Computers & Education 126 (2018) 376–387

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Does teaching with PowerPoint increase students' learning? A meta-analysis

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ARTICLE INFO

Keywords:
PowerPoint instruction
Multimedia instruction
Traditional instruction
Cognitive learning
Meta-Analysis

ABSTRACT

PowerPoint has become a ubiquitous tool for instructors who teach college students. Almost two decades of student learning research has examined the impact of traditional instruction (i.e., *chalk and talk*) versus instruction aided by PowerPoint. This research has revealed inconsistent and contrasting results. To probe this inconsistency, a meta-analysis of 48 studies was conducted to determine if students learn more when taught the same material using PowerPoint compared to traditional instruction. Results revealed that on average, there was no difference in students' learning based on the type of instruction they received (*Hedges' g* = 0.067; 95% CI: −0.103 to 0.236). Moderation analyses revealed that the sampling frame, such as a focus on K-12 versus college students, explained heterogeneity in the findings. Specifically, K-12 students' cognitive learning increased as a result of PowerPoint instruction, but this effect did not emerge for college students. The results of this meta-analysis suggest that researchers should move past strictly comparing the absence or presence of this instructional tool, to instead examine how instructors are integrating features of PowerPoint in ways that help students learn.

1. Introduction

Instructors have access to several digital presentational tools, such as PowerPoint, Prezi, Google Slides, Camtasia, and Keynote, which are used to disseminate course content and supplement teaching. One such tool, PowerPoint, has been adopted by many college instructors for teaching purposes as students expect to be taught by PowerPoint in their college coursework (Rickman & Grudzinski, 2000). In fact, Hill, Arford, Lubitow, and Smollin (2012) found that 67% of college students reported that instructors used PowerPoint; and of these instructors, 95% used this software all or most of the time. Jordan and Papp (2014) explained that PowerPoint is preferred by instructors because (a) job demands are imposed on instructors that favor it (e.g., advising, publishing, and discipline service), (b) textbook publishers provide ready-made PowerPoint presentations that align with textbooks, and (c) students have voiced their preference for PowerPoint. Hill et al. argued that instructors recognize the constraints PowerPoint puts on their students' learning experiences, but still use it to provide clarity and pace their lectures. This prevalence of PowerPoint in the classroom has spurred almost two decades of research investigating its influence on students' cognitive learning.

Researchers (e.g., Alley & Neeley, 2005; Mahin, 2004) have estimated that PowerPoint can be found on over 250 million computers; thus, there is no debate over its prevalence. Early versions of PowerPoint included basic presentation templates to follow and several basic animation options (i.e., appearing, disappearing, "flying in", or bullet points). Though presentation templates and animations remain as features in the latest versions of PowerPoint, many new features have been added. For example, latest versions

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https://doi.org/10.1016/j.compedu.2018.08.003
Received 31 March 2018; Received in revised form 17 June 2018; Accepted 3 August 2018
Available online 04 August 2018
0360-1315/

of PowerPoint allow for collaboration with others in real time, embedding videos, 3D animations that can be turned/moved, and designer recommendations, to name a few (Microsoft, n.d.). Since PowerPoint's introduction in 1987, many researchers (e.g., Daniels, 1999; Erdemir, 2011; Shapiro, Kerssen-Griep, Gayle, & Allen, 2006; Waheeda & Murthy, 2015) have, and still continue to, examine its influence on students' learning outcomes (Levasseur & Sawyer, 2006). These investigations have resulted in mixed conclusions that prolong the debate over implementing PowerPoint in the classroom. Therefore, the primary aim of this study was to provide a summary effect of the impact of PowerPoint on students' cognitive learning to bring coherence to muddled research.

2. Review of literature

2.1. Perceived affordances of PowerPoint

The features of PowerPoint can make this software either more appealing or undesirable for instructors and students. For instructors, PowerPoint offers several affordances, including the ability to display static images or animations, incorporate transitional effects between images, information, or slides, integrate sound effects and/or videos, and provide richer graphics. Students have also identified several perceived benefits and pitfalls to this technology being used by their instructors. Generally, when offered the choice between traditional (*chalk and talk*) instruction and instruction aided by PowerPoint, many studies (e.g., Butler & Mautz, 1996; Daniels, 1999; Hill et al., 2012; Savoy, Proctor, & Salvendy, 2009; Seth, Upadhyaya, Ahmad, & Kumar, 2010) have revealed that students prefer PowerPoint. Specifically, extant research has illuminated two main reasons for why students prefer PowerPoint as a teaching supplement: (1) organization and (2) sustained attention. First, students have reported that PowerPoint helped instruction remain more organized by providing an outline/structure to the lecture, displaying information clearly, helping them follow along with the lecture, highlighting the key points, keeping class time more efficient, making figures and images easier to read, and summarizing important information (Apperson, Laws, & Scepansky, 2006; Hill et al., 2012; Lari, 2014; Sugahara & Boland, 2006). Second, previous research has shown that students believe PowerPoint is beneficial for sustaining their attention, interest, and motivation in class (Akhlaghi & Zareian, 2015; Apperson et al., 2006; Frey & Birnbaum, 2002; Hill et al., 2012; Lari, 2014; Szabo & Hastings, 2000). Most recently, Ledbetter and Finn (2018) found that students believed their instructor was more credible and had more positive affect when their instructors used PowerPoint. This finding is not surprising as students have come to expect PowerPoint instruction (e.g., Hill et al., 2012; Rickman & Grudzinski, 2000). That is, students may take more notice when PowerPoint is missing from instruction and this may influence their affect and impressions of an instructors' credibility.

Although research has demonstrated several benefits of PowerPoint identified by students, this research has also found that students have concerns and reservations when it accompanies teaching. Students have identified that PowerPoint promotes fast paced instruction (i.e., clicking though slides quickly), stifles opportunities for discussion, and encourages instructors to read their teaching content from the slides verbatim (Hill et al., 2012). Likewise, Sugahara and Boland (2006) found that students believed PowerPoint required faster note taking, which limited their opportunities to take detailed notes and created more of a learning distraction. Students have also reported that instruction combined with PowerPoint diminishes student-instructor rapport, because this type of instruction limits the amount of, and opportunity for, interactions between the instructor and student (Nowaczyk, Santos, & Patton, 1998).

Taken together, this research suggests that although students identify issues with PowerPoint, they prefer this method of instruction and believe it is beneficial for their learning experiences (Levasseur & Sawyer, 2006). However, the research on the relationship between PowerPoint and students' (actual) cognitive learning both supports and contradicts these student perceptions. Cognitive learning is considered learning that ranges from simply remembering information to more complex processes of creation (Anderson and Krathwohl, 2001). Shapiro et al. (2006) conducted a meta-analysis on 16 studies that compared traditional (*chalk and talk*) instruction to instruction aided by desktop presentational programs (i.e., PowerPoint) and found that PowerPoint presentations have only a slight positive relationship with student cognitive learning (r = .128). However, since this meta-analysis, 12 years of additional research has continued, comparing instruction with or without PowerPoint on student learning; and more recent research continues to provide mixed findings for its pedagogical effectiveness. That is, previous research has revealed that PowerPoint enhances (e.g., Dean, Lee-Post, & Hapke, 2016; Jalali & Talebi, 2014; Lowry, 1999, pp. 18–21), inhibits (e.g., S. Bamne & Bamne, 2016; Pros, Tarrida, Martin, & Amores, 2013; Waheeda & Murthy, 2015), or has no effect (e.g., Bartlett & Strough, 2003; Nouri & Shahid, 2005; Sugahara & Boland, 2006) on students' cognitive learning. Therefore, considering inconsistent findings spanning over a decade of new research since Shapiro et al.'s meta-analysis, the purpose of this study was to perform an updated meta-analysis to summarize the effect of PowerPoint (versus identical instruction without PowerPoint) on students' cognitive learning. This meta-analysis also included several studies that the original Shapiro et al. meta-analysis included.[1]

2.2. PowerPoint and learning

Generally, researchers have found that students self-report more cognitive learning from instruction that is aided by PowerPoint (e.g., Atkins-Sayre, Hopkins, Mohundro, & Sayre, 1998; Bartsch & Cobern, 2003; Mantei, 2000). This is not surprising given that students believe instruction with PowerPoint is more organized and helps sustain their attention and focus on important information

[1] In addition to recent research, our updated meta-analysis attempted to include several of the studies that the Shapiro et al. (2006) included in their meta-analysis. However, several studies did not provide enough statistical information to convert to an effect size (e.g., Ahmed, 1998).

(Apperson et al., 2006; Hill et al., 2012). Students have also self-reported that PowerPoint increases their comprehension of the material and contributes to their exam preparation (Hill et al., 2012; Nowaczyk et al., 1998). Although the research on students' perceptions of their cognitive learning from PowerPoint instruction is generally positive (Levasseur & Sawyer, 2006), several experimental studies comparing instruction with or without PowerPoint provide inconsistent learning effects. Specifically, researchers have arrived at three different conflicting results regarding PowerPoint's effect on learning: (1) PowerPoint has beneficial effects on learning, (2) PowerPoint has detrimental effects on learning, or (3) PowerPoint has no effect on learning.

Some studies have demonstrated that, compared to traditional instruction, PowerPoint instruction benefits students' perceived and performed cognitive learning (e.g., Akhlaghi & Zareian, 2015; Hassan et al., 2014; Jalali & Talebi, 2014; Kunkel, 2004; Lari, 2014; Lowry, 1999, pp. 18–21; Luttig, 1998; Sagar & Pandey, 2014; Szabo & Hastings, 2000 study 2). Dean et al. (2016) conducted an experiment during two semesters of a marketing management course and had students self-report their instructor's use of different technologies (i.e., PowerPoint, lecture notes, clickers, and MindTap) and found a small positive association ($r = 0.26$) between an instructor's use of PowerPoint and students' perceived cognitive learning. Similarly, Nowaczyk et al. (1998, study 2) examined both the benefits and pitfalls of PowerPoint in an undergraduate psychology course and also found a small positive relationship ($r = 0.20$) between perceptions that PowerPoint helped students' understanding of the course material and their performance on the course exams. Complementing this self-report data, Wilmoth and Wybraniec (1998) compared six sections of a social statistics course in which students received either instruction with or without PowerPoint, revealing that PowerPoint significantly improved students' final grades. Replicating this finding in the context of a physics class, Erdemir (2011) found that students who received instruction with PowerPoint had higher grades than students who received a traditional (*chalk and talk)* style of instruction. Regarding test scores, Othman, Tarmuji, and Hilmi (2017) demonstrated that students given PowerPoint instruction outperformed students in a traditional lecture on a mathematical test. However, Levasseur and Sawyer (2006) cautioned the interpretation of some studies reporting positive findings (e.g., Mantei, 2000; Wilmoth & Wybraniec, 1998) because in these studies, students also received note copies of the PowerPoint slides, which may have accounted for the gains in cognitive learning. Specifically, students' grades or test scores may have increased because they had access to the copied notes rather than the style of instruction they received. That said, this research demonstrated the potential benefits that PowerPoint has on students' acquisition and comprehension of the course material; however, research also contests these findings or has found null effects.

Despite the evidence suggesting that PowerPoint can improve students' cognitive learning, there is also research that demonstrates PowerPoint impedes learning or that traditional (*chalk and talk*) instruction is better. For example, surveying 67 sections of introductory economics, Sosin, Blecha, Agarwal, Bartlett, and Daniel (2004) found that students' academic performance in both macro and micro economics suffered when students reported PowerPoint was used extensively in their courses. Similarly, Sugahara and Boland (2006) asked students to report on their preference for either PowerPoint or traditional (whiteboard) instruction and then compared final examination scores, revealing that students who preferred the traditional style of instruction outperformed students who preferred PowerPoint. In line with these findings, several studies (e.g., Bailey & Morrell, 2013; Bamne & Bamne, 2016; Butler, Pyzdrowski, Walker, & Yoho, 2010; deSa & Keny, 2014; Ogeyik, 2017; Saini, Kaur, Kaur, Thappar, & Bindu, 2015; Savoy et al., 2009; Waheeda & Murthy, 2015) have also reported that students who received traditional instruction had higher test scores and/or higher course grades than students who received PowerPoint instruction. Stefanou, Hoffman, and Vielee (2008) suggested that the differences in learning among these styles of instruction may be due to students' note taking. They found that students who copied the PowerPoint lectures verbatim performed poorly on quiz questions focused on factual recall; however, this same effect appeared for students who received a lecture with overhead instruction.

In addition to the benefits and pitfalls of PowerPoint, several studies have found no differences between student's cognitive learning and the style of instruction. For example, Apperson et al. (2006) had five instructors teach an entire semester without technology, followed by another semester using PowerPoint, which resulted in no differences among students' self-reports of their overall cognitive learning in the course. Additionally, Ricer, Filak, and Short (2005) examined both short-term and long-term retention among medical students given PowerPoint instruction or overhead instruction and found no differences in both short-term and long-term memory based on the type of instruction. Several other studies (e.g., Bartlett & Strough, 2003; Bushong, 1998; Butler & Mautz, 1996; Daniels, 1999; Jandaghi & Matin, 2009; Larson, 2001; Meo et al., 2013; Nouri & Shahid, 2005; Seth et al., 2010) have reached similar conclusions, finding no effect on learning, which may be the reason why Finn and Ledbetter (2017) argued the effect of an instructor's use of PowerPoint on students' cognitive learning remains unclear.

2.3. Purpose for meta-analysis

The purpose of this meta-analysis, then, is to offer an updated empirical estimate for the muddled and inconsistent effects of instructors' use of PowerPoint on students' cognitive learning. Though Levasseur and Sawyer (2006) offered a comprehensive narrative review regarding the effects of PowerPoint in the classroom, Borenstein, Hedges, Higgins, and Rothstein (2009) argued that narrative reviews tend to interpret individual studies based on p-values, which are sensitive to sample size; thus, these narrative reviews have no mechanism for assessing the consistency of a particular effect (i.e., the effect of PowerPoint instruction on student learning). However, meta-analyses focus on effect sizes and partition variance to capture differences among studies (Borenstein et al., 2009). Therefore, to provide coherence to inconsistent findings and provide future researchers with a summary effect regarding PowerPoint, we present the following research question:

RQ1: Compared to teaching without PowerPoint, what is the average effect of teaching with PowerPoint on students' cognitive learning?

2.4. Moderators

Although researchers have found evidence to support or oppose the implementation of PowerPoint in teaching, these studies often use cross-sectional designs or differ on several important factors that may be the reason for significant or non-significant findings (i.e., time frame, amount of treatment provided, manipulation of instructional technologies, and measurement of cognitive learning). In the following sections, we highlight four possible reasons for the influence of PowerPoint on cognitive learning.

2.4.1. Factors related to the instructional environment

PowerPoint may be more effective on students' cognitive learning for some subject matters than others. Indeed, from their meta-analysis, Shapiro et al. (2006) found that the scientific fields were more suitable for PowerPoint instruction. One potential reason for this finding, is that the STEM (Science, Technology, Engineering, and Mathematics) disciplines, compared to the humanities, deal with material that is model-based and complex. PowerPoint affords instructors the ability to provide students high quality visuals and demonstrations (through animations) of complex models. Indeed, Rowley-Jolivet (2002) highlighted the importance of a visual channel of communication for the scientific field. Though Rowley-Jolivet (2002) focused on visual communication during international scientific conferences, her research demonstrates that verbal and visual communication fulfill the cognitive and communicative needs of the science disciplines, more so than the humanities field. In addition to the topic of instruction, the expertise of the learner may impact the effect of PowerPoint. That is, PowerPoint may influence novices' learning (e.g., K-12 students) and experts' learning (e.g., undergraduate students; Kalyuga, Ayres, Chandler, & Sweller, 2003) differently. Specifically, according to expertise reversal effect novices' learning may benefit from PowerPoint slides that contain explanatory information and more details, however experts' learning may suffer from this excess information (Kalyuga et al., 2003).

2.4.2. Factors related to the study method[2]

A notable issue with studies measuring cognitive learning is the discrepancy between students' self-reports and observed (i.e., tests, quizzes, grades) measures of their learning. Previous researchers (e.g., Witt, Wheeless, & Allen, 2004) have found that larger effects emerge when students self-report their cognitive learning, but little or no effects emerge on objective tests of learning. Indeed, Levasseur and Sawyer (2006) concluded that students tend to self-report more learning from PowerPoint instruction than what performance-based measures reflect. Further, Hooker and Denker (2014) demonstrated that students' self-reports of cognitive learning have a small or nonexistent link with observed cognitive learning measures. Related, the method of measuring PowerPoint instruction may also influence students' cognitive learning. For instance, having students self-report the effectiveness of PowerPoint and measuring their learning may reveal biased gains in learning. In contrast, experimental studies that create two conditions of identical instruction taught with or without PowerPoint may reveal smaller effects on learning. Because of these discrepancies, the type of cognitive learning measurement and study method were also included as potential moderating variables. In order to examine the potential moderating effect that the instructional environment and study methods have on students' cognitive learning from PowerPoint, we offer the following research question:

RQ2: How is the effect of PowerPoint on students' cognitive learning moderated by subject matter, sample type, learning measurement, and study method?

3. Method

3.1. Literature search

To create a comprehensive list of empirical studies that examined the influence of PowerPoint on cognitive learning, several steps were taken. First, a keyword search was conducted using the following databases: ERIC, Google Scholar, Education Research Complete, PsycINFO, Communication and Mass Media Complete, and Web of Science (see Table 1). Second, a call for manuscripts was posted on CRTNET (Communication, Research, and Theory Network listserve), followed by an email to members of the National Communication Association's Instructional Development Division, Eastern Communication Association's Instructional Communication Division, and International Communication Association's Communication and Technology Division seeking unpublished manuscripts. Third, calls for unpublished manuscripts were posted to various academic association's social media (i.e., Facebook and Twitter), such as the National Communication Association, Eastern Communication Association, International Communication Association's Instructional and Developmental Communication Division, Association for Educational Communications and Technology, International Society for Technology in Education, International Society for the Learning Sciences, and the American Education Research Association. Fourth, studies that mentioned PowerPoint and cognitive learning and met the inclusion criteria mentioned below were back referenced to identify possible studies for inclusion. This process identified a total of 486 possible articles to be included in this meta-analysis.

[2] Within each individual study, we attempted to code for how PowerPoint was being used, however, several studies did not specify these details. Many studies took a mere exposure approach and compared instruction either with or without PowerPoint, but did not offer further details regarding how the instructor was using PowerPoint in the classroom.

Table 1
Literature search.

Database	Search Terms	Results
ERIC	(("instructional effectiveness" OR Learning) AND (powerpoint OR ″presentation software") AND (SU ("Quasiexperimental Design" OR ″ Comparative Analysis")) Limiters - Publication Type: Books, Collected Works (All), Dissertations/Theses (All), ERIC Publications, Journal Articles, Reports (All), Search modes: Boolean/Phrase	63
Google Scholar	allintitle: (powerpoint OR ″presentation software") (learning OR ″instructional effectiveness" OR recall)	162
Education Research Complete	((DE ″EFFECTIVE teaching" OR ″learning outcome*" OR recall) AND (powerpoint OR ″presentation software")) Limiters - Document Type: Abstract, Article, Report; Source Type: Academic Journals, Conference papers, Search modes: Boolean/Phrase	63
PsycINFO	(powerpoint OR ″presentation software") AND (learning OR recall) Limiters - Publication Type: All Journals, All Books, Dissertation Abstract, Electronic Collection; Methodology: Systematic Review, QUANTITATIVE STUDY	169
Communication and Mass Media Complete	(powerpoint OR ″presentation software") AND (learning OR recall) Limiters - Document Type: Abstract, Article, Book Chapter, Conference Paper, Proceeding	50
Web of Science	(TS = ((powerpoint OR ″presentation software") AND ("learning outcomes*" OR ″instructional effectiveness" OR recall))) AND DOCUMENT TYPES: (Article OR Abstract of Published Item OR Book OR Book Chapter OR Data Paper OR Meeting Abstract OR Proceedings Paper) Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan = All years	55

Note. The initial search yielded 562 unfiltered search results, but after 76 duplicates were removed our total initial search yielded 486 unfiltered search results. Of the 486 studies that were identified as possible candidates, only 48 studies met the inclusion criteria; eight studies were unpublished.

3.2. Inclusion criteria

To be included in this meta-analysis, studies had to meet three inclusion criteria. First, studies had to contain a quantitative measurement of PowerPoint instruction as the independent variable (e.g., students' self-reports of the frequency in which PowerPoint is used in the classroom) or manipulate teaching demonstrations of the same material with or without PowerPoint. Second, studies had to contain a quantitative measurement of students' cognitive learning as the dependent variable, such as students' quiz or test scores, or students' self-reported learning, grade point averages, or course grades (that is, a measure of either perceived or observed cognitive learning). Third, studies must have reported enough statistical information to convert to an effect size, such as sample size, *p*-value, correlation, means and standard deviations, and/or effect sizes. Of the 486 studies that were identified as possible candidates, only 48 studies met these three inclusion criteria. And of the 48 studies included in this meta-analysis, eight were unpublished.

3.3. Variables coded and moderators

The codebook for this meta-analysis included descriptors and possible moderators to code for within each study. First, each article was coded based on the author and the year the manuscript was published or completed. Second, studies were coded for two sample characteristics, such as the sample type and subject matter in which the manipulation took place. To create a possible moderator for sample type, each article was coded for either a primary student sample (e.g., K-12; coded as 0) or a college student sample (e.g., undergraduate and graduate education; coded as 1). The subject matter was also dichotomously coded for either the science (e.g., physics, chemistry, mathematics, etc., coded as 0) or art/humanity (e.g., english, business, psychology, etc., coded as 1) disciplines. The final two codes related to the study manipulation and the measurement of cognitive learning. If studies used an experimental method they were coded as 0, whereas studies using a survey method were coded as 1. Regarding the measurement of cognitive learning, studies were coded for using either objective assessments (e.g., tests, quizzes, grades, etc., coded as 0) or subjective assessments (e.g., student self-reports; coded as 1) of students' cognitive learning.

3.4. Effect-size calculations

Using Comprehensive Meta-Analysis 2.0 (Borenstein, Hedges, Higgins, & Rothstein, 2006), a random effects meta-analysis was conducted to convert the data from each study into the metric of *Hedges' g*. *Hedges' g* is a standardized mean difference effect size statistic that is used to index how much one group (i.e., the experimental group) differs from another group (i.e., control group; Borenstein et al., 2009). Additionally, Borenstein et al. (2009) suggested that *Hedges' g* is preferred to Cohen's d when sample size is small, which several studies included in this meta-analysis contained samples smaller than 30 in both the experimental and control groups (e.g., Carrell & Menzel, 2001; Jalali & Talebi, 2014). Further as Cooper (2010) suggested, we chose this (comparison) metric because most of the empirical data included in this meta-analysis provided comparisons between a mean for the experimental group (i.e., instruction with PowerPoint) and a mean for the control group (i.e., instruction without PowerPoint) on students' cognitive learning. To test heterogeneity among the effect sizes, the Q statistic (which tests the null hypothesis that each study shares a common effect size), T^2 (which is the between-studies variance), and I^2 (which is the ratio of true heterogeneity to total observed variation) were calculated (Borenstein et al., 2009). The aforementioned variables in the codebook were dichotomously coded to allow for subgroup analyses to explain the potential heterogeneity in effect sizes.

4. Results

4.1. Publication bias

Borenstein et al. (2009) indicated that meta-analyses may reveal a publication bias since studies with significant findings tend to be published more often than studies with nonsignificant findings. To investigate the possibility of a publication bias, Egger's regression intercept was calculated. Results of Egger's regression intercept for cognitive learning was not significant (-0.965, 95% CI [-3.413, 1.484], $t = 0.793$, $df = 46$, $p = .432$), which suggests there was no asymmetry of the funnel plot, providing no evidence for publication bias (Egger, Smith, Schneider, & Minder, 1997).

4.2. Overall effect for cognitive learning

Studies included in this meta-analysis varied in methodology (e.g., setting, amount of exposure, information taught, etc.), which would suggest that the true effect size varies as well. For this reason, we conducted a random effects meta-analysis to answer the first research question. The 48 studies combined for an average *Hedges' g* of 0.067, with a 95% confidence interval ranging from -0.103 to 0.236 ($p = .440$). Converted to a correlation metric, the average r was 0.033 with a 95% confidence interval ranging from -0.055 to 0.121 ($p = .461$). These results revealed that on average, compared to traditional instruction, adding PowerPoint to supplement teaching had no effect on cognitive learning (see Fig. 1 for a forest plot detailing the effects and summary effect).

4.3. Moderators

The Q statistic revealed heterogeneity among the studies included in this meta-analysis ($Q = 545.684$, $df = 47$, $p < .001$, $I^2 = 91.387$), which suggests that the variation among the estimate of true effects ($T^2 = 0.311$) and the distribution of the effect sizes around the summary effect size ($T = 0.558$) are due to other factors beyond sampling error. Thus, to answer the second research question, we conducted four subgroup analyses to offer possible explanations for the heterogeneity (Borenstein & Higgins, 2013). For each subgroup analysis, we calculated a mixed effect model (Gurevitch & Hedges, 1999) and consulted the $Q_{Between}$ statistic and its respective p-value. Only one moderator emerged as a possible explanation of the heterogeneity: sample type. Results revealed that there was a significant difference ($Q_{Between} = 8.575$, $p = .003$) between K-12 students ($k = 3$, $g = 1.079$, $p = .002$) and college students ($k = 45$, $g = 0.006$, $p = .942$); suggesting that compared to traditional instruction, PowerPoint increased K-12 students' cognitive learning only (only in 3 studies however). We also found no significant differences between studies that (a) were conducted with students from different subject matters ($Q_{Between} = 2.544$, $p = .111$), (b) for studies that experimentally manipulated PowerPoint versus studies that captured the use of PowerPoint with self-reports ($Q_{Between} = 1.206$, $p = .272$), or (c) for studies that measured students' cognitive learning through objective versus subjective methods ($Q_{Between} = 0.124$, $p = .724$). Individual effect sizes and moderators for each study are displayed in Table 2.

5. Discussion

The purpose of this meta-analysis was to clarify the inconsistent research on the relationship between instructors' use of PowerPoint and students' cognitive learning. Results of the random effects meta-analysis revealed a nonsignificant (*Hedges' g* = .067, $p = .440$) average difference between PowerPoint and traditional instruction on students' cognitive learning. The examination of four moderators revealed that the heterogeneity of the effect sizes may only be due to the different types of samples used (i.e., K-12 versus undergraduate), however this finding must be tempered with an imbalanced comparative subgroups analysis. If on average, PowerPoint has no effect on student learning, then these findings might suggest that future research shift from focusing on a strict comparison of instruction with or without PowerPoint, to focusing more on how instructors are using PowerPoint to influence students' learning. That is, researchers should devote efforts to investigating when and how to use PowerPoint, not if they should use PowerPoint, in order to offer instructors specific evidence about how to integrate it into teaching and/or avoid its pitfalls that might detract from learning.

5.1. PowerPoint has no effect on cognitive learning

Although Shapiro et al. (2006) revealed a small positive relationship between PowerPoint instruction and students' learning, our updated meta-analysis revealed that when lecture material remained the same, but was presented either through traditional methods or by PowerPoint, students' cognitive learning was unaffected. Previous research has found that students believe PowerPoint benefits their learning, and classes that use PowerPoint create more interesting and enjoyable learning environments (Apperson et al., 2006; Hill et al., 2012). However, this student perception does not align with objective summative assessments of performance-based learning. Though researchers have found that students like PowerPoint and prefer this method of instruction, when it comes to actual learning, these preferences may not matter. From a cognitive theory of multimedia learning perspective (CTML; Mayer, 2001), this finding is somewhat surprising, because the combination of verbal and visual instruction should contribute to more meaningful learning experiences (Mayer & Moreno, 2003). For example, instructors who combine verbal lectures with PowerPoint can use the slides to indicate to students how to interpret important information (i.e., signaling effect). However, according to CTML, PowerPoint instruction may also prompt the introduction of extraneous material (i.e., coherence effect) or cause the instructors to narrate the text

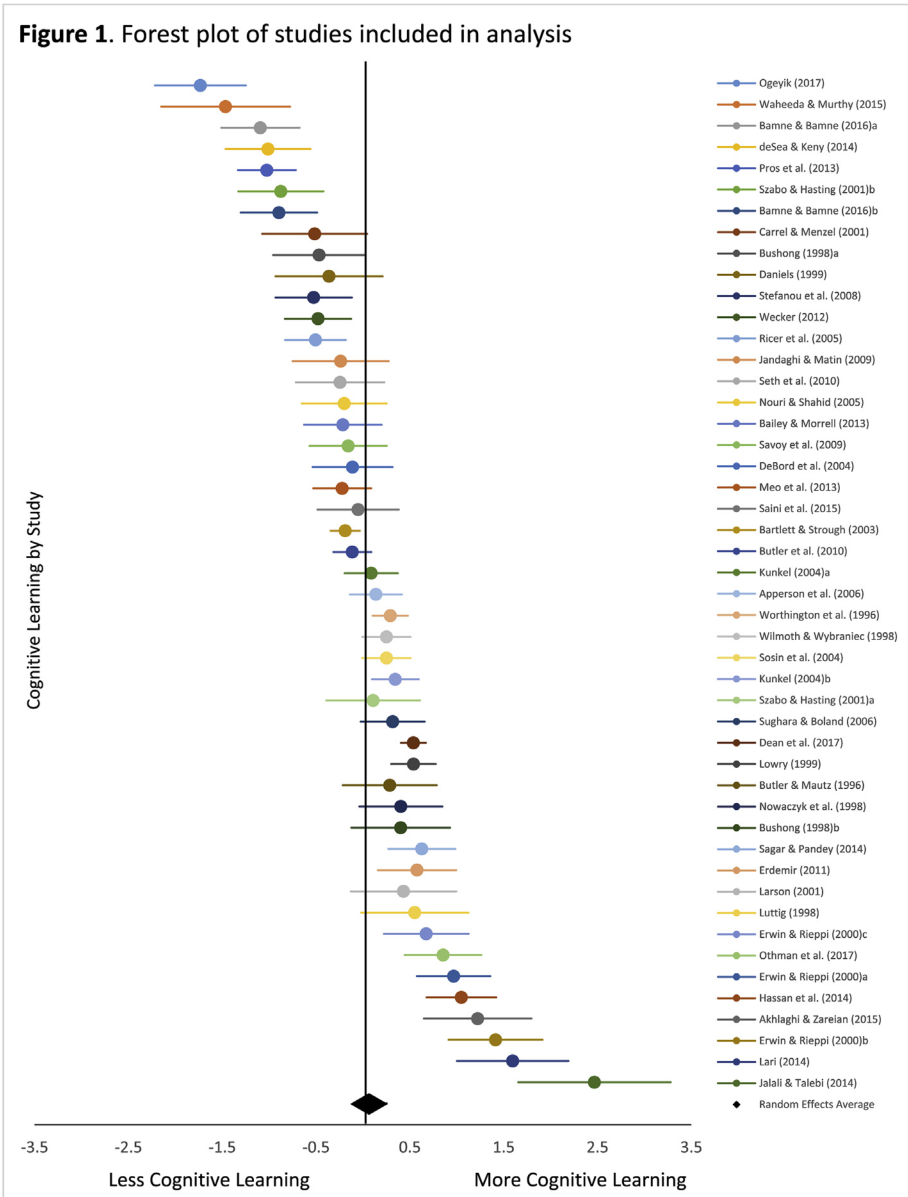

Fig. 1. Forest plot of studies included in analysis in the metric of *Hedges' g*.

on the PowerPoint slides verbatim (i.e., redundancy effect), which can overload students' cognitive processing (Mayer & Moreno, 2003). In this regard, the zero-summary effect from this meta-analysis may not be surprising because many studies did not explicitly state how PowerPoint was being used in the classroom. Thus, in line with CTML, some PowerPoint studies might have overloaded students' working memories whereas others did not, depending on how PowerPoint was specifically implemented in experiments. As Levasseur and Sawyer (2006) put it, “pedagogical theory can be used to construct a strong argument in support of PowerPoint in the classroom, such a theory can also be used to construct a compelling case for keeping this medium out of the classroom” (p. 105).

Notably, though this meta-analysis did not reveal a positive effect for integrating PowerPoint, a negative effect did not emerge either. That is, implementing PowerPoint into instruction does not necessarily mean instructors will hinder their students' learning. However, our meta-analysis suggests that replicating traditional instruction with the sole addition of PowerPoint may not be a worthwhile task for instructors trying to improve their students' learning. That being said, PowerPoint aided instruction does lead to beneficial classroom outcomes, such as increased affect (Ledbetter & Finn, 2018), motivation (Szabo & Hastings, 2000), and interest (Hill et al., 2012). The aforementioned research does demonstrate that even though students' actual learning may not improve as a result of PowerPoint, this method of instruction still offers affective and motivational benefits for students' learning experiences (Levasseur & Sawyer, 2006).

Table 2
Meta-analysis for cognitive learning.

Study	95% CI				Moderators				
	g	LL	UL	*z*	*r*-w	st	pm	cl	sm
Akhlaghi and Zareian (2015)	1.223	.649	1.797	.586	1.88	0	0	0	1
Apperson et al. (2006)	.138	−.139	.416	.069	2.25	1	0	1	1
Bailey and Morrell (2013)	−.214	−.628	.200	−.108	2.10	1	0	0	0
Bamne and Bamne (2016)a	−1.093	−1.510	−.675	−.526	2.09	1	0	0	0
Bamne and Bamne (2016)b	−.895	−1.303	−.487	−.437	2.11	1	0	0	0
Bartlett and Strough (2003)	−.189	−.346	−.032	−.094	2.35	1	0	0	1
*Bushong (1998)a	−.467	−.958	.024	−.234	2.00	1	0	0	1
*Bushong (1998)b	.403	−.124	.929	.203	1.95	1	0	0	1
Butler and Mautz (1996)	.286	−.216	.788	.144	1.98	1	0	0	1
Butler et al. (2010)	−.113	−.316	.091	−.056	2.32	1	0	0	0
*Carrell and Menzel (2001)	−.514	−1.075	.046	−.258	1.90	1	0	1	1
*Daniels (1999)	−.361	−.933	.211	−.182	1.88	1	0	0	1
Dean et al. (2016)	.538	.405	.671	.266	2.36	1	1	1	1
DeBord, Arguete, and Muhlig (2004)	−.111	−.537	.316	−.056	2.08	1	0	0	1
deSa and Keny (2014)	−1.012	−1.465	−.559	−.491	2.05	1	0	0	0
Erdemir (2011)	.577	.159	.995	.287	2.09	1	0	0	0
Erwin and Rieppi (1999)	.967	.575	1.358	.426	2.13	1	0	0	1
Erwin and Rieppi (1999)	1.414	.912	1.915	.664	1.98	1	0	0	1
Erwin and Rieppi (1999)	.675	.224	1.126	.308	2.05	1	0	0	1
Hassan et al. (2014)	1.049	.678	1.421	.504	2.15	1	0	0	0
Jalali and Talebi (2014)	2.468	1.655	3.281	1.053	1.54	1	0	0	1
Jandaghi and Matin (2009)	−.237	−.749	.274	−.118	1.97	1	0	0	1
Kunkel (2004)a	.088	−.196	.372	.042	2.25	1	0	0	0
Kunkel (2004)b	.345	.096	.595	.158	2.28	1	0	0	1
Lari (2014)	1.596	1.001	2.191	.740	1.85	0	0	0	1
*Larson (2001)	.433	−.130	.996	.218	1.90	0	0	0	1
Lowry (1999)	.539	.300	.777	.267	2.29	1	0	0	0
*Luttig (1998)	.552	−.020	1.125	.277	1.88	1	0	0	0
Meo et al. (2013)	−.221	−.530	.089	−.111	2.22	1	0	0	0
Nouri and Shahid (2005)	−.199	−.652	.253	−.101	2.05	1	0	0	1
*Nowaczyk et al. (1998)	.404	−.039	.848	.203	2.06	1	1	1	1
Ogeyik (2017)	−1.733	−2.217	−1.248	−.789	2.01	1	0	0	1
Othman et al. (2017)	.854	.445	1.263	.418	2.11	1	0	0	0
Pros et al. (2013)	−1.024	−1.333	−.715	−.494	2.22	1	0	0	1
Ricer et al. (2005)	−.506	−.830	−.183	−.252	2.21	1	0	0	0
Sagar and Pandey (2014)	.628	.270	.986	.311	2.17	1	0	0	1
Saini et al. (2015)	−.051	−.485	.383	−.026	2.07	1	0	0	0
Savoy et al. (2009)	−.157	−.570	.255	−.079	2.10	1	0	0	0
Seth et al. (2010)	−.243	−.715	.228	−.123	2.02	1	0	0	0
Sosin et al. (2004)	.251	−.007	.508	.125	2.27	1	0	0	1
Stefanou et al. (2008)	−.525	−.933	−.117	−.262	2.11	1	0	0	1
Sugahara and Boland (2006)	.317	−.025	.658	.159	2.19	1	1	0	1
*Szabo and Hastings (2000)	.109	−.390	.609	.055	1.98	1	0	0	1
*Szabo and Hastings (2000)	−.875	−1.329	−.420	−.428	2.05	1	0	0	0
Waheeda and Murthy (2015)	−1.464	−2.150	−.777	−.690	1.72	1	0	0	1
Wecker (2012)	−.478	−.832	−.125	−.228	2.17	1	0	0	1
Wilmoth and Wybraniec (1998)	.251	−.007	.508	.125	2.27	1	0	0	1
Worthington, Welsh, Archer, Mindes, and Forsyth (1996)	.292	.103	.480	.145	2.33	1	0	0	1
Random Effects Average	.067	−.103	.236	.772					

Note. *r*-w = relative weight. For moderators: st = sample type (0 = K-12, 1 = college students), pm = PowerPoint method (0 = experimental manipulation of PowerPoint, 1 = survey measurement of PowerPoint use), cl = cognitive learning measurement (0 = objective, 1 = subjective), sm = subject matter (0 = sciences, 1 = arts/humanities). *indicates the studies that were also included in the Shapiro et al. (2006) meta-analysis.

5.2. Moderators

Coding for moderators in this meta-analysis revealed several methodological similarities among studies. Specifically, a majority of studies were experimental ($k = 45$), conducted among college students ($k = 45$), in the art/humanity fields ($k = 31$), that relied on objective measures of cognitive learning ($k = 44$). Unfortunately, results demonstrated that only the type of sample emerged as a significant moderator. Specifically, the results revealed that among the K-12 studies ($k = 3$), students' learning significantly increased due to PowerPoint instruction. Unexpectedly, the measurement of students' cognitive learning did not emerge as a significant moderator, even though previous research has found that students significantly self-report more learning compared to performance-based measures such as tests (see Levasseur & Sawyer, 2006). However, we caution the interpretation of these results due to the small number of studies (i.e., $k < 5$) that were included in both subgroup comparisons. Surprisingly, the subject matter in which the studies were conducted did not emerge as a significant moderator. The Shapiro et al. (2006) meta-analysis revealed that scientific subject matters were better suited for PowerPoint instruction, however, this was not the case in the current meta-analysis.

5.3. Reframing the question

The results of this meta-analysis suggest that the technology of PowerPoint does not directly influence students' learning. Rather, future research should reframe empirical investigations to focus on *how* instructors are using PowerPoint in the classroom to determine the pedagogical conditions under which PowerPoint is effective. That is, PowerPoint provides a tool for instructors and future research should focus on how instructors are using this tool to provide fruitful insights for educators. Indeed, several studies have tackled this area of research. For example, Hallett and Faria (2006) examined student learning as a result of PowerPoint instruction with only bullet points or PowerPoint instruction with audio, video, text, animation, graphics, and/or special effects, revealing that students learned more with all of these advanced features integrated into the PowerPoint presentation. Other scholars have attempted to parse out specific changes in PowerPoint in relation to learning. For instance, Johnson and Christensen (2011) compared PowerPoint which relied solely on bullet point text and PowerPoint which was image-based but included minimal text, and found no significant differences in students' learning; however, students perceived the image-based PowerPoint to be more satisfying. Regarding bullet points, Schnettler (2006) suggested that researchers should also consider different presentation styles. He argued that speakers and PowerPoint slides are intertwined, specifically, speakers can translate bullet points for the audience and guide their attention. However, Wecker (2012) would caution researchers to consider students' attention allocation, because dysfunctional allocation can inhibit students' retention. In other words, Wecker (2012) found that when students held PowerPoint slides in high regard the important information from the speaker was not retained.

Specifically studying images, Tangen et al. (2011) examined the differences in students' learning and interest when provided PowerPoint presentations that were image congruent (i.e., images on slides supported key concepts), image incongruent (i.e., images on slides did not support the key concepts), or text-based (i.e., bullet points summarizing narration). They found that the two image-based PowerPoints were rated as more interesting by students; however, the image congruent slides and text-based slides were both beneficial for students' learning. Likewise, Bartsch and Cobern (2003 study 2) also found that compared to PowerPoint instruction with relevant images, PowerPoint instruction with irrelevant images detracted from students' performance on recall and recognition tasks, and students were less satisfied with this instruction. In regard to animation, Miller and James (2011) examined PowerPoint with or without animation that progressively presented text, revealed parts of a figure, or demonstrated motion within an astronomical image. Students reported that the animated PowerPoints were more effective, but their first exam scores did not increase. However, Miller and James (2011) concluded that animation may be more effective on students' long-term memory, because students' second and third exam scores later in the semester had significantly improved (revealing support for the animated PowerPoint).

After conducting a meta-analysis on the impact of animations versus statics graphics on students' learning, Berney and Betrancourt (2016) concluded that animations enhanced students' learning more than static graphics. More specifically, when the animations were paired with narration, did not include accompanying text, and students did not control the pacing, student learning improved. Taken together, this initial research suggests that instructors trying to create effective PowerPoints may want to include both images and small amounts of text, but the images should be relevant and support the text-based information or the information that the instructor is narrating for students. Additionally, this research demonstrated that students prefer image-based PowerPoint instruction and that progressively displaying figures or images (i.e., animations) may facilitate more retention. Notably, this body of research also indicates that instructors should be meticulous in choosing the images and animations in their figures to avoid overloading students' cognitive load and detracting from their learning opportunities. Further, Hallewell and Lackovic (2017) suggested that instructors should not only choose their graphics meticulously, but also consider how they are making use of these graphics in meaningful ways during instruction (i.e., representing conceptual information, guiding students' attention, and/or inviting students to think about the meaning of the graphics).

In addition to images and animations, researchers have also examined the strategies of embedding questions or providing students with notes/handouts that align with the PowerPoint. In an attempt to make PowerPoint presentations more interactive, Gier and Kreiner (2009) and Valdez (2013) compared PowerPoint presentations with no questions with PowerPoint presentations that contained several questions for students to answer during instruction. They found that embedding several questions during a PowerPoint presentation enhanced students' learning. Additionally, several studies (e.g., Marsh & Sink, 2010; Nelson-Wong, Eigsti, Hammerich, & Ellison, 2013; Raver & Maydosz, 2010; Wilmoth & Wybraniec, 1998) have examined the influence of providing students with notes/handouts during PowerPoint instruction. This research demonstrates that providing these materials to students significantly enhances their learning. Further, researchers may also want to focus on how students are taught to respond to PowerPoint, specifically, examining the kind of notes that are conducive to students' learning. As mentioned, Stefanou et al. (2008) found that students who directly copy the PowerPoint slides perform worse on a quiz, which may detract from their ability to pay attention to the instructor lecturing. Indeed, Wecker (2012) found that students' learning suffered when they allocated their attention to the PowerPoint slides over the instructor. Thus, identifying how the features and capabilities of PowerPoint can be manipulated to increase learning and to teach students how to respond to PowerPoint may be a more fruitful line of scholarship to pursue.

5.4. Practical implications

This meta-analysis suggests that PowerPoint (alone) does not enhance nor diminish students' learning. Our results suggest that taking traditional instruction, and only adding PowerPoint as a method of a delivery, may not be worthwhile for instructors. Rather, an instructor's time is better spent meticulously creating PowerPoint aided lessons that align with the empirical findings mentioned above, adhering to the principles of CTML (see Mayer, 2001; Mayer & Moreno, 2002, 2003). For example, Garner and Alley (2013) designed PowerPoint instruction that either aligned or violated six multimedia learning principles (i.e., multiple representation principle, contiguity principle, redundancy effect, modality principle, coherence effect, and signaling) and assessed students' learning and reactions to these two presentational methods. They found that PowerPoint instruction in violation of these six principles caused more cognitive overload and hindered students' recall and test scores. Thus, when implementing PowerPoint into instruction, instructors should consult the principles of multimedia learning (see Table 3 Mayer & Moreno, 2003) to avoid overloading students' cognitive processing. Additionally, researchers seem to agree that if instructors are going to implement PowerPoint in the classroom, students will learn more if they are provided notes/handouts that follow along with the PowerPoint. Some instructors might hesitate providing notes to students before class, because this may decrease attendance, however, students have reported no change in motivation to attend class (James, Burke, & Hutchins, 2006) and attendance has not been affected (Worthington & Levasseur, 2015) when students are given access to the notes. That being said, Raver and Maydosz (2010) found that providing notes before lecture or immediately following a lecture did not impact students' learning differently, thus, instructors worried about attendance may consider distributing the notes following instruction.

5.5. Limitations and future research

Although we took efforts to cast a wide net to include studies (especially unpublished studies) that compared the same instruction either presented in a traditional format or PowerPoint format, we recognize that authors with unpublished manuscripts likely missed our call. A second limitation of this meta-analysis is that our moderators were unable explain the heterogeneity among effect sizes, which may be due to the fact that three subgroups analyses were based on one group containing less than five studies (i.e., $k < 5$). Third, this meta-analysis included studies that taught the same material using PowerPoint or traditional methods, however, traditional methods of teachings varied within studies. In other words, some studies compared the same instruction using PowerPoint versus using whiteboards (e.g., Ogeyik, 2017), chalkboards (e.g., Pros et al., 2013), overhead transparencies (e.g., Szabo & Hastings, 2000), or traditional methods that were not specified (e.g., Akhlaghi & Zareian, 2015).

Nonetheless, this meta-analysis offers a few interesting suggestions for future research. As mentioned above, some researchers have already attempted to examine how instructors are using PowerPoint (e.g., images versus text, static images versus animations, embedded questions, and narration). In addition to further investigating how instructors are using PowerPoint, researchers should consider how specific changes with PowerPoint influence different types of students. That is, future research would benefit from including student characteristics in the investigation of the effectiveness of PowerPoint. For example, in line with CTML, the aforementioned research suggests that instructors should avoid implementing features of PowerPoint that overload students' cognitive load, but this cognitive load may depend on the students' level expertise. Specifically, Kalyuga, Chandler, and Sweller (1998) found that inexperienced students needed both a diagram and additional explanatory text, but experts processed the diagram-only material better. Further, Kalyuga et al. (2003) argued that normal instructional techniques that are effective for novices may be ineffective or detrimental for experts, known as the expertise reversal effect. Additionally, research may want to consider how and where students are allocating their attention during instruction with PowerPoint. Wecker (2012) revealed that students' retention suffered from traditional PowerPoint when students believed PowerPoint slides were important for their learning. Wecker (2012) argued that students' directed their attention accordingly, which led to dysfunctional attention allocation (i.e., toward the written slides and not the information from the speaker) and subsequently diminished retention. Relatedly, our meta-analysis revealed that college students were the predominant sample under investigation, which limits the claims that be drawn from this research. Future research should consider how instructors are using PowerPoint within a younger student population and students outside of the university setting. Additionally, research has found that the degree of novelty that students attach to PowerPoint may account for their perceptions of its effectiveness (e.g., Burke & James, 2008). However, little is known about the specific features of PowerPoint instruction that students find novel and what instructors can do to keep the novelty of their presentation from diminishing.

6. Conclusion

This meta-analysis was conducted to summarize the effectiveness of PowerPoint versus traditional instruction on students' cognitive learning. Our results revealed that PowerPoint had no effect on learning. Thus, instructors who wonder if they should incorporate PowerPoint into their teaching are contemplating a pedagogical decision that may have little value for students. Instead, of asking "should I use PowerPoint?", instructors should consider how they are using PowerPoint (e.g., to show animated pictures that might catch and hold students' interest?), when (e.g., during a review session before a midterm to highlight key points to study?), and why (e.g., to play a learning-based game in class that students will find entertaining?). Additionally, instructors and researchers should consider how students are being taught to respond to PowerPoint instruction (i.e., the type of note taking that results from this style of teaching). Researchers should investigate these more complex questions and test PowerPoint design decisions that are theoretically grounded to offer educators more tangible and useful suggestions for how to effectively integrate PowerPoint into their instruction. For now, if the binary instructional debate continues to be "should instructors use PowerPoint to teach?," then the empirical evidence suggests "it does not matter, so teach how you prefer."

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