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Posters that foster cognition in the classroom: multimedia theory applied to educational posters

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Despite a decline in popularity within US society, posters continue to hold a prominent place within middle and high school science classrooms. Teachers' demand is satisfied by governmental and non-profit science organizations that produce and disseminate posters as tangible products resulting from their research, and instruments to communicate scientific content to teachers and students. In this paper, we examine the design of such posters for their implied, underlying assumptions about learning and their alignment to the unique setting of the classroom. Based on this analysis and research into both cognition and the design of multimedia, we propose a design framework for educational posters that activates students' attention, catalyzes cognitive processing, provides a framework to guide student's construction of knowledge and connects to extended learning through live or web-based exploration of phenomenon. Based on this framework, we present a prototype poster and explore implications for poster producers, teachers, and academic researchers.

Keywords: visual learning; poster design; visual literacy

Introduction

Whereas the poster has experienced a significant decline as a means of communication within society at large, a walk through the exhibit hall at the National Science Teachers Association's convention reveals that posters continue to flourish as a communication medium in science education. These posters, frequently produced by Education and Public Outreach (EPO) programs associated with publicly funded scientific organizations, contain colorful images, graphs, and pictures that "complement the fact-filled information, making the posters ideal for the classroom" (NASA, 2010). The hordes of teachers leaving the exhibit hall loaded with these freebies, and the prevalence of posters in middle and high school science classrooms makes clear the persistent role of posters in science education. However, whether these posters are actually ideal for the classroom or if they have any educational value is much less clear.

To date, many critical examinations of the poster have been conducted. Such academic works have focused heavily on their role as art (e.g., Rivers, 2007),

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propaganda (e.g., Seidman, 2008), or advertising (e.g., Timmers, 1998). In such discussions there is occasional mention of posters' ability to educate but such mentions are cursory. In fact, no broadly accepted definition for what makes a poster effective in the classroom exists. Thus, teachers with finite wall space and planning time have little guidance for evaluating the pedagogical power of posters. Similarly, design recommendations do not exist for poster producers interested in creating posters that are more than pretty pictures on the classroom wall.

It is from this latter perspective, as EPO staff faced with the practical problem of producing posters that are desirable to teachers (they will hang them), have communicative power (convey content to students) and also have pedagogical power (support the instructional process), that two of the authors of this paper have undertaken the development of a new poster. The third author approaches this work as a science teacher educator concerned with assisting teachers to select, modify, and use posters in research-informed ways.

This paper describes the genre of EPO posters and examines the alignment between these posters and the classroom enterprise. The implied, underpinning educational philosophy of these posters and current understanding of cognition are discussed. Next, we explore the Cognitive Theory of Multimedia Learning (CTML) as a basis for developing more effective classroom posters. From this learner-centered perspective, we define a poster design framework that leverages evidence-based best practices likely to foster student cognition. Because of our unique position as both researchers and poster developers, we describe our application of this design framework to construct a sample poster. The paper concludes with implications of this work for teachers in the classroom, poster producers, and researchers interested in the efficacy of posters in the classroom.

EPO posters in the classroom

Since desktop printing allows anyone to create pseudo-posters or "any visual presentation printed on a fair sized piece of paper" (Rickards, 1971), clarifying what is and what is not a poster is needed to frame any discussion of educational posters. Evolving out of works of art and public notice, Rickards (1970) defines a poster as "a separate sheet, affixed to an existing surface (as opposed to those markings and images rendered directly on the surface). Secondly, it must embody a message; a mere decorative image is not enough. Thirdly, it must be publicly displayed. Finally it must have been multiply produced; a single hand-done notice is not a poster within the meaning of the act. . ." Based on this definition and evolution, posters are both a product with decorative qualities for appreciation as well as an instrument to communicate a message (Carter, 2008).

Posters produced by scientific EPO efforts fit this definition; they are mass-produced, contain text, figures, and other imagery to convey a message (Figure 1), and are designed in a large format suitable for hanging on the wall. The combination of an artful design, interesting graphics, and imagery makes them tangible products showcasing the organization's research. Simultaneously, the informative text makes them an educational instrument capable of communicating scientific content and/or processes to viewers. This practice is supported by the broadly accepted belief, perhaps best summarized by the Wright Center for Education (2010), that "posters are an effective way to invite student interest in science. . . posters can capture the imagination of students and teachers alike, thereby enlivening the study of science for all."

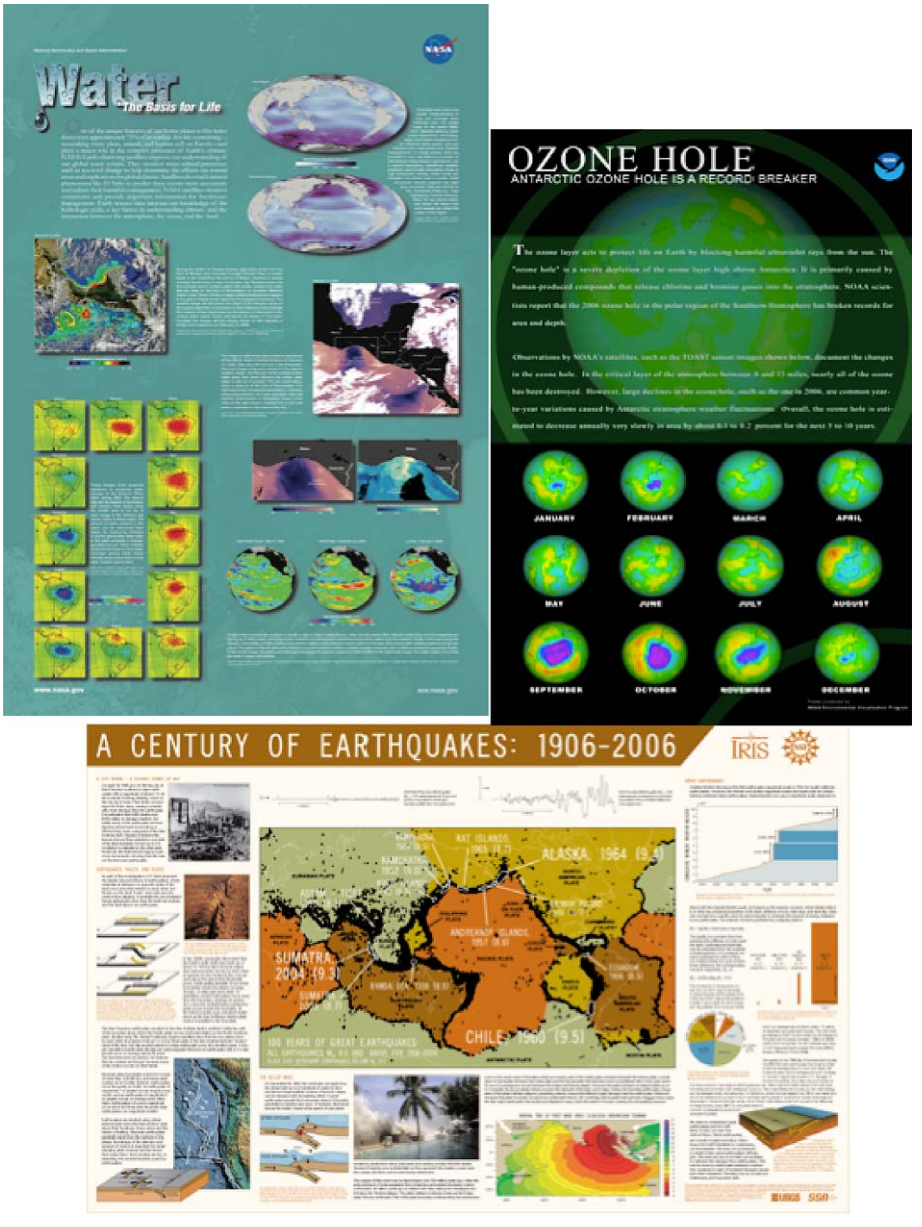


Figure 1. "Water" by NASA (top left), "Ozone Hole" by NOAA (top right) and "A Century of Earthquakes" by the IRIS Consortium (bottom). Produced to showcase the organization and communicate content, these posters are distributed at rates of over 20,000 copies (left) to 3400 copies (bottom) annually.

The classroom as a unique setting for posters

Throughout their history, posters have been used in public spaces to exhort, sell, educate, convince, and to appeal to passersby (Stermer, 1970). Regardless of the message, the assumption is that "the poster is a quick firing weapon aimed at a moving target" (Whittick, 1971). Therefore, the development of posters in public spaces has sought to attract attention, be immediately self-revealing, and deliver a message that creates an impression (Timmers, 1998). If effective, this brief interaction results in the desired behavior (e.g., purchasing, voting, etc.). Overtime, poster designs have become increasingly refined. Modern posters now convey a highly distilled message (Hegarty, 1998) through a combination of powerful visuals, limited text, and bold colors all blended together to create a simple, stylized design (Seidman, 2007).

Unlike the public spaces where posters are traditionally used, the middle/high school classroom allows a unique set of interactions between the poster and viewer. Figure 2 depicts the interaction of a poster within a science classroom. First, the teacher, gatekeeper of the classroom's walls, must hang the poster. This initial step is different from non-educational posters that are frequently hung by someone paid to do so. Therefore, educational posters must first appeal visually to teachers and immediately establish relevance between the content of the poster and the curriculum.

Once on the wall, educational posters may foster sporadic, individual, incidental learning. However, a small-scale, preliminary study of poster use following distribution found that teachers' were skeptical of the occurrence of such self-directed learning and suggested that others (teachers or classmates) may be a critical factor influencing individual learning from posters in the classroom (Hubenthal, 2009). For example, a teacher might direct students' attention to the poster by explicitly referencing it during instruction. In this way, the teacher's instruction combines with

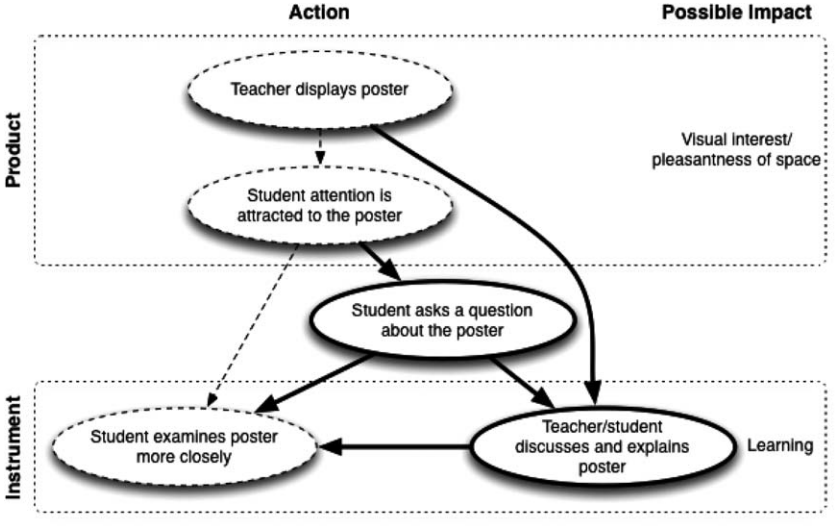


Figure 2. Traditional poster theory assumes a self-directed learning process to communicate content (dashed lines). However, the classroom setting offers other likely avenues for posters to convey information to students (solid lines).

the poster's visual aspects to initiate content-specific conversations. Similarly, other students may notice the poster and ask the teacher or other students a question about the poster thereby attracting further attention. In both cases, posters do not solely convey content, but rather catalyze conversation.

(Mis)alignment of EPO poster design with classroom use

Unfortunately, the design of many posters produced by EPO efforts are poorly aligned with the classroom environment and unlikely to support the classroom specific interactions described above. For example, conventional EPO posters tend to be multiplex, or attempt to simultaneously transmit many messages through primarily text (e.g., Figure 1). This approach is similar to the science community's tradition of producing and selecting images not to stand alone, but to highlight points and illustrate arguments that are being made in the text of a publication (Dumit, 2004). To fit this explanatory text into the finite space of the poster, the font size and the size of the central and secondary images are reduced. As a result, EPO posters frequently have a high text to image ratio. For example, the primary image of Figure 1 (bottom) uses approximately 25% of the poster's space, whereas advertising posters as early as the 1890s dedicated as much as ~70% of their space to the main visual image rather than the supporting text (Pettersson, 1997). As a result, all posters shown in Figure 1 are unreadable to students more than a few feet away and reading the text requires an extended period of time. In the classroom, these conditions are impractical since most students, if interested, lack the freedom to get close enough and the time for extended reading. Thomson, Hall and Russell (2007) observed, during an anthropological study of elementary classrooms, that self-directed learning from exemplar student work posted on the wall was unlikely to be effective for the same reasons. The over-reliance on text to convey the message also limits teachers' ability to reference the poster as a visual aid during instruction.

In addition to a practical mismatch between the design elements of the poster and the realities of the classroom, the multiplex use of text is poorly aligned with a current research-informed understanding of cognition. "Decisions about how to design a multimedia message always reflect an underlying conception of how people learn – even when the underlying theory of learning is not stated" (Mayer, 2009). The heavy dependence on presenting large quantities of text and numerous figures to convey the message from EPO posters (Figure 1) suggests that many poster producers view the poster as a vehicle to transfer information into the students' memory. In such a transmission view, the teacher presents the information by hanging the poster and learners passively receive the information via reading and store it in their memory. This design may be adequate if the goal of the poster is to facilitate the occasional, short-term memorization of factual information. However, to produce a poster that can truly educate, the EPO poster must be redesigned, beginning with the learning philosophy from which posters are constructed.

(Re)designing the educational poster

As previously noted, little academic research has been conducted on the efficacy of classroom posters. However, there has been a significant effort to understand how students learn from presentations involving words and pictures. While none of this research has been explicitly conducted on posters, this line of research can serve as

the foundation for redesigning educational posters. The CTML is an evidenced-based theory that describes learning from words and images (Mayer, 2009). CTML leverages multimedia design as a tool to increase learning by accounting for the physiological information processing system of the learner and recognizing cognition as an active process of personal knowledge construction in light of prior knowledge (Bransford, Brown, & Cocking, 2000). This model is distinct from the transmission view of posters, presented above, and alters how one views the roles of the participants interacting with posters. For example, envisioning learning as an active process, the role of the student becomes one of sense-maker, whereas the teacher constructs a learning environment that cognitively coaches, scaffolds, and assists the learner in the sense-making process. Here the poster serves to both present information and suggest a guiding structure to shape how the learner processes the information.

Constructing a design framework for posters that fosters cognition

Our goal for this project was to construct a poster that was more likely to foster student learning in a classroom than traditional EPO poster designs. Based on the operation of a poster in the classroom described above and CTML, we envision a powerful educational poster as one that is aesthetically pleasing, with a sciency look and feel (teachers will want to hang them), has attention grabbing power to stimulate student attention and interest (noticeable and stimulating), has cognitive power to catalyze cognitive processing (sense-making) and protractive power to extend learning beyond the location-specific, static, two-dimensional limits of the posters (facilitates interactions with content that extend beyond the traditional, student/poster interaction). To guide the development of a research-informed EPO poster, we constructed the poster design framework presented in Table 1. This research-based framework adapts concepts from CTML's learner-centered view of multimedia and incorporates pedagogical approaches to foster student cognition.

Eye-catching aesthetics

The overall look and feel of the poster generally involves a spectrum of artistic components, including both visual elements such as color pallet, shapes, and textures, as well as design and composition elements such as emphasis, harmony, and flow. Collectively, these artistic elements support our overall goal of fostering cognition in several ways. First, an attractive and interesting design should appeal to teachers and motivate them to hang the poster in the classroom rather than discarding it (Griffin, 1992). Next, the poster's artistic/eye-catching appeal should attract a student's attention to the poster, a pre-requisite to incidental learning.

An added benefit of an aesthetically pleasing poster is its ability to contribute to the overall pleasantness of the classroom environment. The pleasantness of a space has been shown to impact students' feelings (Maslow & Mintz, 1956; Mintz, 1956b), persistence at a task (Santrock, 1976), and attitudes and behaviors such as attendance, class participation, and rapport with the instructor (e.g., Graetz, 2006; Wong et al., 1992). Further and more specifically to posters, Stone and English (1998) have concluded that the presence of a task-related poster for filing or computational tasks, and a scenic poster for creative tasks, resulted in increased perceptions of the pleasantness of the workspace and higher levels of reported confidence.

Table 1. The Cognitive Theory of Multimedia Learning and other educational research imply design considerations for the construction of posters that foster cognition.

Power	Design Elements	Description	Reason
Attractive / Cognitive	Aesthetics	Visual appeal of the poster including; artistic design, color pallet, layout, overall size, print quality, etc.	- Encourages teachers to hang the poster - Contributes to overall classroom aesthetics - Attracts student attention
	Curricular Connection	Explicit and intentional connections to the curriculum including; broad overarching themes, process skills or individual content chunks	- Posit ions poster within curriculum and fosters a "sciency" classroom environment - Encourages teachers to hang the poster and rotate with topics/units - Affords both direct and indirect linkages to topics currently being studied
	Invitation to Inquiry	Uses cognitive learning theory to attract and engage learners in a minds-on way (e.g. title as question, visual analogy, or discrepant imagery)	- Activates students' attention and catalyzes cognitive processing; creates "need-to-know" - Provides a framework to guide students' construction of knowledge
	Message	Explicit learning objectives distilled to essential ideas	- Creates purpose - Defines what the learner should be able to do, know or believe - Distinguishes germane from extraneous text and visual content
	Text/Image ratio	Decrease volume of explanatory text and increase size of central imagery	- Reduces the visual complexity and lowers the initial cognitive load - Increases approachability (less investment) - Central or iconic images are visible to more students Complimentary visual, text, and pedagogical elements increase visual power and educational effectiveness - Fosters teacher/student/poster interactions
Protractive	Extensions	Provide opportunities for students to extend understanding through elements outside the 2-D, static space of a poster	- Integrates poster into instructional process - Offloads related but extraneous information from the poster to the web - Extends time on task - Fosters interactions with supporting live or simulated phenomenon

Curricular connection

Beyond aesthetics, the visual aspect of EPO posters should have obvious curricular connections. This establishes the relevance of the poster in light of content and process standards that guide teachers' curricular and instructional decisions (e.g., AAAS *Benchmarks*, NRC's *National Science Education Standards*). Knowing where it fits in their school's/state's/national curriculum should encourage teachers to pick up and hang the poster. This same obvious curricular connection also helps students to understand the relationship between the poster and the content being presented in the classroom.

Simple message

Similar to developing learning objectives, an explicit statement of what the learner should be able to know or do as a result of instruction, defining a simple message for a poster creates purpose and establishes learner focused outcomes for the product. Given the static, two-dimensional nature of the poster, this message must be highly distilled to a limited number of core ideas. Hagerty (1998), in his discussion of how posters sell products, notes "much (poster) advertising fails, not because it has not got something interesting to say, but because it fails to simplify its message, thus confusing the public." In addition, a narrow, focused message sharpens the boundary between information that is germane and that which is extraneous. Eliminating extraneous material from the design of multimedia products has been shown to enhance learning from them (Harp & Mayer, 1998; Mayer, Heiser, & Lonn, 2001).

Balancing the text/image ratio

As previously indicated, a reliance on text as the primary communicator of the content is problematic. Instead imagery, artistic elements such as font styles, and pedagogical strategies to convey the content should be complimentary to any text used. The more integrated and focused the text and graphic elements of a poster become, the more arresting and influential the poster. In this way the power of the poster has been compared to the parsimonious power of poetry (Timmers, 1998). At a practical level, less text allows both the images and words of the poster to be larger. Therefore, self-directed learning and teacher references to the poster are supported as students are able to clearly see the primary components of the poster from their seats.

Achieving a balance of text to images is also important from a physiological level. Learners possess a dual-processing system where incoming information is processed through separate systems for words and pictures (Paivio, 2006) and/or auditory and visual material (Baddeley, 1999). Cognitive learning theory suggests that processed information moves through these finite channels (Baddeley, 1999; Chandler & Sweller, 1991) and into the short-term working memory for active processing (Wittrock, 1989). While text is eventually transferred to the verbal working memory, it must be initially processed by the visual working memory causing competition with graphics for limited cognitive resources (Mayer, 2009). Since these two components initially function independently, posters have the potential of overloading the working memory by overwhelming either one (or both) of these

components. As a result, posters with a lower, more appropriate cognitive load are more approachable as they require a more manageable investment from the learner. As the phrase "less is more" connotes, right-sizing the complexity and density of information is an important instructional consideration.

Invitation to inquiry

A traditional view of posters suggests that a poster must immediately identify its message to the viewer in a "crystal clear," didactic way. However, students in the classroom are positioned in front of posters for a much longer period of time and have the benefit of others as information sources. Thus, we suggest that the self-revealing nature of traditional posters is less relevant for educational posters. Instead, the extended temporal scale of poster/student interactions in the classroom offers an opportunity to use graphics and text to purposefully account for learning as a cognitively active process requiring students' extended engagement rather than simple, transitory attention (Bransford et al., 2000).

Actively engaging learners can be accomplished through the use of intentional, inquiry-oriented, pedagogical strategies. For example, the poster's text and imagery can be combined to create attention-grabbing analogies or thought-provoking "discrepant" imagery that puzzles the observers and leaves them at a loss to explain what they have seen and with a desire to make connections to the content (O'Brien, 2010). Analogies connect the similarities of two concepts: the target, unfamiliar concept, is connected to a familiar concept, the analog that shares attributes with the target (Glynn, 2008). Well-selected analogies have the power to interest and excite student learning (Harrrison & Coll, 2008), and have been found to increase students' learning of concepts (Paris & Glynn, 2004). To further activate student cognition, poster titles can be reframed as interrogative questions rather than declarative statements thereby providing a clear, explicit invitation to inquiry. While not directly dependent on written questions, advertisers recognizes that "a powerful message delivered by a posters is one that opens insides your head, not one that is laid out ready made before you" (Hegarty, 1998).

Extensions

Redesigned posters have an unprecedented opportunity to serve as a gateway to additional learning. Once students have become engaged in a topic through incidental and/or teacher-directed interactions with the poster, the poster's impact on students' content achievement, thinking-skills and attitudes towards science can be further enhanced by positioning the poster within an instructional cycle such as Biological Sciences Curriculum Study's 5E Teaching Cycle; Engage–Explore–Explain–Elaborate–Evaluate (Bybee, Taylor, Gardner, Van Scotter, & Powell, 2006). A traditional view of posters suggests the primary position of a poster would be the Explain phase of instruction. However, conceptualizing alternative positions for the poster within the teaching cycle is significantly easier with a poster that is developed from a learner-centered perspective. For example, a poster could be constructed with engaging imagery and an interrogative title to capture the attention of students (Engage), and setup a related in-class investigation where students collect empirical data and develop logical arguments based on the data (Explore). Alternatively, poster producers might design a poster with discrepant imagery that follows

other instruction and requires students to apply their knowledge to a novel, yet near-transfer situation (Elaborate). A poster, designed to be complimentary of other learning phenomena offers novel opportunities to reinforce and extend learning beyond what can be facilitated from conventional posters.

Having captured students' attention and creating a need-to-know, a poster has the potential to extend learning by marrying the older medium of the poster to the Internet through the use of a prominent, simple URL. Not only does this steering strategy have the potential to impact learning by extending the time period students employ their cognitive "resources" to the subject matter (Bransford, 2000), it also allows a poster to tie into the cognitive power of web-based science instruction to increase student's motivation and achievement (e.g., Riffell & Sibley, 2005). For example, after being engaged in thinking about a phenomena illustrated on a poster, students could follow a simple, prominent URL to explore an online animation that dynamically elaborates on phenomena students explored initially via the static poster. As a result of the dual-channel information processing system of learners described above, the use of such animations has been shown to help people learn more deeply than from pictures and printed words alone (Harskamp, Mayer, Suhre, & Jansma, 2007).

Cursory evidence of posters' ability to steer students to the Internet to extend their learning exists (Johnson, 2003); this represents a trend likely to grow as the prevalence of the Internet in US homes continues to grow. The Current Population Survey conducted in 2009 estimates that 68.7% of American households have Internet access at home (US Census Bureau, 2010). Evidence also suggests that increasingly students may not have to wait until they get home to surf to the URL on the poster. Currently 69% of US public schools report wireless access in all or part of the school and large numbers of teens, including those in minority and lower social-economic groups, access the web from cell phones (Tech-trends, 2010).

Applying the framework to construct a sample poster for the classroom

To test the practical nature of the framework presented above, we have employed it to design a sample poster (Figure 3). The development began with brainstorming concise messages that we wanted to convey to students. A number of messages were tried but ultimately the following was chosen,

> Learners will be able to explain that seismic waves propagate outwards, as wave fronts, in all directions following an earthquake.

This particular message was selected for several reasons. First, understanding seismic wave propagation is a first-order concept that explains how we know what we know about earthquakes and Earth's interior structure. Next, the concept of waves and their propagation cuts across physical science, earth science, and physics courses. As a result, the concept is likely to have broad appeal to a spectrum of teachers. This concept is also directly linked to an existing analogy, commonly used when discussing earthquakes. Finally, as illustrated in Figure 3, data from an actual earthquake was available to help students visualize this phenomenon.

Development next focused on conceptualizing a strategy to foster cognition primarily through an integration of imagery, words and artistic elements. The final product aligns with the framework in Table 2 and develops attractive power from the striking color pallet and the juxtaposed imagery of a faucet against the promi-

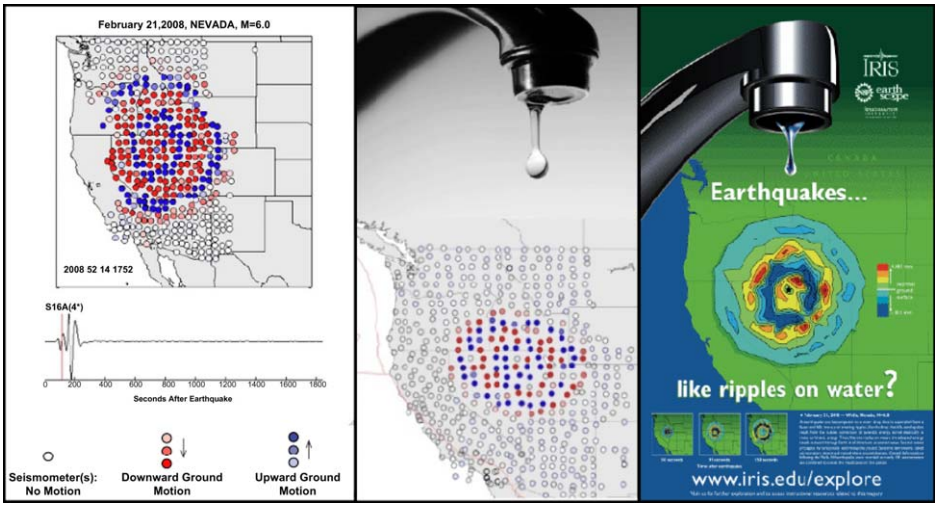


Figure 3. A data visualization snapshot shows seismic waves propagating from an earthquake (left). The visualization is distilled and combined with imagery to create an analogy (center). By applying educational and multimedia design principles, the analogy is strengthened and prepared for the classroom (right).

nent word Earthquakes (what does a faucet have to do with an earthquake?). The familiarity of the analog of the analogy, a dripping faucet, also contributes to the poster's attractive power, as it is something that most students would already be familiar. As a result, the content is less intimidating to the student.

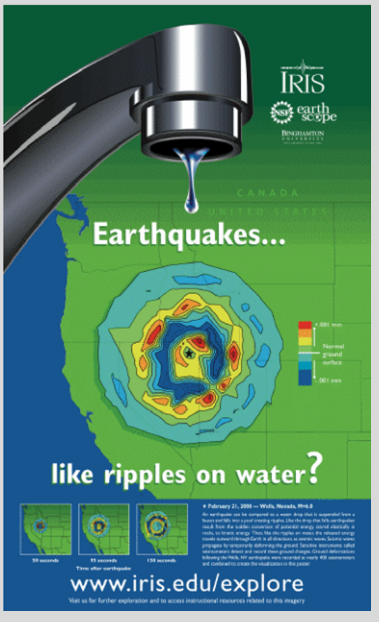
Combining this visual analogy with an interrogative echo of the analogy as the poster's title contributes to the poster's cognitive power. Here students are not only invited to think about the analogy, but these design elements also suggest a guiding structure shaping how learners process the presented information. Additional details (smaller time lapse images and short text block), are available, but not necessary, to provide additional details in a quickly consumable fashion that builds on the poster's primary message.

Finally, using graphic design principles, the overall construction of the poster focuses attention to a bright spot on the faucet, which flows down through the drop to the poster's title, data visualization and analogy text. Ultimately, your eye is led to a prominent, simple URL. Visitors to this website, whether teachers or students, will find avenues to protract student learning from the poster. For the teachers, the website includes the resources necessary to foster further exploration of the concepts. Such resources include background information, animations, a teaching cycle describing the use of in-class phenomena to minimize student alternative and maximize intended conceptions. For students, the website features an online learning cycle that offers opportunities for students to explore, explain, and elaborate on what they learn through a multimedia presentation.

Discussion

The analysis above explores the challenges and unique opportunities related to the use of posters to educate. In the classroom, many EPO posters fail to achieve their potential as an instructional instrument and as a result are relegated to merely a col-

Table 2. The "Drip" prototype exemplifies the design framework presented above.



Power	Elements	Alignment with prototype
Attractive	Aesthetics	- Bold attention-grabbing color pallet - Discrepant imagery - Layout focuses attention to flow through faucet, drip, title, data, and to the URL
Attractive	Curricular Connections	Earthquakes & seismic waves
Attractive	Invitation to inquiry	Visual analogy & interrogative title activate thinking
Cognitive	Message	Learners will be able to explain that seismic waves prorogate outwards, as wave fronts, in all directions, following an earthquake.
Cognitive	Image/text ratio	- Limited number of visual elements - Large primary visual - Smaller secondary elements o descriptive paragraph o time-lapse images - Obvious relationship between central image and secondary images
Protractive	Extensions	Prominent URL - Off-load additional content - Extend learning o Associated instructional cycle features live and simulated phenomena for exploration o Online learning sequence leveraging animations and simulations

lection of pretty pictures on the wall. This failure, as evidenced by the text-heavy, busy, conceptually dense designs of many EPO posters, stems primarily from an unstated belief that education is based on the transfer and passive reception of knowledge and a lack of understanding of the operation of middle/high school classrooms. However, by approaching the medium of posters from a learner focused perspective such as the CTML and recognizing the complementary, synergistic potential of the instruction delivered by teachers, we propose that it is possible to design posters that foster cognition through direct student/poster interactions, student(s)/teacher/poster interactions, and extended opportunities for learning through student/poster/internet (and/or live in-class phenomena) interactions. The design framework presented in Table 1 above provides specific guidelines for poster producers as they undertake their next project. While the goal of the design framework is to generate posters that appear clean and easily approachable to a layperson, we found the construction of such research-informed products, at least initially, required a greater effort than including the explanatory text traditionally found on EPO posters. Moreover, it also required a marriage of skills and understandings derived from the graphics arts, educational and scientific fields.

It should be emphasized that our recommendations address EPO posters in middle and high school classrooms. We recognize that other audiences and settings are likely to have their own unique needs that require additional specialization. For example, EPO posters designed for elementary grades, especially grades K-3, would, by necessity, require more prominent visuals as well as fewer and simpler words because of the limited reading level of those students. Conversely, posters designed for display cases in college science department hallways might assume more relevant prior science background knowledge, longer attention spans and greater motivation. Thus a final recommendation for EPO poster producers is that they identify a primary audience for their products and move away from the concept of producing one-size-fits-all posters.

Implications beyond poster producers

In addition to affecting the work of poster producers, we believe our effort to develop an educational poster that fosters cognition also has practical implications for teachers. Teachers do not need to wait for poster producers to alter their approach to and design of posters. Instead teachers can retrofit their existing poster collection so it is more closely aligned with the design framework presented above. The most immediate and easiest approach is to develop a strategy to rotate the posters that are on the walls in a way that aligns with the current unit of instruction. This keeps the images on the walls relevant to the content being covered in class and draws attention to posters as they change.

Next, teachers might enhance the attractive/attention-grabbing power of posters and invite student inquiry by developing thought questions to accompany their posters. These alternative poster titles could be written or printed on large paper and posted overtop of or next to the poster. While the result of such an addition may not appear as refined as if the poster producer had incorporated it into the original design, the effect of inviting inquiry might be even more pronounced as the edit will look "out of place" leaving students to wonder why their teacher made "edits" to what appears to be a perfectly good poster. This further helps the poster to become a minds-on learning resource.

Like the addition of a question to the poster, teachers can also extend learning opportunities beyond the poster by posting relevant URLs next to their poster. If the teacher is technologically savvy, the URL might point to a webpage they have specially created to accompany the posters. Alternatively, the URLs may refer to existing, professionally designed, websites where students can learn more about the topics of the poster.

Finally, teachers can reduce the cognitive load of posters by either cutting off or covering up the extraneous information shown on posters. This not only allows the learner to focus on the germane information, it also presents an opportunity for the teacher to creatively combine several posters into something that is more instructionally intentional.

In addition to implications for teachers, this work suggests new areas of investigation for academic researchers. Since there is a paucity of academic literature regarding posters in the classroom, much of our thinking was generated through small scale, unpublished interviews with classroom teachers and the alignment of resultant ideas with existing theories of multimedia design and cognition. Thus, much of what we have presented is theoretical and preliminary and

is based on a logical extension of ideas that have proven effective elsewhere. Perhaps suggestive of the merit of these ideas, others have also begun to construct EPO posters that align with the framework we present above (Physics Central, 2011). Thus, the efficacy of many of these concepts imbedded in the framework could be explored individually (e.g., Is the use of poster titles framed as questions more effective at inviting inquiry?) and as a whole (e.g., Does the sample poster illustrated above foster the construction rather than absorption of knowledge). An additional avenue for research that we feel offers exciting potential is assessing the efficacy of the use of posters as an in-class advertisement for online learning opportunities.

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