Title
The Decorated Learning Environment: Simply Noise or an Opportunity for Incidental Learning?

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 43(43)

ISSN
1069-7977

Authors
Godwin, Karrie E.
Kaur, Freya

Publication Date
2021

Peer reviewed

The Decorated Learning Environment: Simply Noise or an Opportunity for Incidental Learning?

Karrie E. Godwin (kgodwin@umbc.edu)
University Of Maryland Baltimore County, Department of Psychology, 1000 Hilltop Circle
Baltimore, MD 21250 USA

Freya Kaur (fkaur1@umbc.edu)
University Of Maryland Baltimore County, Department of Psychology, 1000 Hilltop Circle
Baltimore, MD 21250 USA

Abstract

Maintaining attention during instruction is challenging as children face various sources of distraction (peers, announcements, noise) as well as competition from the visual environment itself. Prior studies found decorated environments promote off-task behavior and reduce learning. Additionally, many classroom displays are not relevant to ongoing instruction. This raises the possibility that increasing alignment between displays and instructional content may afford opportunities for incidental learning, reducing the detrimental effects of environmental off-task behavior. To investigate this possibility, participants completed a lesson in which alignment between the lesson content and displays was manipulated (relevant, educational but irrelevant, or no displays). Attention to the lesson and learning gains for content presented in the lesson and/or displays were measured. Results suggest younger children's learning can benefit from displays that reinforce the lesson content. However, there was no evidence of incidental learning from displays without additional lesson support. Implications for classroom design are discussed.

Keywords: attention; classroom environment; learning; incidental learning; off-task behavior; on-task behavior

Introduction

If you walk into a typical elementary school classroom in the United States, one might see a room transformed with bright primary colors, festive bulletin boards, charts, posters, number lines, even perhaps the children's own art work hanging from the ceiling (for discussion see Bullard, 2010; Tarr, 2004). The rationale for creating decorated learning environments may be based in part on teachers' intuition that this type of visual environment can stimulate children, getting them excited to learn. Despite the appeal of this belief, recent research indicates that such highly decorated visual environments may not be optimal for learning as they can increase attentional competition resulting in increased off-task behavior and decreased learning (e.g., Fisher, Godwin, & Seltman, 2014; Hanley, Khairat, Taylor, Wilson, Cole-Fletcher, & Riby, 2017).

For example Fisher, Godwin, and Seltman (2014) presented kindergarten children with 6 science lessons. Half of the lessons were presented in the decorated condition and half in the streamlined condition. After the lesson, a short assessment was administered to measure learning. The authors found that the decorated learning environment promoted more off-task behavior and children obtained lower learning outcomes compared to a learning environment that was visually streamlined (i.e., posters and charts were removed). The authors found that children's patterns of attention allocation varied as a function of the manipulation to the visual environment such that children spent more time engaged in off-task behavior directed toward the environment in the decorated condition compared to the streamlined condition. Additionally, susceptibility to distraction from the visual environment may be heightened in special populations - for example, children with Autism (Hanley, Khairat, Taylor, Wilson, Cole-Fletcher, & Riby, 2017).

The role of the visual learning environment may be particularly influential for younger children in light of the prolonged development of attention and in turn children's propensity to distraction. There has been considerable work examining the development of attention (e.g., Bartgis, Thomas, Lefler, & Hartung, 2008; Higgins & Turnure, 1984; Miller & Weiss, 1981; Oakes, Kannass, & Shaddy, 2002; Tabibi, & Pfeffer, 2007; Trick & Enns 1998; Welsh, Pennington, & Groisser, 1991). Attention has been shown to follow a protracted developmental trajectory. With age, distractibility gradually decreases and the ability to selectively attend to a particular task continues to improve throughout middle childhood (e.g., Ruff & Capozzoli, 2003; Ruff & Rothbart, 1996).

Yet, when we look at the typical classroom visual environment, it is not clear that the developmental constraints of children's attentional system are reflected in contemporary classroom design practices. Observational studies of elementary school classrooms have found that on average classrooms covered nearly a quarter of their walls with displays (Godwin, Seltman, Scupelli, & Fisher, 2020). Other studies have estimated that only approximately half of the visual displays present in a classroom are academic in nature (Almeda, Scupelli, Baker, Weber, & Fisher, 2014). These design choices may be problematic as they may increase attentional competition as well as extraneous cognitive load.

According to the Cognitive Load Theory, extraneous load (i.e., load that is unnecessary or irrelevant to the instructional task) may reduce available cognitive resources that could otherwise be dedicated to processing information relevant to the given task (e.g., Chandler & Sweller, 1991; Sweller, Ayres, & Kalyuga, 2011). The inclusion of "seductive details" (i.e., irrelevant elements often intended to foster interest or motivation; Mayer, 2018) have generally been found to disrupt performance and learning (e.g., Eng et al., 2020; Harp & Mayer, 1997; Harp & Maslich, 2005; for review see Sundararajan & Adesope, 2020). Removing irrelevant material or information (in line with the Coherence principle) may help reduce extraneous load and improve learning (Mayer, 2008).

However, prior research has found that children incidentally encode their visual environment (Godwin, 2016). Indeed, children encode aspects of their visual learning environment in sufficient detail that they are able to recognize elements of the visual environment from a close lure even after a delay (e.g., in a forced choice task children can accurately identify educational displays that were present in the learning environment on a delayed post-test; Godwin, 2016). This finding raises the possibility that the classroom visual environment could be utilized to *bolster* student learning, ***if*** there is greater alignment between the visual displays and the learning task.

The present study begins to address this question by providing a systematic experimental investigation to examine whether the detrimental effects of off-task behavior directed toward the environment can be attenuated, if the classroom visual environment is augmented such that the teacher and the environment are both reinforcing the *same* learning objective. However, even with greater alignment between the visual environment and the learning objectives, it is possible the visual environment may still overwhelm children's fragile attention system, dividing attention, increasing cognitive load, and hampering learning. The present study begins to disentangle these two possibilities. As noted previously, visual displays are a prevalent feature in many elementary school classrooms; furthermore, younger children are known to be particularly susceptible to distraction due to their still developing attention regulation system. Consequently, in the present study primary and upper elementary school children were recruited to assess whether younger children are more vulnerable to distraction from visual displays during a learning task and whether the potential benefit of display alignment varies across grade levels.

Method

Participants

The sample consisted of 85 elementary school children (*Mage* = 9.26 years, *SD* = 1.22 years, 38 females, 47 males) comprised of 41 primary grade students (grades 1 and 2) and 44 upper elementary students (grades 4 and 5). Parents/Guardians reported their children's race and ethnicity as follows: 12.9% African American, 1.2% Asian/Pacific Islander, 74.1% Caucasian, 1.2% Hispanic, 7.1% two or more races/ethnicities, 1.2% other, 2.4% did not report. Participants were recruited from in and around a city in the Midwest of the United States. All participants were tested individually by trained research assistants or the authors in a quiet space adjacent to their classroom or in a laboratory.

Design

In this study, the visual environment was manipulated using cardboard trifolds (36" x 48") that were used to present visual displays. There were three visual display conditions which were randomly assigned between participants: (1) General displays, (2) Relevant displays, and (3) Streamlined or no display condition. In the general display condition, academic posters, unrelated to the lesson topic, were displayed on a trifold. In the relevant display condition, posters with information reinforcing the lesson or related to the lesson topic were displayed. In the streamlined condition, a blank white trifold was used. Assessment questions probed participants' learning for content presented in the lesson, relevant posters, and content presented in both the lesson and relevant posters.

Procedure

The study consisted of three phases: a pre-test, science lesson, and post-test. The pre-test was presented on a laptop computer and consisted of 12 multiple-choice questions that were read aloud to participants. Then, participants completed the lesson in their assigned display conditions (i.e., General display, Relevant display, or Streamlined display). Participants listened to a short pre-recorded science lesson about the Earth's Surface that was presented on a laptop computer. A mobile eye-tracker was used to measure participants' attention to the lesson. After the lesson, a post-test was administered. The post-test was analogous to the pre-test. Note, that no posters were present during the pre-test or post-test. Immediately after the post-test, a smile scale was administered as a self-report measure of participants' enjoyment of the lesson and trifold displays.

Attention Measure

Attention to the lesson was indexed using a mobile eye tracker (Tobii X3-120). Areas of Interest (AOI's) were drawn around each lesson slide to measure the total proportion of time participants' were fixating on the lesson. Note that the attention data is forthcoming. Extraction and analysis of the eye-tracking data is underway.

Visual Displays

Alignment of the visual displays to the lesson was manipulated between-subjects using three cardboard trifolds.

The trifold for the general display condition consisted of 12 posters with information that was unrelated to the lesson (see Figure 1a). To increase ecological validity, content that was unrelated to the lesson, but academic in nature, was displayed on the general trifold. For example, the general trifold included posters relating to math, language arts, and geography.

The trifold for the relevant display condition consisted of 12 posters with information that reinforced the lesson content or that was directly related to the lesson topic, *Earth's Surface* (see Figure 1b). For example, posters with information reinforcing content presented in the lesson included posters about deltas, earthquakes, and canyons. While other posters were related to the lesson topic (e.g., floods, caves), but contained content that was not directly discussed in the lesson. Note, that the number of posters presented on the trifolds was equated across the general and relevant display conditions.

The trifold used for the streamlined condition was a white blank trifold. No images or information was presented on this trifold.

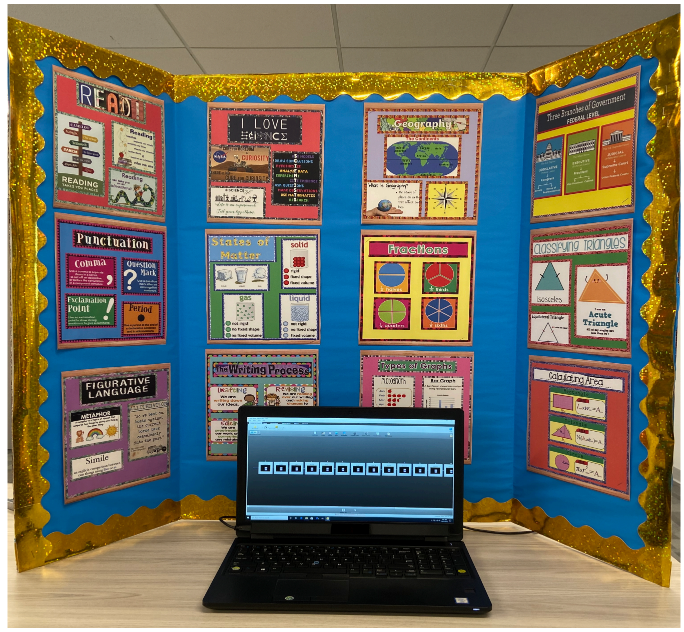
Lesson

Participants listened to a short science lesson. The science lesson consisted of a read-aloud that presented information (i.e., text and images) relating to the topic *Earth's Surface*. Read-alouds are a common instructional technique and a method that has been used successfully in the prior literature (e.g., Fisher et al., 2014; Hanley et al., 2017). The lesson was pre-recorded and presented on a laptop computer. The lesson was approximately 6.5 minutes. The lesson content was aligned to the Ohio State Education Science Standards. The lesson was designed as an independent learning activity, as such during the science lesson, the experimenter moved to the back of the room and was not in direct sight of the participant.

Learning Assessment

The pre- and post-test were administered to participants by trained research assistants and the authors of this paper. The learning assessments consisted of 12 multiple-choice questions that were presented on a laptop computer and read aloud by the experimenter. Participants selected their answer orally from four response options. Participants' responses were recorded by the experimenter. The pre-test and post-test included three question types that targeted information that was presented in the lesson (4 questions), information that was presented in the lesson and also reinforced in the relevant posters (4 questions), as well as topically related information that was presented only in the relevant posters (4 questions). The pre-test and post-test were identical; however, the presentation order of the test items was reversed for the post-test. Two presentation orders were created. For Order 1, the presentation order of questions was randomized and for Order 2, the presentation order utilized in Order 1 was reversed. The presentation order was counterbalanced across participants. Gain scores were calculated for the learning assessment (i.e., $Mean_{post\text{-}test} - Mean_{pre\text{-}test}$ = Total Gain Score) and for each question type (i.e., $Mean_{post\text{-}test} - Mean_{pre\text{-}test}$ for lesson questions, lesson and poster questions, and poster questions).

(A)



(B)

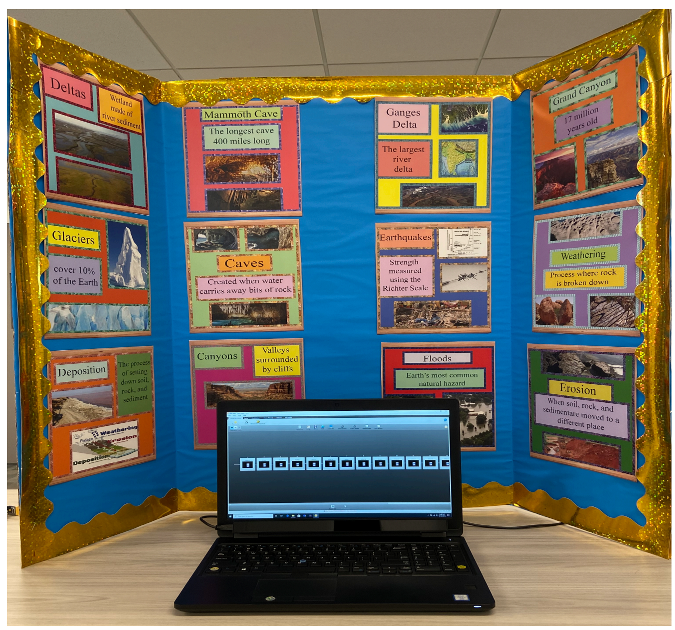


Figure 1: Cardboard trifolds were utilized to manipulate the alignment of the visual displays to the lesson. Panel A presents the General Display condition in which the posters were unrelated to the lesson. Panel B presents the Relevant Display condition in which the posters directly reinforced the lesson content or were topically related to the lesson content.

Smile Scale

The smile scale is a child friendly scale that was used to measure the extent to which participants' liked the lesson and the trifolds. The 5-point pictorial scale consists of 5 cartoon faces depicting different facial expressions (i.e., big frown, frown, neutral expression, smile, big smile). The faces were scored from 1 to 5 such that lower scores indicate greater dislike of the lesson/trifold. The experimenter explained the scale to the participants and worked through an example together. Participants were then asked to rate how much they liked the lesson, after which they were asked to rate how much they liked the trifold that was used during the lesson.

Results

Learning Outcomes

Pre-Test Scores Mean pre-test scores were relatively low for both primary students (*M* = .27, *SD* = .11) and upper elementary students (*M* = .37, *SD* = .15) suggesting that the lesson content was largely novel.

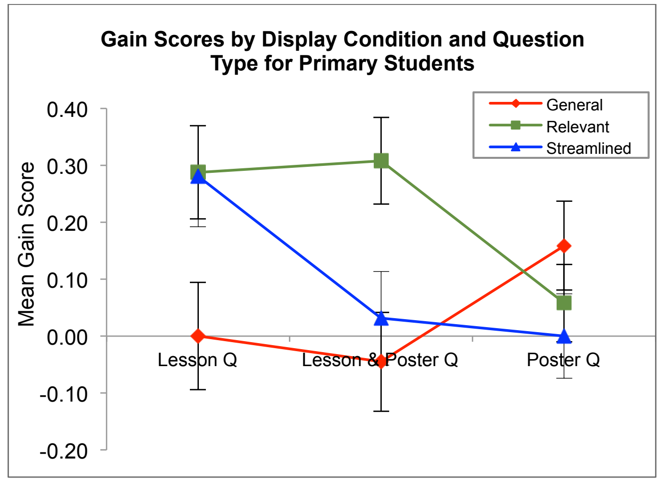
Post-Test Scores Evidence of learning was obtained for both grade levels. Total gain scores, pooled across question type and display conditions, ranged from 12% to 14% for primary and upper elementary students respectively. Additionally, for both grade levels post-test scores (*M* = .39, *SD* = .17; *M* = .50, *SD* = .20 for primary and upper elementary respectively) were significantly higher than their pre-test scores; both paired sample $ts \geq -4.72$, $ps \leq .0001$.

Effect of Display Alignment on Gain Scores

In order to examine the impact of the alignment of the visual environment on children's gain scores a 2 (grade level) x 3 (display condition) x 3 (question type) mixed ANOVA was conducted in which grade level (primary vs. upper elementary) and display condition (relevant, general, streamlined conditions) were between-subjects factors and question type (lesson, poster, or lesson and poster questions) was a within-subject factor.

The results of the mixed ANOVA revealed a main effect of question type ($F(2, 154) = 4.41$, $p = .014$, partial $\eta^2 = .054$). Pairwise comparisons found that participants exhibited larger gain scores for the lesson questions (*M* = .20, SE = .04) compared to the poster questions (*M* =.06, SE = .03; *p* = .004). No other comparisons were significant (both $ps \geq .12$). There was no significant main effect of grade level ($F(1,77) = .28$, $p = .60$) and no significant main effect of display condition ($F(2, 77) = 1.45$, $p = .24$). However, these main effects were qualified by a significant three way interaction between question type, display condition, and grade level ($F(4, 154) = 2.84$, $p = .03$, partial $\eta^2 = .07$) indicating that the interaction between display condition and question type differed across grade levels; see Figure 2 (Panels A & B). In order to more closely examine the three-way interaction, results from the pairwise comparisons are discussed below.

(A)



(B)

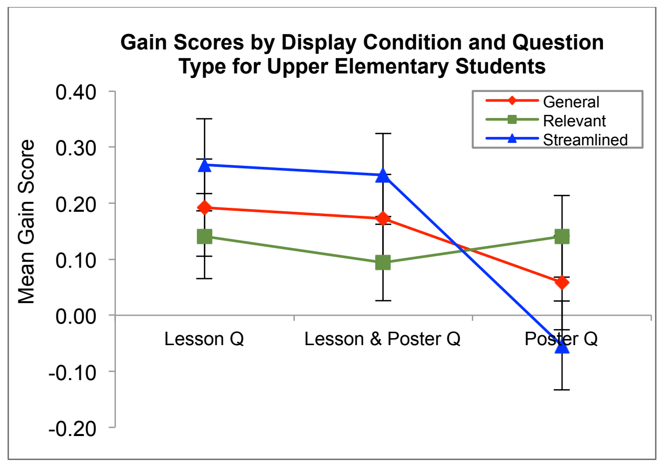


Figure 2: Displays gain scores by question type (questions probing content from the lesson, content presented in both the lesson and relevant posters, or content presented only in the relevant posters) as a function of display condition (General displays, Relevant displays, and Streamlined conditions) for primary students (Panel A) and upper elementary students (Panel B). Error bars represent the standard errors of the means.

Lesson Questions For questions probing content presented only in the lesson, primary students obtained significantly larger gain scores in both the streamlined (*M* = .28, SE = .078) and relevant (*M* = .29, SE = .09) display conditions compared to the general display condition (*M* = 1.388E-17, SE = .094); both $ps \leq .03$. Importantly, there was no significant difference in lesson gain scores between the streamlined and relevant display conditions (*p* = .95).

In contrast, upper elementary school students obtained numerically larger gain scores in the streamlined condition (*M* = .27, SE = .08) compared to both the relevant (*M* = .14, SE = .08) and general (*M* = .19, SE = .09) display conditions; however, these differences were not statistically significant (*ps* ≥ .27).

Lesson and Poster Questions Primary students benefited from displays that reinforced the lesson content. Mean gain scores for this question type were larger in the relevant display condition (*M* = .31, SE = .08) compared to both the general display condition (*M* = -.05, SE = .08) and the streamlined condition (*M* = .03, SE = .07; both *ps* ≤ .008) in which the posters were not aligned with the lesson or were absent. There was no significant difference between gain scores in the streamlined and general display conditions for lesson and poster questions (*p* = .48).

Akin to the results for lesson questions, upper elementary school students obtained numerically larger gain scores in the streamlined condition (*M* = .25, SE =.07) compared to both the relevant (*M* = .09, SE = .07) and general (*M* = .17, SE = .08) display conditions; however, these differences were not statistically significant (*ps* ≥ .12).

Poster Questions Interestingly, primary students did not exhibit robust incidental learning from information presented only through the visual displays. In the relevant display condition, for questions probing content presented in the relevant posters (and *not* in the lesson), participants obtained a mean gain score of .06 (SE = .08) and this did not differ significantly from gain scores in either the streamlined (*M* = -2.08E-17, SE = .07) or general display (*M* = .16, SE = .09) conditions (both *ps* ≥ .41) in which participants would not be expected to exhibit significant learning gains for this question type.

Upper elementary students had numerically larger gain scores in the relevant display condition (*M* = .14, *SE* = .07) compared to the streamlined (*M* = -.05, *SE* = .08) and general display (*M* = .06, *SE* = .08) conditions, but these differences were not statistically significant (both *ps* ≥ .08).

Smile Scale

Smile Scale Lesson Recall that smile scores could range from 1 to 5, with lower scores reflecting greater dislike for the lesson. Mean smile scale ratings for the lessons indicated that participants generally liked the lesson (*M* = 3.96, *SD* = .82). Note that due to time restrictions limiting how long participants could be absent from their classroom, 9 participants did not complete the smile scale lesson question and thus did not contribute data to these analyses. Results of a 2 (grade level) x 3 (display condition) ANOVA revealed no significant effect of grade level ($F(1, 70)$ =.54, p = .46), no significant effect of condition ($F(2,70)$ = .03, p = .98) and no significant interaction ($F(2, 70)$ = .98, p =.38). See Table 1 for mean smile scale ratings by grade and condition. Further, the extent to which participants reported liking the lesson was not significantly correlated with participants' total gain scores (*r* = -.02, *p* = .89).

Table 1: Mean (SD) smile scale ratings by grade level and display condition.

		General	Relevant	Streamlined
Primary	**Lesson**	3.80 (1.14)	3.77 (1.17)	4.07 (.88)
	Trifold	4.30 (.82)	4.23 (1.36)	2.93 (1.28)
Upper	**Lesson**	4.15 (.55)	4.08 (.49)	3.83 (.58)
Elem.	**Trifold**	4.69 (.75)	4.42 (.79)	3.83 (.83)

Trifold Mean smile scale ratings for the trifold were relatively high (*M* = 4.03, *SD* = 1.16) indicating that participants generally liked the trifold displays. Note, that 10 participants did not complete the smile scale trifold question and thus did not contribute data to these analyses. Results of a 2 (grade level) x 3 (display condition) ANOVA revealed a main effect of grade level ($F(1, 69)$ = 4.26, p = .04, partial η^2= .06). Pairwise comparisons found that upper elementary students (*M* = 4.31*, SE* =.17) rated the trifolds more favorably than primary students (*M* = 3.82*, SE* = .17; *p* =.04) – although it is important to note that mean smile scale ratings for both grade levels indicate they liked the trifolds. Additionally, there was a main effect of display condition ($F(2, 69)$ = 8.64, p < .0001, partial eta^2 = .20). Pairwise comparisons suggest that participants report liking both the relevant (*M* = 4.32, SE = .21) and general (*M* = 4.50, SE = .22) trifold displays more than the streamlined trifold (*M* = 3.38, SE = .20; both *ps* ≤ .002). Although participants mean smile scale ratings for the streamlined trifold were significantly lower than the other two display types, mean smile scale ratings indicate that participants did not *dislike* the streamlined trifold. There was no significant interaction between grade level and display condition ($F(2, 69)$ = .83, p = .44). See Table 1 for mean smile scale ratings by grade and condition. Smile scale ratings for the trifolds were not significantly correlated with participants' total gain scores (*r* = -.06, *p* = .59).

Discussion

Given the gradual maturation of attention regulation, it is perhaps not surprising that inattention, or off-task behavior, is common in elementary school classrooms (Godwin et al., 2016; Roberts, 2001). Prior laboratory work suggests that streamlining the visual environment is one way in which educators may be able to help reduce attentional competition, and improve learning outcomes (e.g., Fisher et al., 2014; Hanley et al., 2017). Observational research of elementary school classrooms suggests that classroom displays are often not academic in nature (Almeda et al., 2014) and thus not always tightly coupled to the ongoing instruction. Consequently, visual displays may increase attentional competition as well as extraneous cognitive load. The present study began to investigate whether (1) elementary school children could learn incidentally from the visual displays, (2) whether aligning the displays with the lesson content could help reinforce learning and thereby reduce the detrimental effects of off-task behavior directed toward the environment, and (3) whether these effects vary across grade levels.

The results from the present study point to several important findings. A significant interaction between display conditions (relevant, general, streamlined), question type (lesson questions, lesson and poster questions, poster questions) and grade level was found. The observed effects were driven largely by the primary grade students. For assessment questions derived exclusively from the lesson, primary students obtained larger gain scores in both the streamlined and relevant display conditions compared to the general display condition. These results partially support prior research (Fisher et al., 2014; Hanley et al., 2017), in that educational displays unrelated to the ongoing lesson (i.e., general displays) were found to be detrimental to learning. However, the present findings also suggest that primary students *can* benefit from the presence of relevant displays. Interestingly, the relevant displays appear to help reinforce the lesson content as reflected by students' larger gain scores compared to both the streamlined and general display conditions for questions tapping content that was delivered in both the lesson and relevant posters. However, we did not obtain evidence that children benefit purely incidentally from displays that portray related content if it is not also simultaneously reinforced by the lesson. These findings tentatively suggest the need to ensure greater alignment between visual displays and instruction for young children who still have immature attention regulation systems and thus can be drawn off-task by visual displays. Aligning the visual displays with the lesson content may reduce the observed negative effects of environmental off-task behavior on children's learning.

As noted previously, the observed effects were not consistent across grade levels. It is possible upper elementary students were better able to sustain their attention to the lesson and thus were less susceptible to the manipulation of the visual displays compared to the primary students. This hypothesis will be explored with the forthcoming eye tracking data.

This experimental study provides an initial systematic investigation of the impact of the alignment of the visual environment on children's learning. In the present study, we opted to utilize trifolds to tightly control the visual environment. This design choice provides an effective initial test of our research question as trifolds ensure stability in the visual environment across participants and testing sites. Additionally, trifolds facilitate the ease with which the alignment between the visual displays and the lesson content can be systematically manipulated. However, in future research it will be important to determine if these effects generalize to genuine classroom settings. Furthermore, in many elementary school classrooms teachers provide instruction on multiple subjects in a single classroom increasing the challenge of creating visual environments that are aligned with the ongoing instruction. This points to the need to have more adaptive classrooms so that displays can be dynamic. We are currently exploring these possibilities.

The present findings add to a growing body of literature indicating the importance of engaging in purposeful classroom design and suggests limiting the use of displays that are irrelevant to ongoing instruction. It is also important to keep in mind that optimizing classroom visual environments to support attention regulation and learning may have unintended consequences for children's affect or motivation. In the present study, results from the Smilescale provide preliminary evidence that children did not *dislike* the streamlined trifolds; although, they reported liking the relevant and general displays more. Future research will need to consider the affective role of the visual environment and investigate potential implications for student motivation.

In conclusion, streamlining the visual environment may help reduce unnecessary attentional competition and reduce cognitive load. Additionally, these results tentatively suggest decorated visual environments need not always be detrimental to learning. By aligning the visual displays to the ongoing instruction, educators may be able to reduce the detrimental effects of children's wandering attention and help bolster young children's learning.

Acknowledgments

We thank Aimee Wildrick for her help in designing the lesson and learning assessment. We thank Aimee Wildrick Megan Musso, Morgan Kish, and Kayla Whitlock, for their help collecting and entering data. We also thank the children, parents, and teachers who made this project possible.

References

Almeda, M. Scupelli, P., Baker, R.S., Weber, M., & Fisher, A. (2014). Clustering of design decisions in classroom visual displays. *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge (LAK). ACM, New York, NY, 44-48.* https://doi.org/10.1145/2567574.2567605

Bartgis, J. Thomas, D. G., Lefler, E. K., & Hartung, C. M. (2008). The development of attention and response inhibition in early childhood. *Infant and Child Development,* 17, 491-502. https://doi.org/10.1002/icd.563

Bullard, J. (2010). Creating environments for learning: Birth to age eight. Upper Saddle River, NJ: Prentice Hall.

Chandler, P. & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 8*(4), 293-332.

Eng, C. M., Godwin, K. E., & Fisher, A. V. (2020). Keep it simple: streamlining book illustrations improves attention and comprehension in beginning readers. *npj Science of Learning, 5*(1), 1-10.

Fisher, A.V., Godwin, K.E., & Seltman, H. (2014). Visual Environment, Attention Allocation, and Learning in Young Children: When too much of a good thing may be bad. *Psychological Science, 25*(7), 1362-1370. https://doi.org/10.1177/0956797614533801

Godwin, K. E. (2016). *The Relationship Between Selective Sustained Attention and Learning in Young Children.* Unpublished doctoral dissertation. Carnegie Mellon University.

Godwin, K.E., Almeda, M.V., Seltman, H., Kai, S., Skerbetz, M. D., Baker, R. S., & Fisher, A.V. (2016). Off-task Behavior in Elementary School Children. *Learning and Instruction*, 44, 128-143. http://doi.org/10.1016/j.learninstruc.2016.04.003

Godwin, K. E., Seltman, H., Scupelli, P., & Fisher, A.V. (2020). Attentional Competition in Genuine Classrooms: Analysis of the Classroom Visual Environment. In S. Denison, M. Mack, Y. Xu & B.C. Armstrong (Eds.), *Proceedings of the 42nd Annual Meeting of the Cognitive Science Society* (pp.2239-2245). Austin, TX: Cognitive Science Society. cogsci.mindmodeling.org/2020/papers/0524/0524.pdf

Hanley, M., Khairat, M., Taylor, K., Wilson, R., Cole-Fletcher, R., & Riby, D. (2017). Classroom displays-attraction or distraction? Evidence of impact on attention and learning from children with and without autism. *Developmental Psychology.* https://doi.org/10.1037/dev0000271

Harp, S.F., & Maslich, A.A. (2005). The consequences of including seductive details during lecture. *Teaching of Psychology, 32*(2), 100-103. https://doi.org/10.1207/s15328023top3202_4

Harp, S. F. & Mayer, R. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102. https://doi.org/10.1037/0022-0663.89.1.92

Higgins, A. T., & Turnure, J. E. (1984). Distractibility and concentration of attention in children's development. *Child Development,* 55(5)*,* 1799-1810. https://doi.org/10.2307//1129927

Mayer, R. (2008). Applying the science of learning: Evidence-based principles for the design of multimedia instruction. *American Psychologist, 63*(8)*,* 760-769. https://doi.org/10.1037/0003-066X.63.8.760

Mayer, R. E. (2018). Taking a new look at seductive details. *Applied Cognitive Psychology*, *33,* 139-141. https://doi.org/10.1002/acp.3503

Miller, P. H., & Weiss, M. G. (1981). Children's attention allocation, understanding of attention and performance on the incidental learning task. *Child Development*, 52, 1183– 1190. https://doi.org/10.2307/1129505

Oakes, L., Kannass, K.N., & Shaddy, D.J. (2002). Developmental changes in endogenous control of attention: The role of target familiarity on infants' distraction latency. *Child Development*, 73, 1644-1655. https://doi.org/10.1111/1467-8624.00496

Roberts, M. (2001). Off-task behavior in the classroom: Applying FBA and CBM. Retrieved from:http://www.nasponline.org/communications/spawareness/Off-Task%20Behavior.pdf

Ruff, H. A. & Rothbart, M. K. (1996). *Attention in early development: Themes and variations.* New York, NY: Oxford University Press.

Ruff, H. A. & Capozzoli, M. C. (2003). Development of attention and distractibility in the first 4 years of life. *Developmental Psychology,* 39(5), 877-890. https://doi.org/10.1037/0012-1649.39.5.877

Sundararajan, N. & Adesope, O. (2020). Keep it coherent: A meta-analysis of the seductive details effect. *Educational Psychology Review, 32*, 707-734. https://doi.org/10.1007/s10648-020-09522-4

Sweller, J. Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory.* New York: Springer. https://doi.org/10.1007/978-1-4419-8126-4

Tabibi, Z. & Pfeffer, K. (2007). Finding a safe place to cross the road: The effect of distractors and the role of attention in children's identification of safe and dangerous road-crossing sites. *Infant and Child Development, 16,* 193-206. https://doi.org/10.1002/icd.509

Tarr, P. (2004). Consider the walls. Young Children, 59(3), 1-5. Retrieved from http://qqq.naeyc.org/files/yc/file/200405/ConsidertheWalls.pdf

Trick, L. M., & Enns, J. T. (1998). Lifespan changes in attention: The visual search task. *Cognitive Development*, 13, 369–386. https:doi.org/10.1016/S0885-2014(98)90016-8

Welsh, M. C., Pennington, B. F., & Groisser, D. B. (1991). A normative-developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology*, 7(2), 131–149. https://doi.org/10.1080/87565649109540483