Why Media Matter

Media Effectiveness from a Performance Perspective

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Whether media affect learning has been debated for decades. The discussion of media's effectiveness has raised questions about the usefulness of comparison studies, not only in assessing applications of technology but in other areas as well. Arguments that media do not affect learning are re-examined and issues concerning media effects on expert performance are examined. Studies of mediated expert performance in telemedicine are used to show media affect performance and suggest media contribute to learning. Media present information crucial to performing certain tasks and the use of identical or similar media in learning these tasks should have positive effects on transfer. The usefulness of media comparison studies in telemedicine is discussed and it is argued that such studies are valuable for practical decision making regarding the deployment and application of technology in training and the workplace.

The subject of media influences on learning is revisited in this article. Whether instructional outcomes can be attributed to media, methods, or both has been debated since Clark (1983) asserted that there is no evidence supporting learning benefits from the use of any specific medium. Kozma (1991, 1994a, 1994b) challenged Clark's claim that only methods affect learning and others took up the debate (cf., Ross, 1994a, 1994b; Jonassen et al., 1994; Morrison, 1994; Reiser, 1994; Shrock, 1994; Tennyson, 1994, Ullmer, 1994). Recent exchanges by Clark (2005) and Luterbach (2005a; 2005b) indicate the original debate still rages. Moreover, some of the arguments expounded by Clark have migrated to other contexts. Kirschner et al. (2004) and Reeves et al. (2004), for example, have cited Clark's criticisms of lack of significant differences in media comparison studies to attack comparative studies of group size and other factors in collaborative learning research. Although Kirschner et al. (2004) state that they consider Clark's criticisms definitive, individual comparison studies of media and meta-analysis of these studies that have been conducted since the original debate suggest the problem is still open (cf., Lou et al., 2006; Machtimes & Asher, 2000; Sonnenwald et al., 1999).

The issue is compounded by the convergence of technologies that occurred since Clark's (1983) original discussion (Kozma, 1991). In 1983, there was very little integration of media. Video was broadcast or on tape and slide or opaque projectors were needed to display pictures, although some slide projectors could be linked to audiotape recorders and automatically advanced by pulse tones. Most computers could display only text or crude graphics and color options were limited. Efforts linking computers, slide projectors, videodiscs, and other analog peripheral media were just starting. Today most analog methods for capturing and presenting multi-media have been replaced by digital ones, and digital multimedia technologies have been linked to varied input and output devices to rapidly generate motion and resistance stimuli affecting the senses of feel and touch important to learning skills, such as surgery and flying, that earlier media could not present (cf., Dev et al., 2002; Luterbach, 2005a). Is it still meaningful in an age when video is delivered by computer to suggest, as Clark (1983) did, that student attributions about the relative difficulty of computers versus television affect performance more than the media themselves? In a time when computer chips are being embedded in television sets and computers are interconnected via phone, cable, and other networks, the question of selecting among different delivery systems has become secondary to choosing what media to employ within an integrated, seamless, and transparent communication environment.

The question of whether media affect learning will be re-addressed in this article from a performance perspective. There are two reasons for this focus. First, there is increasing emphasis on finding ways to improve performance in the workplace by ways other than providing instruction and training (Reiser, 2002; Rossett, 2002), so the question of whether media might differentially affect performance is important in its own right. Second, if media can be shown to affect performance, then it also might be an indicator that media can contribute to learning how to perform. If the information and content certain media convey affect performance better than others, then it is reasonable to assume that identical or very similar media will positively affect learning the performance. The use of such media to convey the same content in instructional programs should promote transfer of knowledge and skill in the workplace. Research on the use of video in telemedicine will be used to show how media affect physician performance and to make the case that for given skills and tasks the use of certain media in education and training should more positively affect transfer than others. It also will be argued that while comparative studies addressing media *versus* method are not very useful, comparative studies of media *and* method are highly appropriate in telemedicine and instruction. Before examining media's role in performance, however, it is useful to dissect the arguments contending that only methods, not media, affect learning.

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The Media and Method Conundrum

It is important to note that the contributions of methods to learning are *not* disputed. None of the authors advocating media's contributions to learning (Kozma, 1994a, 1994b; Reiser, 1994; Ullmer, 1994) or those addressing both sides of the issue (Jonassen et al., 1994; Morrison, 1994; Ross, 1994a, 1994b; Shrock, 1994; Tennyson, 1994) have asserted this, and there is a rich body of research and theory supporting instructional strategies ranging from the provision of practice and feedback to situating and sequencing instruction (cf., Medsker & Holdsworth, 2001). The media versus method argument focuses primarily on whether media are mere vehicles for delivering instruction and that, if so, *only* the instructional methods delivered count and methods can be devised to achieve *any* given learning outcome with *many* different media (Clark, 1983). The problem is the distinction between media and methods is not clear, since certain media have features, attributes, or affordances that accommodate some methods more than others (Reiser, 1994). The mere vehicles argument involves three dichotomous issues: whether media and methods can be uncoupled, whether it is possible to unambiguously demark so called "surface" features and "structural, active ingredient" features in instructional programs (treatments), and whether media contribute only to learning efficiency, not effectiveness.

The Uncoupling Argument

Clark (1983) argues that although symbol systems and symbolic elements are correlated with media, neither the media nor the symbol system affect learning because a variety of media and symbol systems can be employed to achieve the same performance. Consequently, only the instructional methods contribute. Clark uses zooming and animated arrows as examples of symbolic elements and cites studies showing the attention directing benefits of zooming in motion media might be attained as well with successive static close ups and other methods for isolating details. Clark's (1994b) "armchair replaceability test" states that if for any treatment using one medium (and its attributes) one can think of a treatment in another medium (and its attributes) that could produce similar results, then the cause of the results is some shared or uncontrolled property of the treatments.

There are two troubling aspects of the uncoupling argument. First, it characterizes media attributes only in relation to accommodating symbolic elements while ignoring their capacity to convey different information and content. For example, still images are limited in portraying motion or real time interaction that video affords but video images tend to lack resolution, factors that impact the performance of physicians and other experts. Symbolic elements might be replaced in different media, but the exact content they convey often cannot. Second, while the "replaceability" test can be taken to show treatments share similar properties, it can also be considered an indicator that media share similar properties for delivering the treatments.

How many different media options must there be before it can be claimed that the information and symbol systems that media support are irrelevant? Feedback about individual and group performance in sports competitions, for example, often is provided by reviewing video recordings of contests. An armchair assessment might indicate film could be exchanged for video easily because of their shared features, but an audio recording of someone who narrated the play or a coach's verbal review of game notes would not likely work as well. The players would have to recollect aspects of the game from their unique perspectives during play and imagine the action described in the mind's eye, adding extraneous cognitive load and unnecessary information processing to that which is more crucial to directly performing a task or understanding what is to be learned. This additional overhead has consistently been shown to encumber performance in human computer interaction and learning research (cf., Van Merriënboer & Ayres, 2005; Olson & Olson, 2003; Patel & Kushniruk, 1998). There are realistically few options in this sports example and the most salient ones involve media with almost identical attributes.

Media and method typically have been researched by using the same method with different media. The problem with this approach is that not all the features of the media being compared are utilized, only the common ones (Ross, 1994b). Clark (1983; 1994b) cites the lack of significant differences in these controlled studies as evidence media do not affect outcomes, but these studies have only controlled for media differences in the sense that one might control for differences between a sprinter and a paraplegic by sticking the sprinter's legs in casts. To preserve internal validity and control media and method interaction, external validity, making the research mirror practice in the real world, is sacrificed. Decision makers and practitioners generally want to exploit a technology's features and the interaction of media and methods usually is the primary interest (Ross & Morrison, 1989). Using instructional methods in the absence of media is hard to conceive and media and method confounding may be inevitable (Luterbach, 2005b; Kozma, 1994b), a point that Clark (1983, p. 451) acknowledges. If methods cannot be delivered without media, then the assertions Clark makes about media comparison studies can be made in reverse about studies comparing methods. The results observed in any comparison of method, whether significant or not, also can be attributed at least partially to media or a media-method interaction (Ullmer, 1994).

The Active Ingredient Argument

In contexts where varied media and methods are compared and differences are identified, Clark (1994b) argues media only have irrelevant surface features while methods have deeper, structural importance and are the "active ingredients" inducing the outcomes. The surface versus deep distinction has been adopted by collaborative learning researchers who have labeled studies of group size as "surface" ones failing to address "real" learning determinates (Kirschner et al., 2004). The active ingredient argument uses the medical analogy that tablets, liquids, suppositories, and injections (the media) are all capable of delivering an active ingredient in medicine (the real determinant) and only affect speed, purity, and cost of administration. But the analogy is only partial, since some medicines (e.g., Penicillin G) cannot be taken orally because they are neutralized by ingestion, while others kill bacteria by direct contact and must be administered at the point of infection. If there is no interaction between mode of delivering a medication and its effectiveness, it should be possible to drink isopropyl alcohol to treat skin cuts, despite the warnings on the bottle.

The "surface" versus "real" distinction assumes that treatments can be divided in this binary way. Moreover, the classification itself is a matter of judgment. One might generalize the surface attribution that Kirschner et al., (2004) assigned to studies of group size in collaborative learning to those of class size and school size in formal education, the implication being that, as surface features, they do not deserve study. Teachers and others have long advocated smaller classes and schools and the evidence supports them (cf., Bill and Melinda Gates Foundation, 2005; Glass & Smith, 1979). Class size, group size, media-technology and other issues practitioners must address are valid subjects of study because decisions have to be made about them, decisions that can be informed by evidence.

There is much "surface" research involving media in medicine, including efforts to generate surfaces of three dimensional anatomical structures from two dimensional images of gross anatomy, computer tomography (CT) or magnetic resonance image (MRI) data. The research goals are to develop and assess applications that help students visualize anatomy and that assist practitioners in diagnosis and surgical planning (cf., Johnson et al., 2006; Pommert et al., 2001; Silverstein et al., 2002; Welch et al., 2005; Yoo et al., 2002). Media comparison studies indicate these three dimensional representations are advantageous (Garg et al., 2001; Silverstein et al., 2006; Silverstein, 2003; Welch et al., 2005). Is this surface research to generate structures and measure their affects on performance and learning "surface" or "structural" in the sense that Clark (1994a) and Kirschner et al. (2004) use the terms? What constitutes a surface treatment as opposed to a real one and why are so called surface treatments ipso facto irrelevant? Researchers and practitioners treating the media-method confound as a given do not have to make arbitrary judgments between what is surface and what is real.

The Efficiency Argument

The Clark view (1994b) is that media features contribute only to the speed and cost of learning, not effectiveness. It is hard to imagine that medical students could learn heart sounds, however, without listening to analog or digital recordings or through the direct use of stethoscopes. The latter, though authentic, has disadvantages because it is hard to share the sound a student hears with the instructor or other students and the sound will vary depending on the patient and the stethoscope's placement. Recordings allow collection and use of prototypical examples and their manipulation in systematic ways to achieve more effective and efficient instruction. It might be possible to teach heart sounds in a very different medium, such as print, if students learn to read some notation system denoting rate and rhythm, much like some musicians learn musical notation. Since most musicians can learn to play without reading notes and heart sounds can be learned directly, the skill of reading notation is neither necessary nor sufficient for learning in either context. As in the sports feedback example discussed previously, there are realistically few information, symbol, or media options. More mental processing is required as the media options vary from accommodating the information inherent in conducting the task and the resulting cognitive overhead can detract from doing and learning the performance.

It is not always possible or realistic to separate efficiency and effectiveness. Transfer studies, for example, examine how learning something in one context (A) affects learning or performance in another (B), usually documenting time, error rates and other variables. Few would contend, however, that learning A (regardless of the medium *or* method employed) only affected the efficiency of B. If content and symbol systems associated with a medium can contribute to the efficiency of learning, they also may add to effectiveness. Media can make it easier to concentrate on the task and reduce errors in interpreting content. Indeed, there are many skills, such as assessing a patient in crisis, where efficiency is part of effectiveness. If the right diagnosis and appropriate actions are not made in time, the performance is ineffective. Even if media contributions to learning were confined to efficiency, any additional time savings could be used to make the knowledge and skill more automatic or to acquire additional knowledge.

Media and Performance

The question about whether media affects performance is related, but somewhat different from the media versus method question in learning. In telemedicine, for example, media are used to transmit data and information, usually to an expert who acts on it. The expert has already acquired the requisite skills, but still may need to learn about a patient's condition and gather information in order to act. The method, if there is one, is more pattern matching and problem solving by experts and, in a sense, media are the methods for getting patient information to experts so they can exercise these skills. Confounding issues persist in this context because content is conveyed via media.

It is often impossible to control for the differential effects of content and media in telemedicine in the way studies have tried to control for media and methods in instruction, especially in cases where the content is inherent in the medium. The CT and MRI images taken of the same anatomy in Figure 1 illustrate the point. One does not have to be a clinician to see at a glance that the two images convey very different information; that hard matter is depicted better in one medium and soft tissue better in the other. Studies of the effectiveness of CT and MRI in diagnosis and treatment planning are of considerable interest and generally involve comparing clinician diagnostic accuracy and confidence when given data in these modalities (cf., Andersson et al., 2005; Hosalkar et al., 2005; Lubovsky et al. 2005; Robertson et al., 2003). It is hard to envision radiology students being able to learn how to read CT and MRI scans without being exposed to the scans themselves or representations of them in a substitute medium that can encode substantially identical information. But media more common to general instruction and training than CT and MRI can be used to further illustrate the point. For example, black and white and color photos theoretically might be used to diagnose skin diseases and teach diagnosis, but the former lack the attribute of color essential to classifying most skin lesions.

Studies of the use of video in telemedicine provide additional evidence of how the capabilities of this medium differentially affect performance in varied medical specialties—differential effects having implications for instruction. Two evidence based reviews of telemedicine research by Hersh et al. (2001a; 2001b) summarize findings where more than just audio is used (telephone consults) and where telemedicine is employed as a substitute for face to face patient care (e.g., in specialties other than radiology and pathology). Although several technologies might be employed as a substitute for face to face interaction, the most used medium is video. The studies cited in the Hersh et al. (2001a; 2001b) reviews involving the use of video for distant diagnosis in three specialties will be used to show how the medium impacts performance and illustrate the ways video has been researched in telemedicine. The studies focus on whether the technology introduces artifacts that might be sources of error, since an overriding concern in using any medical intervention is to first do no harm.

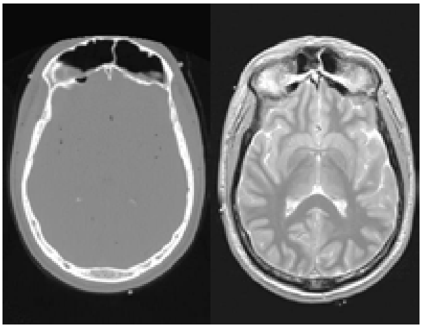

FIGURE 1. Visible Human CT (left) and MRI (right) images of the head taken of the same plane.

Tables 1 through 3 show the results of telemedicine studies in dermatology, ophthalmology, and otolaryngology. All of these studies compared the diagnostic agreement of experts when patients were examined in person or remotely via media. Some studies focused on the agreement among individual clinicians, while others checked how well diagnoses of individual clinicians compared to those made by a team of physicians or diagnoses derived from biopsies. The first dermatology study in Table 1 (Lesher et al., 1998) used digital video, while the second (Krupinski et al., 1999) used digital photography. There is higher agreement when dermatologist make diagnosis from in person exams then from video (Lesher et al., 1998) and the level of agreement between in person and remote diagnoses is higher for photographs, although in person exams are still better, even when photographs are judged acceptable (Krupinski et al., 1999). The first ophthalmology study in Table 2 (Nitzkin et al., 1997) compared agreement of individual diagnoses made locally to those made remotely via video to a criterion diagnoses made by a team examining patients in person, while the second compared the in person and remote diagnoses of individuals (Marcus et al., 1998). The level of in person and remote agreement in these studies is higher than in the dermatology studies, although it drops with the presence of cataract, indicating that patients with this condition should be examined in person. Both studies in Table 3 comparing in person and remote diagnoses in otolaryngology using video showed agreement levels similar to those in ophthalmology (Pedersen et al., 1994; Sclafani et al., 1999). The exception was for remote diagnoses made from recorded exam clips, although longer clips were judged more sufficient (Sclafani et al., 1999).

TABLE 1
DIAGNOSTIC AGREEMENT TELEMEDICINE DERMATOLOGY STUDIES USING VIDEO

Video (Lesher et al., 1998)	**In Person Agreement** Full = 94% Partial = 6% Total Full/Partial = 100%	**In Person/Remote Agreement** Full = 78% Partial = 21% Total Full/Partial = 99%	
Digital Photo (Krupinski et al., 1999)	**In Person/Photo Agreement** 84%	**In Person/Biopsy Agreement** 89%	**Photo/Biopsy Agreement** 76%
	Photo Acceptability for Sharpness = 83% **for Color** = 93%		

TABLE 2
DIAGNOSTIC AGREEMENT OPHTHALMOLOGIC TELEMEDICINE USING VIDEO

Video Study 1	**In Person/Team Agreement**	**Remote/Team Agreement**
(Nitzkin et al., 1997)	91.2%	86.5%
Video Study 2	**In Person/Remote Agreement**	**In Person/Remote Agreement**
(Marcus et al., 1998)	No Disease = 95%	Disease (cataract) = 83%

TABLE 3
DIAGNOSTIC AGREEMENT IN OTOLARYNGOLOGIC TELEMEDICINE USING VIDEO

Video Study 1	**In Person/Remote Agreement**	
(Pedersen et al., 1994)	Same Specialist = 100%	
Video Study 2	**In Person Agreement**	**In Person/Remote Agreement**
(Sclafani et al., 1999)	(Resident/Specialist) = 95%	(Specialist/Specialist) = 85%
	In Person/Remote Asynchronous Record Agreement	
	(Specialist/Specialist) = 64%	
	Records Judged Sufficient = 62%	

A number of observations can be made from these studies. First, they indicate that the effectiveness of video in telemedicine varies among specialties. Diagnostic consistency degrades significantly when video is used for distant examinations of the skin than when it is used for examinations of the eyes, ears, nose and throat. The need to palpate in dermatologic exams and video's lack of resolution compared to still pictures are factors. In contrast, diagnostic exams in ophthalmology and otolaryngology use optical devices (ophthalmoscopes and endoscopes), rely less on touch, and display output visually, often via video. Consequently, remote eye, ear, nose and throat examinations with video are more congruent with normal clinical practice. Second, the studies provide valuable guidance both to decision makers and clinicians who deploy and use telemedicine systems. They suggest what medical problems and specialties might benefit most from remote consultation via video, when telemedicine might be done best asynchronously or synchronously in real time, and where evidence of certain abnormalities mandates in person examinations because there is reason to have less confidence in remote assessment.

Instructional Implications

If performance in remote consultation is affected by the similarity of the media employed with that used in regular practice, it might also affect learning the performance. Video, for example, would have higher fidelity in learning endoscopy than still images and an endoscopic simulator incorporating both video and haptic feedback would offer even greater fidelity. In a way, the outcomes of the telemedicine studies examining how well performance transfers from one context (face to face) to another (remote) have commonalities with studies investigating how learning a task in a training context might transfer to performing the task on the job. Transfer studies show that generally the more key features of a task and its context are modeled in the training environment, the greater the transfer (Gentile, 2000) and it would follow the more media can accommodate these features, the greater the transfer as well. To the extent that many of the media used in practice often employ multiple modalities (sight, touch, and sound), studies showing the benefit of multimedia (Mayer, 2001; Park & Etgen, 2000) also support the assertion that the similarities between media used in practice and training would positively affect learning.

These observations complement those of Luterbach (2005a, 2005b) who has argued that only computer driven simulations can provide the real time visual and motion feedback necessary for flight training. While Clark (2005) discounts this argument because actual airplanes are an alternative training medium, there are realistically few other plausible media options. To contend actual airplanes are an alternative only suggests simulator fidelity with actual flight promotes transfer and that the two media (simulator and aircraft) share attributes providing the information required to perform the task. Luterbach (2005a; 2005b) also argues that certain training goals, such as flying, are holistic, mixing cognitive, motor and affective learning that limit media options and those options expand as objectives become more basic. In certain fields, however, the role of content may be just as important in determining media choice as the level of learning. For example, learning the characteristics of melanoma is a lower level instructional goal than learning to diagnose skin disease, but the lesion's features dramatically constrain media choice.

Comparison Studies

Since criticisms of media effectiveness in instruction are often accompanied with objections to comparison studies, it is useful to examine the role of these studies in other contexts. Each of the telemedicine studies cited in this article involves media comparisons. They all describe the technologies used in great detail. When a protocol for transmitting video conforms to a widely used standard (e.g., H.320 or H.323), the brand of the videoconferencing system is still specified because there can be variability in the way different companies implement standards. The brands and models of the cameras and monitors used are described as well as monitor resolution because lens and monitor characteristics also vary. Data transfer rates and available network bandwidth are usually discussed because the former affects resolution and the latter, if it is inadequate or subject to congestion, can introduce artifacts such as latency, jitter, and pixilation. All these factors affect picture quality and, consequently, the performance of clinicians. The rich technology descriptions as well as the goals and design of the studies indicate the researchers assumed media would be a factor from the start, and the evidence supports this.

All the studies involved comparing mediated performance with that when patients and physicians interact in person. Different technologies have been compared in telemedicine either within studies (e.g., Maurin et al., 2005) or by examining the results obtained from different studies (e.g., Krupinski et al., 1999; Lesher et al., 1998). In this sense, study design is not all that different from those comparing distance learning with face to face or mediated instruction with classroom. It is hard to conceive of how any diagnostic telemedicine technology (or method for that matter) could be adequately assessed without some comparison. The basis of comparison in standard telemedicine research, reasonably enough, usually is the diagnosis generated from standard patient-physician encounters, either those involving a single physician or those setting an even higher "gold standard" involving consensus of a team or some other definitive test such as biopsy. And when emerging technologies such as 3D imaging or 3D video are assessed, they often are compared to other more commonly available 2D technologies (cf., Nixdorff et al., 2005; Welch et al., 2005). These comparisons are made to ensure that the technology does not make medical decisions worse. Seen in this way, a non-significant difference is re-assuring and may be considered a positive outcome by those having to decide which technologies to deploy.

There has long been a concern that research and evaluation can over simplify and be overly rigid (cf., Gooler, 1971; Stake, 1975). There are always dangers research and evaluation studies can overlook issues of importance to decision makers and other constituency groups and that conclusions might be made that are unjustified, whether a study involves comparison or not. But this does not mean that controlled comparison studies are without value. Researchers doing telemedicine or instructional comparison studies do not just administer evaluation instruments and walk away. They observe and monitor the treatments that they measure and these observations help pinpoint aspects of the treatment or its implementation that produce any measured effects. In telemedicine studies, transmission failures, number of unacceptable images, default settings and adjustments, clinician satisfaction and difficulties using equipment are often observed and documented in much the same way media researchers in education and training record the implementation and use of their technologies.

Clark's (1983) critique of media comparison studies focused on their limited usefulness to researchers interested in building theories of learning, although he did acknowledge that the study of media attributes may contribute to instructional design (p. 451). Educational evaluators have argued for some time that evaluation is best served by examining issues inherent in instructional programs instead of those of concern to social science (House, 1973; Stake, 1975). More recently, the notion that educational research should focus on theory at all and the feasibility and meaningfulness of exerting controls to compare the "same" things in such studies has been questioned (Glass, 2000). But one does not need to take a position on these broader concerns to appreciate the usefulness of studies comparing different media to practitioners having to make decisions about developing, adopting, and deploying technologies and programs. Making decisions between apples and oranges is part of their everyday life and the crux of their decision making. Given alternative technologies, they want to know which are likely to be less costly, which are likely to be more efficient *and* more effective, and which are likely to cause the least harm. They are not concerned whether the issues are surface or structural so much as that they are real. The medium and method confound is acceptable to them if the media accommodate the methods of interest, and the evidence comparison studies provide can assist them in making these judgments.

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