where content was supplemented with illustrations versus reading the same content without illustrations.

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Teaching Implications: Teachers and textbook authors should consider the use of illustrated instructions to convey difficult material, especially bottleneck concepts.

Picture This: Studying the Effectiveness of Illustrated Instructions

Anyone who has constructed a Lego set or assembled a piece of IKEA furniture is familiar with instruction booklets replete with vivid images instead of being chockful of text. Each page helps the user transform a pile of plastic or wood into anything from a pirate ship or an airplane to architectural wonders, or at least cabinets or bookshelves. While pictorial instructions may not be preferred by all, they certainly make tasks more manageable. Early reviews document the utility of illustrations in aiding reading comprehension (Levie & Lentz, 1982) and it is clear materials with illustrations aid learning in general (Frick & Schuler, 2023; Mayer, 2021). Just as adding pictures to instructions may help build a Lego set, adding illustrations to learning material may also help students learn and retain information better. In this study we compare the efficacy of two types of instructions, traditional text-based instructions and illustrated instructions, to see if one leads to better learning.

Theoretical Reasons Illustrations are Useful

Illustrations may work because they can reduce the load on working memory given that working memory capacity is limited (Cowan, 2001). Cognitive science suggests there are more reasons than this (Frick & Schuler, 2023; Young et al., 2013). Many learning theories suggest why illustrated text reading should be beneficial. For example, the cognitive theory of multimedia learning (CTML, Mayer, 2021) and the integrated model of text and picture comprehension (Schnotz & Bannert, 2003; Schnotz et al., 2014) both indicate the importance of illustrations in the process of learning.

The CTML (Mayer, 2021) is based on Atkinson and Shiffrin's multi-store model (1968), Baddeley's working memory model (1992), and Clark and Paivio's dual-coding theory (1991). CTML proposes two processing channels: an auditory-verbal and a visual-pictorial channel. In

line with dual coding theory, CTML assumes that having information present in both channels enhances memory for that information (Mayer, 2021). Clark and Paivio's (1991) dual coding theory goes further in highlighting the benefits of using a visual in conjunction with verbal information. It proposes that we have distinct neural channels for processing these types of information, and as such using both channels to learn new material leads to better comprehension than using either one independently.

Illustrations in Learning

If you pick up a psychology textbook or look at one online, you are likely to see a blend of text, figures, and photographs. In fact, early studies of how textbooks vary had students rate different textbooks for each of these features. Students differentiated between books based on these features, rating the photographs or illustrations in some books better than the photographs or illustrations in others (Gurung & Martin, 2011). Illustrations have not always been a part of textbooks, with early textbooks having next to no photographs or illustrations at all (Weiten & Houska, 2015). How illustrations are used can also vary.

Illustrations are not novel tools in efforts to aid learning (Dwyer, 1967; Levie & Lentz, 1982). Illustrations can provide examples of concepts or summarize them. Illustrations have also been used as note taking aids during lectures, often being used to signal noteworthy information in both books and presentations (Bui & McDaniel, 2015). Labels and highlighting as visual cues, for example, often lead to greater attention and improved learning (Scheiter & Eitel, 2015).

In this study, we focus on the use of illustrations specifically to describe material in place of direct text, referred to as *illustrated instructions* (Boling et al., 2004). This terminology focuses on the specific use of visuals in contrast to the general use of illustrations to supplement or complement text, often referred to as multimedia material (Mayer, 2021). Unlike illustrative

diagrams which feature drawings of each major component of a process (e.g., how a car engine works) with accompanying text describing the relationship between the components (Mayer & Gallini, 1990), illustrated instructions do not have accompanying text descriptions.

Illustrated instructions are defined as visual representations intended to aid learning (Boling et al., 2004) and are a subgroup of infographics, visualizations of data, and information that help convey a message in a concise, clear, and aesthetic fashion. Infographics use graphs, diagrams, icons, and sometimes pictures to present data in a clear way, often contextualizing the numbers with more details (Lamb & Johnson, 2014). Buoyed by studies showing that understanding and memory for course material improves with the use of infographics (e.g., Elena Gallagher et al., 2017), we tested if illustrated instructions help students better learn presented content.

Pragmatic Uses and Tests of Illustrations

Illustrations have been shown to work in practice. Learning materials consisting of illustrated texts and multimedia materials can support learning and deeper understanding (Cromley et al., 2021; Mayer, 2021). In healthcare, illustrations help patients understand and remember instructions (Houts et al., 2006). In both chemistry and geology, studies show significant learning advancements with the use of visually based learning modules (Dangur et al., 2014; Gagnier et al., 2017). Illustrating concepts has been especially recommended for undergraduate neuroscience education (Sahiti & Stamp, 2022). In support of the innovations demonstrated by Lego and IKEA manuals, step by step illustrations improve recall of conceptual knowledge and problem-solving information (Mayer & Gallini, 1990).

Some recent studies have looked at more academic uses of illustrations. Embedding illustrative diagrams in a textbook improved understanding of relationships between concepts,

shown with better short-answer and multiple-choice performance, and helped participants build more coherent mental models, shown as better multiple-choice performance (Bui & McDaniel, 2015). The use of illustrations to summarize information or make steps in a process easier is not the same as the use of visuals as a design element. For example, Harrington and Gabbert-Quillen (2015) tested if adding visuals to a syllabus changed student perceptions of the course or the instructor. The visuals did not make a difference in perceptions but when used to highlight material, as in a visual addendum to a syllabus, student retention of syllabus details increased (Mocek, 2017).

In one direct comparison of a content-equated visually rich versus a text-based syllabus, students viewing the visually rich syllabus showed significant differences in eye movements (e.g., number of fixations, viewing sequences) when viewing the two types of syllabi, but remembered more information from the text-based syllabus (Overman et al., 2020). In contrast, students in a separate study who viewed a more visual syllabus had more positive views of the professor (e.g., kinder, more approachable) than students who read the text-based syllabus (Nusbaum et al., 2021). Of note, there were no benefits of visually rich syllabi in terms of helping students to pay attention to and remember course information (Nusbaum et al., 2021). Perhaps the outcome would be different for the material students focus on for a test, a possibility we explore in this study.

The Current Study

The broader research literature suggests that reading text supplemented by visuals or infographics which summarize content may be beneficial (Boling et al., 2004; Mayer, 2021) even if recall of items on a syllabus is not increased by visual design (Nushbaum et al. 2021). This unevenness in utility may be a function of a dearth of studies using materials explicitly created to

test key differences. Apart from strong experimental work by Bui and McDaniel (2015) and Nusbaum et al. (2021), few other studies directly test finite, circumscribed sets of content by creating illustrations designed to integrate explicitly with the text.

In this exploratory study we focused on advice provided to students on how to study. A rich body of research highlights the most effective ways to study (Dunlosky et al., 2013), and although students are aware of these methods and intend to use them, they still do not utilize these techniques effectively (Bartoszewski, & Gurung, 2015; Blasiman et al. 2017). Three recent publications aimed at students may help increase the extent to which students use effective methods (Gurung & Dunlosky, 2023; Sumeracki et al., 2023; Willingham, 2023). Gurung and Dunlosky (2023) used illustrated instructions for each major type of study technique described (e.g., retrieval practice, spaced practice) in addition to textual descriptions of each concept, providing an opportunity to test the utility of illustrated instructions against text-based instructions.

In the current study we created brief text-based instructions to directly correspond to the illustrated instructions in the book. Our main research question was, do visual instructions lead to better learning of the presented material as shown by higher quiz scores than the text-based instructions? Based on CTML (Mayer, 2021), we hypothesized that participants receiving illustrated instructions would learn more of the presented content, operationalized as scoring higher on a multiple-choice quiz on the material they just read.

Method

Participants

Undergraduate introductory psychology students volunteered for this study and received class credit. Participants who completed the entire study ($N = 114$) reported an average grade

point average of 3.50 (*SD* = 0.72). Our human subjects board asked us to minimize the number of identifying features collected to lessen the risk of any participants being identified in case of a data breach. Consequently, we did not measure any demographic variables such as gender or age. General demographic data for the introductory psychology program shows it to be predominantly female (65%) and White (60%). The demographics of the university are 52% female and 61% White.

Materials

We created two forms of instructional material**,** text-based and illustrated. The basic content of the information in both sets of material were derived from recent research (Gurung & Dunlosky, 2023). The illustrated instructional material was comprised of artwork featured in the published book and used with permission. The artwork illustrated some of the examples in the book and provided brief textual explanations of each study technique albeit in a brief, truncated way. We wrote text only instructions to match the content shared by the illustrations. Both sets of materials provided directions on how to use three study techniques (number of words of text-only instructions in parentheses): Spaced Practice (395 words), Interleaved Practice (366 words), and Retrieval Practice (430 words). To create the text for the study, we first read the chapters corresponding to each study technique. We then described the technique and provided some context and background material for the technique mirroring how content is normally presented in textbooks. We aimed to use a similar style and reading level. All text and illustrated instructions are available as open materials (htpps://osf.io/ery4u/).

All students completed some general questions about their classroom behavior before the quiz, designed to be a distractor task. We asked students which of 10 distracting activities they participated in while reading and studying for a test in class, using a scale ranging from 1 (*Never)*

to 5 (*Always).* We also asked how long on average they study before doing something else, and then had participants complete 10 questions from a procrastination scale (Schwarzer et al., 2000).

Our main dependent measure was scores on a quiz. For each study technique, we wrote five multiple-choice questions based on the material provided. Five student research lab members checked both sets of instructional materials to confirm all quiz questions could be answered based on the information available in both the illustrated and text-based instruction material. Sample questions included, "What does spacing practice mean?" "What is one unique feature of interleaving practice?," and "What is the first step in spaced practice?" All the multiple-choice questions had four possible responses. We created three composite scores, one for each study technique, with participants earning one point for each correct answer (i.e., scores ranged from 0 to 5).

Procedure

The institutional review board approved this study (IRB-2020-0558). All participants accessed this study online through SONA, an online software system where they could choose from a variety of studies. For participating in the study, students received research credit which is a class requirement in general psychology at our institution. Participants first completed a consent form. We then randomly assigned participants to one of two instructional material conditions, using a between-group, single factorial design (illustrated instruction, text instruction). We told participants we would share three important ways to improve their study skills, asking them to pay close attention and learn the techniques to the best of their abilities. We informed them we would test their knowledge of each technique later in the study, and that each screen would be timed to present material for three minutes. We used three minutes after

pilot testing the materials on undergraduate research assistants who reported this was the amount of time they needed to process the text-based instructions.

Each of the three study techniques was presented in random order, for three minutes each, after which the "Submit" button became available. Participants could click the button at any time after it appeared, and we measured the time spent on each screen. After completing a short distractor task (indicating the extent to which they participated in ten potentially distracting activities during studying), participants completed a quiz based on the information they just learned. Participants then completed measures as part of a separate study (level of distraction, academic self-efficacy, need for cognition, typical studying habits), before reporting their average grade point average.

Results

To test the primary hypothesis, we used SPSS (Version 27.0) and conducted a multivariate analysis of variance (MANOVA) using instructional material (illustrated or text) as the fixed factor. We examined our data to assess whether they met the assumptions for a MANOVA (e.g., normality, homogeneity of variance, random independent samples, linear relationship between dependent variables and covariates, homogeneity of regression slopes, and independence of covariate and independent variables; Field, 2018). We list means and standard deviations for all variables by condition in Table 1.

Given that the number of words in the instructions varied between the two conditions, we examined the time spent on the materials first. In all cases, participants spent more than three minutes on the screens (all times over 200 seconds). We tested to see if the amount of time spent on each set of instructions before clicking to move to the next page varied between conditions. An analysis of variance showed participants' time on screen with instructions did not vary

significantly between illustrated and text-based instructions for spaced practice $F(1, 109) = 0.12$, $p = .735$, $\eta_p^2 = .00$, and interleaving material $F(1, 109) = 0.11$, $p = .746$, $\eta_p^2 = .00$. Participants spent significantly longer on the retrieval practice text-based instructions (which had more words than the other two text instructions) versus on the illustrated instructions $F(1, 109) = 5.47$, $p = .021$, $\eta_p^2 = .05$ (see Table 1).

In support of our hypothesis, we found a significant multivariate main effect for type of material, Pillai's Trace $F(3, 108) = 3.36$, $p = .022$, $\eta_p^2 = .09$. Test of between-subjects effects demonstrated that two of the three variables showed significant univariate tests. Participants viewing the visual instructions scored higher on both spaced practice $F(1, 110) = 6.00$, $p = .016$, $\eta_p^2 = .05$, and interleaving questions $F(1, 110) = 4.31$, $p = .04$, $\eta_p^2 = .04$. As it is possible that students with a higher GPA may perform differently across conditions, we conducted a post hoc analysis controlling for GPA. GPA was not a significant covariate in the MANCOVA $F(3, 84) = 1.98$, $p = .124$, $\eta_p^2 = .07$. We also conducted a post hoc analysis controlling for time spent on instructions for retrieval practice given this variable varied between instruction types. Time spent was not a significant covariate in the MANCOVA $F(1, 105) = 0.18$, $p = .911$, $\eta_p^2 = .01$.

Discussion

This concise study provides support for the utility of illustrated instructions in fostering student learning. Participants who used illustrated instructions to learn about three study techniques performed higher on a quiz testing the material than participants who used text-based instructions. Many students bemoan large reading assignments and find comprehending college text assignments challenging (Yozamp et al., 2023). Our results suggest textbook authors should illustrate important concepts. Although it may not be feasible to have all content illustrated in the way done in this study, focusing on and illustrating only challenging concepts may be more

feasible. For example, research on introductory psychology, research methods, and statistics classes indicates some of the terms and concepts students have trouble with are statistical significance, independent variables, and operant conditioning (Gurung & Landrum, 2013; Stoa et al., 2022). These terms would be good candidates to be illustrated.

In this study we wanted to take a direct approach comparing illustrated instructions and text-based instructions. Although we provide strong evidence for the potential of illustrated instructions, our study has some key limitations. First, we operated from existing artwork, which although commissioned to supplement a text, was not created based on theory. Creating artwork or illustrated instructions based on CTML (Mayer, 2021) may yield even stronger evidence for the utility of illustrated instructions. For example, Mayer suggests selecting words that are relevant to both the learner and the information and also ensuring the images are relevant to the task at hand. Mayer also suggests integrating words and illustrations with prior knowledge which we may not have done effectively. Second, we note that the text-based and illustrated instructions could be made even more comparable. There are still some discrepancies between the graphics and text. For example, our text describing part of the graphic for spaced practice has 117 words (the winner's podium). The corresponding graphic has 12 words. Although there are significantly more words in the text-based instructions as part of the operationalization of the independent variable, we do acknowledge that both types of instructions have extraneous details in them. A purer test may be to compare illustrated instructions with only text relating directly to the task at hand. It may be possible, like Lego and IKEA, to have only images and symbols for instructions but this would not be feasible in the context of textbooks and sharing academic information. The text instructions do also have some extraneous information (e.g., Hermann Ebbinghaus) not covered in the illustrated instructions at all.

Another limitation of the study relates to whether the two instructions are similar. Although an experiment and not part of class, we wanted to keep the two conditions as realistic as possible. To that end, we did not equalize the two conditions completely. We hope our design and results will catalyze more work on this topic and aid future researchers in creating more equitable comparisons of illustrated and text-based instructions. We also did not collect demographic information on the participants to limit identification of students (even with indirect identifiers).

Finally, it is prudent to explore alternative explanations for why learning was higher in this study. It is possible that part of the effect we unearthed is due to the heightened attention paid to visuals. Students also spent little more than nine minutes on all three sets of material. The learning findings may not apply when a student studies for a longer period (e.g., an hour study session), or for larger portions of content (e.g., a chapter). These are both possibilities we did not test for in the current study.

It is likely that there are key individual differences that may influence the effectiveness of illustrative instructions. Whereas literature debunking the notion of learning styles suggests matching a learning preference to a teaching style is not critical to learning (Kirschner, 2017; Pashler et al., 2008; Rogowsky et al., 2015), a student's preference for visual material could make them pay more attention to illustrated instructions (Lehmann & Seufert, 2020), an avenue for future exploration. Factors such as cultural context, the reading level of a text, novelty of material, and quality of writing and examples can all influence how much a student can learn from reading. Not all illustrations may be beneficial as some images may hurt learning by promoting fear or other emotions (Kühl & Münzer, 2023). Our study did not manipulate any of these factors, providing an agenda for follow-up studies on this issue. Additionally, although we

forced both groups of participants to interact with the instructions for at least three minutes, future work can consider letting participants move forward themselves. It is possible that participants would have spent less than three minutes on the illustrated instructions and remembered the material inaccurately compared to the text which takes longer to read.

The explicit result of this study suggests that for some material, illustrated instructions may have an advantage over text-only instructions. In an age where more adults are spending more time on their screens and significant generational differences are being unearthed (Twenge, 2023) this may be a good time to explore the use of more illustrated instructions which akin to social media reels, may provide more attention grabbing. This is also a good opportunity to conduct further classroom-based studies testing the promise of multi-media learning and infographics. This first foray cautions against major generalizations but urges a closer look at how material is presented to students.

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Table 1

Means and Standard Deviations for Quiz Scores Across Conditions and Time on Screen

	Instructional Materials		Time on Page	
	Text Based	Illustrated	Text Based	Illustrated
	M(SD)	*M(SD)*	*M*(SD)	*M*(SD)
Spaced Practice	3.43 (1.19)	3.94 (0.99)	238.21 (113.19)	247.43 (169.43)
Retrieval Practice	3.04 (1.19)	3.00 (1.22)	250.62 (140.87)	206.37 (43.10)
Interleaving	2.53 (1.21)	2.97 (1.01)	271.86 (174.84)	282.15 (143.00)

Note: Scores could range from 0 (no correct answers) to 5 (all correct). Time on page is listed in seconds. A MANOVA showed a significant difference between groups for spaced practice and interleaving. An ANOVA showed a significant difference for time on page for retrieval practice.