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Evaluating media-enhancement and source authority on the internet: the Knowledge Integration Environment

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Access to the internet increases variability in media and source authority for students who generally rely on teachers and textbooks. Some internet sources are more credible than others (e.g., a New York Times article on the web vs. a private citizen's homepage). Some sources are impressively produced with graphics and media-enhancements, while others are unadorned text. We explore the question of how source authority and media-enhancement impact students' interpretation of evidence as they conduct a Knowledge Integration Environment project as part of integrated science instruction in a culturally diverse high school.

Introduction

Design of Knowledge Integration Environment (KIE) activities using internet materials raises two questions about student interpretation of internet resources. First, will students gravitate toward evidence represented by higher credibility sources? Second, how will media-enhancement affect the rating and use of individual pieces of evidence? As we design KIE activities that involve students in using the internet for science projects we must also address these central issues about evidence interpretation.

Schools rely more and more on the internet as an information resource (Butler 1995, Johnson 1995, Lewontin 1995). This new resource provides rich opportunities to support the development of scientific argumentation skills, going well beyond those available in typical instruction. Understanding how students engage in scientific argumentation, evidence analysis and theory discrimination has been a focus of much recent study (Kuhn 1993, Linn 1995), as has the role of computers and the internet in teaching about these processes (Linn 1995, Cavalli-Sforza *et al*. 1994, Ranney and Shank 1995, Tabak *et al*. 1995). In order to take advantage of rich internet contexts in KIE activities, we need to expand these studies by investigating the role of media-format and source credibility on student evidence analysis in diverse academic settings (Sutton 1991, Rocheleau 1995, Cheek and Agruso 1995, Anderson 1984, Pallas 1988, Peng 1995, Stevens and Grymes 1985). By better understanding the role of source authority and media-enhancement in

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student argumentation and theory discrimination, we can better develop KIE activities and other educational internet tools for all students.

Credibility literature

Students rarely have opportunities to assess source credibility in school. The teacher and textbook are typically the only sources and, students are taught to accept information from these sources without question. We investigate how students assess credibility when this new skill is required. The credibility of an authority affects belief change among adults (Reinard 1988, Hovland *et al*. 1953, Maddux and Rogers 1980). Source credibility is associated with high levels of education, intelligence, professional attainment and, familiarity with the issue (Hass 1981). These cues may be minimal and still have an effect (Hastie *et al*. 1984). How will adolescent students react to these cues?

Students may react to source credibility similarly to adults but, two other possibilities exist. For some students, a source may be more credible if the source is only slightly more informed than the student (McGuire 1985). Children are more influenced by students only a few years older than themselves than by much older children or by same-age peers (Stukat 1958). Students might prefer lower credibility sources closer to their own level. More likely, given schools' non-emphasis on source monitoring skills, students may neglect source information partially or altogether. Shimura and Squire (1991) and Johnson *et al*. (1993) have demonstrated this finding in non-internet settings. Research distinguishes memory for facts and memory for context (Humphreys *et al*. 1989; McKoon *et al*. 1986, Tulving 1986), showing that these components of memory are dissociable and distinct (Hasher and Zacks 1979, Jacoby and Dallas 1981, Chaiken *et al*. 1989). If source information is indiscriminately encoded or ignored initially, eventual connections will be incomplete due to this initial deficit. Attribution decisions are often unconscious (Johnson *et al*. 1993), so we may need to focus on facilitating active source monitoring skills as part of our social supports for learning (see Linn 2000) in the Knowledge Integration Environment.

Media-format literature

On the internet, presentational sophistication of information varies greatly, ranging from unadorned text to highly produced multi-media productions. These media-enhancements are often unconnected to the credibility of the information but, may affect the way that students evaluate the importance of the information. This study compares the inclusion of static images with written text because static images are the most common media-enhancements on the internet.

Media-enhanced pieces of evidence can influence student evidence evaluation and usage by enhancing recall or credibility of the information. The first of these categories is addressed in the literature on electronic text and learning. Research shows that static images 'benefit learning when the illustrations represent text-relevant information, elaborate upon it, or illustrate information central to the text' (Wetzel *et al*. 1994). A review of studies on this topic found that relevant illustrations aided learning from text, that illustrations may work best in terms of aiding memory, that readers prefer illustrated over non-illustrated text and, that illustrations may help poor readers more than good readers, particularly when the illus-

trations are not too complex (Levie and Lentz 1982). Another study found that low SES students benefited more than high SES students from the illustrations (Rohwer and Harris 1975). This pattern of benefit applies to students with lower prior knowledge, as well as to lower ability students (Levie and Lentz 1982, Peeck and Jans 1987, Winn 1989). Illustrations seem to help students in a number of ways, including acting as organizational aids, evoking prior domain knowledge and, establishing preliminary mental models of the situation (Kozma 1991). Additionally, media-enhancements might improve the credibility of evidence. As mentioned above, students prefer pieces of text with illustrations better than those without (Levie and Lentz 1982). Furthermore, for many students, 'seeing is believing' (McGuire 1985). This would lead us to believe that students would be more likely to use and believe arguments and pieces of evidence that are media-enhanced. For all of these reasons, we might assume that media-enhancement with representational images will impact the students' evidence evaluation.

There are also two potential perspectives predicting that representational images would not have a significant influence on student evidence evaluation. The first concerns studies of the impact of static images on attitude formation with regard to text. They indicate that the images may be more distracting than helpful in attitude formation (Edell and Staelin 1983). The second perspective involves learning studies of the educational impact of media-enhancement with static images. These studies show confusion in comprehension resulting from the overload of information (Moore and Nawrocki 1979). For both of these reasons, media-enhancement might not play a role in students' evaluation of evidence.

Methods

Participants

Eight classes of sophomores, students in the second year of US high school, about 15 years of age, (approximately 240 students) in untracked integrated science classes in a large public urban high school participated in this study. The school has an enrolment of 4000, evenly distributed amongst African-American, Hispanic, Euro-American and, Asian-American students.

Procedure

On the first day, the teachers introduced the topic of dinosaur extinction, emphasizing that the debate remains ongoing in the scientific community. Students worked in randomly assigned same-gender groups of two or three. At the onset of the activity, students were introduced to the two main theories of dinosaur extinction, and asked about their initial preferences regarding the two theories. They rated their position along a continuum from one to seven, with one signifying complete agreement with the meteor theory, four signifying that the students were unsure between the two theories and, seven signifying complete agreement with the geologic theory. The students then read short background biographies for each of the two presenters without being told which presenter would present each theory. Students then rated their initial judgement of how much each presenter knew about dinosaur extinction. After answering questions about their initial preferences, students browsed (on the internet) and evaluated each piece of evidence,

writing explanations about the importance of each piece of evidence to the debate. After completing their survey of the evidence, students composed a 'letter to the editor' of a fictitious science journal about the dinosaur debate in which they stated their final arguments. Afterward, they provided final ratings of the two theories.

Curriculum

This project was presented to students using the Knowledge Integration Environment (KIE), a versatile software framework that scaffolds students' use of internet resources, as well as other complimentary activities including authoring, electronic conversations and argument organization. A special 'Dinosaur Debate Project' was created for the purposes of this study. The Knowledge Integration Environment was developed with a NSF grant to help students use the, 'as-yet untamed (and growing) internet to acquire skill in interpreting scientific material, gain an integrated understanding of complex scientific ideas, and develop a propensity toward integrating knowledge in general' (Bell *et al*. 1995).

We modified internet pages relating to potential causes of dinosaur extinction to produce twelve pieces of evidence for the debate. Six pieces supported the 'meteor impact' theory of dinosaur extinction and, six supported the 'geological changes' theory of extinction. By the nature of the two theories, the meteor theory involves a tighter causal chain of effects, while the geologic theory involves a looser confederation of potential factors. Relevant media images were collected for each piece of evidence in order to produce 'media-enhanced' versions of each piece of evidence. Each student received half of the evidence items as media-enhanced. Similarly, each piece of evidence was attributed to a source: either a university professor or a dinosaur enthusiast. This source information was also controlled so that half the students received the higher authority for one side of the debate while the other half received the higher authority for the other side of the debate.

Design

Each class was assigned one of two authority treatments. In each treatment, two fictitious scientists presented evidence for the competing theories regarding the cause of extinction. In the first treatment, the 'high authority' (the university professor) presented evidence supporting the meteor theory, while the 'low authority' (the dinosaur enthusiast/newsletter writer) presented the evidence for the geological changes theory. In the second treatment, the two authority levels were switched to support the opposite theories. Within each authority treatment, there were two evidence treatments that determined which pieces of evidence were media-enhanced for each side (see figure 1).

Measures

Each student group used a seven point scale to indicate measures of: (a) initial preference of theory before reading about the presenters or seeing the evidence; (b) initial attitudes regarding the credibility and knowledgeability of the two presenters before seeing the evidence or knowing which theory each presenter supported;

Classrooms:	1, 5	2, 6	3, 7	4, 8
Authority Treatment:	Meteor Theory = High Geological Theory = Low		Meteor Theory = Low Geological Theory = High	
Media Enhanced:	Odd-numbered evidence items	Even-numbered evidence items	Odd-numbered evidence items	Even-numbered evidence items
Text Only:	Even-numbered evidence items	Odd-numbered evidence items	Even-numbered evidence items	Odd-numbered evidence items

Figure 1. Experimental design.

(c) rating of the importance of each evidence piece; (d) final ratings of their preference between the two theories; and (e) final ratings of the knowledgeability of each presenter on the topic of dinosaur extinction. Additionally, students selected the three most important and, one least important piece of evidence for each theory. Based on these choices, students wrote letters in which they reviewed the debate for a journal, building arguments for each theory, as well as determining how effectively each side had made its case. Gender and the teachers' assessment of reading ability were also recorded for each group.

Results and discussion

Students responded positively to the dinosaur debate and the Knowledge Integration Environment. The teacher reported that for many students, 'this was one of the first writing/analysis projects that they completed this year'. Students actively debated the theories and pieces of evidence. No student or teacher questioned the authenticity of the evidence we had created and, many of the teachers continued to ask questions about the 'scientists' who had constructed the sites even after we explained that we were the authors of the sites.

A complex picture of the factors influencing students' interpretation of evidence emerges from this study. We found that students respond to source authority and media-enhancement in significant patterns reflecting student characteristics and knowledge integration patterns. The results will be presented in the following order: (a) student ratings of the two theories; (b) student reactions to individual pieces of evidence; (c) the role of media-format; and (d) the role of authority. Due to the interactions of these factors with one another, results and discussion relevant to all factors appear in all sections but, each section will maintain the stated focus.

Students rated the dinosaur extinction theories prior to reviewing the evidence and after completing the activity. As a group, students had a slight preference for the meteor theory ($M = 3.5$, compared to a neutral value of 4 on a seven point scale). As a group, the final position was similar ($M = 3.8$). However, groups with high reading ability moved toward the meteor theory, while groups with low reading ability moved toward the geologic theory ($F(1, 35) = 8.855$, $p < 0.0053$) (figure 2). This movement toward the meteor theory by the higher proficiency readers evidences a finer understanding of the causal chain involved in the meteor evidence, while the movement of the lower proficiency readers toward the geologic

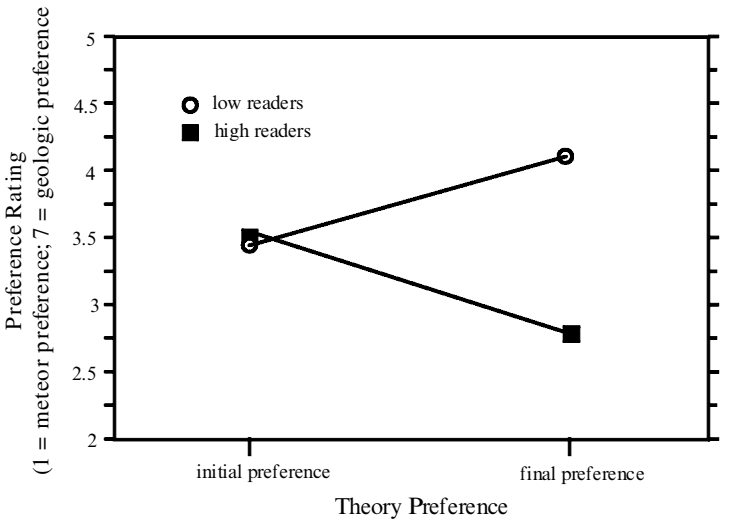


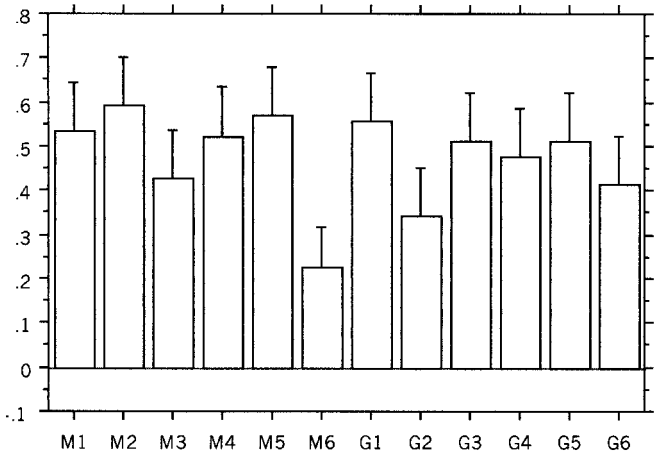
Figure 2. Initial and final theory positions by average reading level category.

theory may be an effect of the media-enhancements included in the geologic evidence.

Evidence ratings

Each evidence item was received by half the students as text-only and by half as media-enhanced (where a picture was added to the text). Students rated the importance (on a 1 to 7 scale) of each item as they encountered it. After they had viewed all of the evidence, students were asked to choose the three pieces of evidence from each theory that they considered most important. Finally, students chose the least important piece of evidence for each theory.

Overall, students rated certain pieces of evidence more highly than others independent of media ($F(11,759) = 12.26$, $p < 0.0001$), showing that students were reading and considering the evidence text carefully. Similarly, certain pieces of evidence were more likely than others to be chosen as 'most important' independent of media ($F(11,902) = 3.718$, $p < 0.0001$) as shown in figure 3. All three pieces chosen most frequently as 'most important' involved physical evidence of causal phenomena potentially destructive to the dinosaurs (e.g., iridium in the 'KT boundary' indicating meteor debris, the Yucatan location of the Chicxulub meteor crater and, the impact of mountain ranges on global weather patterns). Evidence supporting claims on a more abstract level (e.g. the ratios of gold to iridium), or those with more diffuse claims (e.g. the ramifications of new land bridges), were chosen more infrequently. Students tended to rank the meteor pieces of evidence more highly than the geologic pieces of evidence ($F(1,67) = 10.203$, $p < 0.0021$) which follows these patterns, with more of the meteor evidence concretely and directly supporting a central causal claim. Interestingly, even the most damning pieces of evidence for disproving the opposing theories in the debate were not among the pieces most frequently chosen by the students. Clearly students need



Meteor Evidence:
M1: Scientists Have Found A Clay Layer All Around The Planet With Soot In It
M2: High Levels Of Iridium In The KT Boundary Clay
M3: Shocked Quartz Found In The KT Boundary Clay KT Boundary Clay layer
M4: A Meteor Impact Would Block The Sun
M5: The Chicxulub Impact Crater
M6: The Ratio Of Gold To Iridium Is Not The Same

Geologic Evidence:
G1: New Mountains Changed Weather Patterns
G2: Mammals And Dinosaurs Could Move Between Continents
G3: Cold Weather Causes Thinner Egg Shells have been born.
G4: Most Dinosaurs Were Extinct Before The KT Boundary
G5: The KT Boundary Clay Could Have Come From Huge Volcanic Eruptions
G6: Dinosaurs Could Survive the Cold And Dark

Figure 3. Differences in choices of most important pieces of evidence by theory.

curricula that help make thinking visible to support and scaffold their scientific argumentation skills (see Linn 2000).

Media influence

How does media affect the rating of evidence? No effect of media was found for the students overall but, an interesting pattern emerged when the effect of media-enhancement was analysed by gender. While not significant for the entire set of evidence, boys tended to choose a piece of evidence more frequently as 'most important' when it included the accompanying image, while girls tended to choose pieces of evidence as 'most important' more frequently when presented as text-only $(F(1,80) = 1.811, p < 0.1811)$. Further analysis of the evidence and accompanying images suggested a possible cause for this unusual tendency. Analysing the images, we distinguished between pictures that included dinosaurs and those that didn't. Furthermore, we distinguished action pictures, such as small mammals eating dinosaur eggs and, informational graphs and charts. The accompanying images for six of the 12 pieces of evidence involved dinosaurs, usually in active

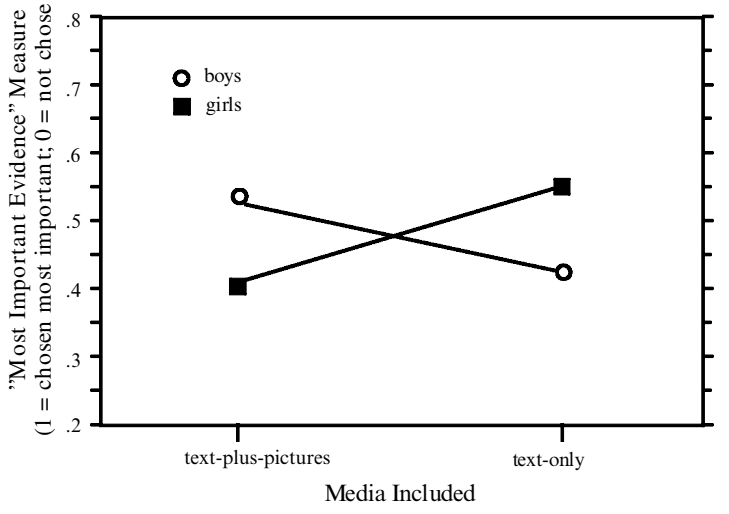


Figure 4. Interaction gender and media-enhancement in choosing most important pieces of evidence.

or violent settings (e.g. a dinosaur struggling along through a cold, dark environment, dinosaurs moving away from an erupting volcano, or baby dinosaurs breaking out of their egg shells). When the entire subset of evidence with dinosaur/action images was analysed for the interaction of gender and media-enhancement, the suggested pattern became manifest and, was strong enough to account for the initially observed pattern. As shown in figure 4, boys were more likely to choose these pieces of evidence as 'most important' when the dinosaur/action images were present, while girls were less likely $(F(1,80) = 8.842,\ p < 0.0039)$. This pattern did not extend to the non-dinosaur subset of evidence and, thus, seems to be a gender specific/topic specific result indicating that choosing gender-neutral images requires careful thought in building gender-equitable internet environments.

The importance of informational graphs and charts followed a less clear pattern but, suggested that if the charts were relatively clear and direct in their support of a concrete causal phenomenon potentially destructive to the dinosaurs, girls were more likely to choose the piece of evidence as 'most important' with the image than without. The satellite picture of the suspected meteor crater on the Yucatan peninsula provides an example in this category. Further inquiry is necessary but, clearly images need to be carefully chosen to make thinking visible and clarify complex connections for our students (see Linn 2000).

Credibility

There is no overall effect of authority on preference rating of evidence for students as a whole group, by gender, or by average reading ability. Students accurately rated the authority of the two presenters before finding out which theory each presenter supported $(F(1,75) = 42.220,\ p < 0.0001)$, and continued to discriminate after the activity was completed regardless of their final theory choice $(F(1,64) = 11.555,\ p < 0.0012)$ (see figures 5a&b). Their written explanations confirm the clarity with which they discriminated authority levels—as one student

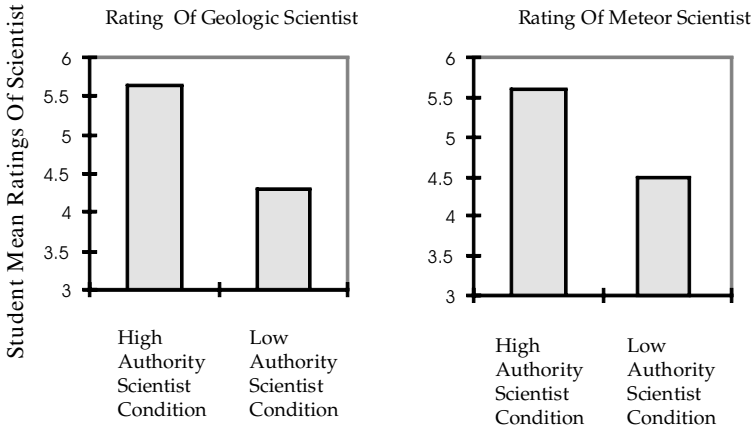


Figure 5a. Students' scientist ratings by authority condition collapsed over time.

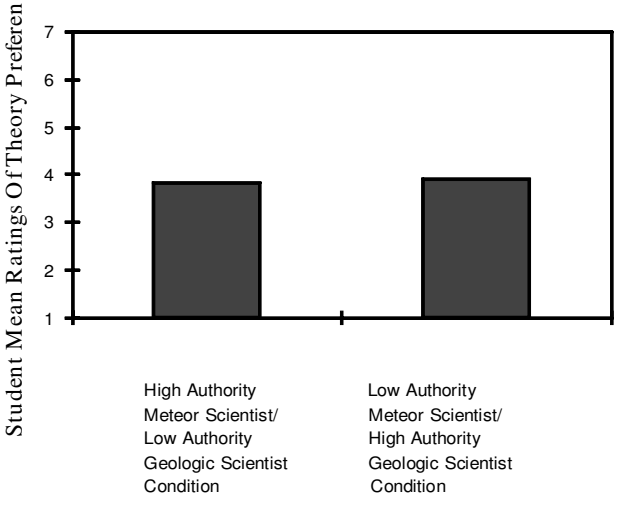


Figure 5b. Students' final rating of theory preference by authority condition.

wrote, 'Obviously Rutherford (the professor) has a lot more training than Graham (the newsletter writer)—what does Graham know about dinosaur extinction!?!' And, yet, in the letters students wrote to the 'scientific journals', almost no students connected their discussions of the theories to authority. Although students can clearly distinguish between credibility levels, they do not use this information when evaluating the evidence they are reviewing.

In fact, the influence seems to move in the opposite direction, with students promoting or deflating their ratings of scientists consistent with the direction of their theory change. This was true for the final ratings of the geologic scientist $(F(2,57) = 4.512,\ p < 0.0152)$ as well as the meteor scientist $(F(2,57) = 3.081,\ p < 0.0536)$. This information combined with the preceding information would seem to indicate that students do not abandon their initial attributions of authority but, that these assessments are tempered or diluted by their decisions about the theories and the intervening content information to diminish cognitive dissonance and build coherence.

Conclusion

This study investigated the impact of media representation and authority on student evidence evaluation in a debate about dinosaur extinction. The students took the debate seriously and considered the evidence carefully. Students debated with each other earnestly, and, students gravitated toward individual pieces of evidence for each theory independent of media-enhancement or authority.

Although students could reliably judge the higher authority source as being more knowledgeable and trustworthy than the lower authority source both before and after the activity, between-group comparisons of the two authority treatments revealed no significant differences in students' final preference of theory. That is, students who had evidence for the meteor theory presented by the professor ('high authority') were no more likely to prefer this theory than students who had the same evidence presented by the amateur dinosaur enthusiast/newsletter writer ('low authority'). This result suggests that students did not consider source authority in their process of theory evaluation, which makes sense given the non-emphasis of source monitoring in school settings.

These results applied to all gender and academic ability groupings, and were consistent with the source monitoring and source memory literature suggesting that memory for fact and memory for source are distinct and dissociable (Hasher and Zacks 1979, Jacoby and Dallas 1981, Chaiken *et al*. 1989). If source information is neglected initially, eventual connections will be incomplete due to this initial deficit. Because attribution decisions are often unconscious (Johnson *et al*. 1993), we are focusing on facilitating active source monitoring skills by students as part of our social supports for learning (see Linn 2000) in the Knowledge Integration Environment to make up for this deficit in traditional classroom practice.

Consistent with the findings of Linn *et al*. (1998), the effect of media is complex. Overall, students were no more likely to choose a media-enhanced evidence item than a text-only item as one of their 'most important' evidence pieces. This finding runs counter to earlier non-internet findings (e.g. Levie and Lentz 1982) that students prefer pieces of text with illustrations to those without. In our study, images enhance some evidence pieces more than others. The direction and cause of the influence, however, does not follow a simple overall pattern. In some cases, illustrations do seem to evoke prior domain knowledge and establish preliminary mental models of the situation as suggested by Kozma (1991). In terms of gender, boys were more likely than girls to choose a piece of evidence as 'most important' when the accompanying image involved dinosaurs and action. Girls seem to prefer pictures that add information in a direct and concrete manner. These results suggest that choosing gender-neutral images requires careful consideration in order to build gender-equitable educational materials for the internet. Further inquiry is necessary but clearly the added content of a particular image and, not the image's mere presence, determines the importance of the image in students' interpretation of that evidence. This finding supports a knowledge integration perspective wherein a student's interpretation depends on the repertoire of models and ideas with which the student is currently working. The image must be connected to this current repertoire to be useful and, is evaluated in terms of this repertoire. As part of our group's goal of making thinking visible (see Linn 2000), we continue to research the proper implementation of media-enhancement to

facilitate productive connections between the models and ideas of students' repertoires with new materials that students encounter on the internet.

Today, classrooms are moving from dependence on teachers and textbooks with known authority to the diverse information resources provided by the internet. As a result, students will need to integrate interpretations of source credibility into the evaluation of internet information while separating media from that message. By better understanding the role of source authority and media-enhancement in student interpretation of internet resources, we can better develop educational tools to harness the internet for all students.

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