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Media Mixes and Learning Networks[1]

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The effectiveness of employing a symbol system for instructional pruposes depends on the extent to which the specifically selected coding elements activate in the learners mental skills that are sufficiently mastered by them and are relevant to the requirements of the learning task. (Salomon, 1979, p. 110)

Media do not influence learning any more than the truck that delivers groceries influences the nutrition of a community. (Clark, 2001b, p. 5)

All methods required for learning can be delivered by a variety of media and media attributes.... Therefore, aside from the identification of necessary methods for learners and tasks, it is important to derive media that are capable of delivering the method at the least expensive rate and in the speediest fashion. (Clark, 2001c, p. 313)

INTRODUCTION

There has been little research on the effect of different media mixes and sequencing on the process and outcomes of asynchronous learning networks (ALNs). The past decade of research on distance education has primarily emphasized design issues, interactivity, active learning, and learner characteristics, mostly through descriptive research (Berge & Mrozowski, 2001). This chapter reviews some of the theories and findings about media characteristics in general that seem most applicable to conceptualizing the pros and cons of incorporating multimedia into online courses, and selected studies that included medium as a variable. The following sections introduce the diversity of ALNs, and summarize some relevant media

[1]Portions of this chapter were adapted from Rice (1992) and Spencer (2002). Eunhee Kim contributed to the review of multimedia studies.

typologies, media characteristics theories, and educational media theories. Then extant studies using multiple new media for educational settings are reviewed to try to identify both particular lessons learned and implications for new media implementation in ALNs.

THE MEDIA CORNUCOPIA

Rumble (2001) identified a variety of changes in the concept and application of distance education from 1971 to 2001. Relevant among these are a shift from a transmission model of education toward a more constructivist model, facilitated by computer-mediated communication, and a related shift from a bureaucratic, assembly-line approach toward a greater focus on the student, flexibility, and global reach. Note the paradoxical shift to more communicative and interactive learning associated with the use of technology, often critiqued as a depersonalizing factor.

"Text-only" computer-mediated communication (CMC) through threaded conferences or e-mail lists dominated the first decade of asynchronous learning networks (e.g., Harasim, 1990; Hiltz, 1986, 1994). Recently, however, the hardware, software, and high-speed network connections have become available to allow the integration of many other forms of digitized, networked, and interactive computer-mediated communication. Chief among these are synchronous chats; asynchronous, digital audio via freely available software, such as Real Audio® or Powerpoint® slide shows with digital audio accompaniment; real-time classwide data analysis; posting of digital photos or diagrams or graphics (including animated graphics); synchronous "net meetings" via video or audio; group decision support systems; and interaction via "virtual reality" types of mechanisms, such as avatars. Current developments include extremely mobile or pervasive devices such as hand-held computers, wireless-enabled tablet PCs, and asynchronous digital voice message boards accessible from mobile phones.

These developments mean that courses may now combine face-to-face, traditional media, text-based CMC media, and new audiovisual media to deliver materials, coordinate group projects, provide access to processible information and discussions from local as well as international institutions, and foster interaction among students and external participants. Printed textbooks, articles, and chapters may be replaced with CD-Roms or online libraries, which can add audio, video, graphics, databases, and interactive exercises. Of course, traditional classes have used a variety of media, including chalkboards, music players, videocassette recorders and TV monitors, maps, and so on.

ALNs can be seen as a way of freeing the individual learner from time and space barriers to two-way communication, which, in supportive situations, can foster self-learning (Keegan, 1986). Learning networks can also be thought of as a way to increase the efficiency of educational delivery, applying industrial production methods of division of labor (Peters, 1988). A third approach emphasizes both the learner's independence and freedom of choice as well as the communication process of learning, because ALNs can provide access and guided conversation to diverse learners (Holmberg, 1989).

Many mediated courses use a mix of face-to-face meetings, online discussions (synchronous or asynchronous), and lectures delivered by television, videotape,

CD-Roms, or online multimedia. One pattern for a mixed media or "blended" or "hybrid" course is an intensive weeklong session on campus at the beginning of a year followed by online reading, discussion, and testing, such as for the University of Illinois online master's program in library science. Another pattern is face-to-face meetings at the beginning and end of a semester, as in Rutgers University's undergraduate communication internship program, during which students discuss and evaluate each other's experiences through a web-based structured discourse space. A third and probably the most common pattern for hybrid courses is regularly scheduled face-to-face sessions that are combined with online discussions and group work; an example of this is at the University of Central Florida, where many courses meet face to face only 1.5 hours a week instead of 3, and do the other half of the course online.

What do we know about the effects of using multiple media in online courses, or about the appropriate sequencing of such media? What theories can help to frame research questions about the effect of media mixes on the process and outcomes of online classes?

DO MEDIA DIRECTLY AFFECT LEARNING?

Whether media by themselves actually have measurable impacts on the process and outcomes of education is controversial. Clark (2001a) argued that results consistently show no significant learning benefits from any specific medium per se. Meta-analytic studies show (when controlling for differences in content or instructional method across media, for novelty effects for new media, for variations across instructors, curricular reform, or effort) little or no remaining independent effect of the medium (Clark & Craig, 2001; Russell, 1999; Schramm, 1977). The counter point of view says that, of course, pedagogy and content are the important variables, but certain media may be better suited than others to support specific types of content and/or specific pedagogies (e.g., collaborative learning strategies), thus representing independent effects of the medium (Kozma, 2001b; Orr, 1997).

As pointed out in Hiltz's (1994) study of a Virtual Classroom®, computer-mediated communication is especially well suited to collaborative or cooperative learning strategies. For example, most courses in the original 3-year Virtual Classroom® study included one or more "seminar"-type segments in which the students became the teachers. Individual or small groups of students were responsible for reading material not assigned to the rest of the class, preparing a written summary for the class of the most important ideas in the material, and leading a discussion on the topic or material for which they were responsible.

The online seminar format had several advantages compared to the face-to-face seminar. First of all, in the face-to-face situation the seminar format is generally restricted to small classes of very advanced students, because it is too time consuming to have more than about 15 students doing major presentations. Second, less advanced students may feel very embarrassed and do not present material well in oral reports to their peers, and are even worse at trying to play the role of teacher in conducting a discussion. In the written mode, students can take as long as they need to polish their presentations, and the emphasis is placed on the quality of their work and ideas, not their public speaking skills. Other students can read material in a

much shorter time than it would take to sit through oral presentations. If the material is poorly presented, members of the class may press the "break" key, whereas etiquette dictates that they must sit and suffer through a poor student presentation in the face-to-face situation. Finally, in an online course it is easier for students to interact directly with each other, and provide class content, than in face-to-face classes (Quinn, Mehan, Levin, & Black,1983).

Another example of how collaborative learning is facilitated by ALN is the group project. At NJIT, most students do not live on campus, and are also working either part time or full time. Thus, it is almost impossible for a team of students to find a convenient time and place outside of class hours to work on a project together. The online asynchronous team conference not only allows them to work together "anytime, anywhere," but also motivates more equal participation, because the instructor can observe the group work and determine if all members have contributed to the project. Just knowing that the instructor can and will do this tends to discourage "free riding" or "social loafing" among group members.

Dede (1996), among others, emphasized the importance of "learning through doing," which involves individualized presentational and constructivist experiences in problem-solving, case-based contexts, available to students on demand. Dede maintained that new forms of distributed learning, especially those offering multimedia and hypermedia, have the potential to provide this kind of learning process. Multimedia educational applications supply information in multiple formats, allowing those with different learning styles to use material in preferred presentational modes (Alavi & Leidner, 2001). Hyperlinking capabilities allow the development of knowledge webs that provide distributed access to experts, archival resources, experiential environments, and collaborative learning. Other computer-based capabilities help to facilitate communication among participants while structuring group dialogue and decision making. Examples include using a group support system (GSS) in anonymous mode, fostering brainstorming to generate ideas for discussion, or providing a simulation of a newsroom for a journalism class.

RELEVANT MEDIA THEORIES

Research is a constant interplay between theory and evidence. There are several theories about the dimensions and characteristics of different media on the process and outcomes of group communication that can help to frame investigations of media-mix effects in online classrooms. Rice and Gattiker (2000; see also Culnan & Markus, 1987; Rice, 1993a) offered three propositions about the role of media characteristics in general.

First, media may be compared in many ways, and comparisons must take into account the communicative context and how the medium is implemented, so that no medium is absolutely preferable or inherently better or worse. The characteristics typically associated with specific media (discussed later) are not completely fixed or inherent but can result from intentional design, moderator roles, participation patterns, implementation, and user choices and involvement (Eastmond, 1993; Rice, 1987, 1999), although of course some features or capabilities are constrained or enabled by technology.

Second, CMC has many more capabilities than just the by-now familiar "overcoming constraints of time and space." Because content is processed through computers in digital form, the ability to reprocess, combine, and analyze information in many forms from multiple sources has profound implications (Rice & Gattiker, 2000).

Third, much of what we feel is "natural" about traditional media is largely an artifact resulting from the confounding of particular characteristics (e.g., material production, forms of access, oral or print mode, social conventions, etc.) with a particular communication medium in the context of familiar or habitual use (e.g., the traditional telephone in the home; Rice, 1993a, 1999; Smith & Dillon, 1999).

Bretz's Media Typology

In 1970, Bretz published a foundational analysis of media characteristics for instructional purposes. He first clarified that communication media are systems as well as subsystems of larger user systems such as instruction, advertising, and so on. The larger user system includes the sender and receiver, both of whom use the communication system (which includes people in the programming, etc.) Bretz noted, "Each medium requires the message to be encoded into a different format, using a different set of techniques, and resulting in a different kind of program" (p. 37) and each medium allows many kinds of programs (i.e., formatting). Thus, it is misleading to posit that a particular medium has one specific effect or single best application. Furthermore, a particular media system cannot be fully evaluated within its own system—it must be evaluated within the larger user system(s) and coordinated by the "user" with many other functions.

Bretz's typology argued that there were two primary dimensions of instructional media: telecommunication (transmission) versus recording/storing; and combinations of sound, visual (picture, line graphics, print), and motion (and semi-motion). Icons (pictures and line graphics) are more appropriate for representing people, places, and things, because they represent something; symbols (line graphics and print) are more appropriate for generalities and abstract concepts. Combinations of these two dimensions result in seven classes of media: audio-motion-visual, audio-still-visual, audio-semimotion, motion-visual, still-visual, audio, and print.

These seven types can be combined into multimedia, in sequential or simultaneous conditions. Thus, for instance, a still-visual (not time based; e.g., a photograph) can be synchronized with a time-based medium (e.g., videotaped panning and zooming over photographs). To serve for self-instruction and as an object of study, such a single or multiple medium needs playback, freeze, and other features under the control of the learner, while maintaining synchronization across all displays.

Social Presence and Media Richness

Social presence (Short, Williams, & Christie, 1976) and media richness (Daft & Lengel, 1986) theories both emphasize how communication media differ in the extent to which (a) they can overcome various communication constraints of time, location, permanence, distribution, participation, and distance; (b) transmit the social, symbolic, and nonverbal cues of human communication; and (c) convey equivocal information. The essential underlying principle is contingency theory.

A good match between the characteristics of a new medium (e.g., relatively high social presence or media richness in multimedia conferencing) and one's communication activities (e.g., equivocal tasks like strategic decision making) will lead to "better" (more effective, less time consuming, more satisfying, etc.) communication performance. Thus, a medium may not only be "too lean" for particular tasks, but also "too rich" for others.

Social presence theory argues that different media foster different levels of perceived intimacy and immediacy. Face-to-face contact yields the highest level of social presence, and asynchronous written communication provides the lowest level of social presence (Rice, 1993b; Short et al., 1976). Presence in general is thought to have an intensifying effect on media users, increasing or enhancing enjoyment, involvement, task performance and training, desensitization, persuasion, memory/socioemotion, and parasocial interaction (Lombard, Ditton, & Reich, 1997). Short et al. (1976) reviewed and conducted social psychological surveys and experiments that suggested a set of activities as likely to be affected by differences in a medium's social presence: less personal tasks (exchanging information, problem solving and making decisions, exchanging opinions, generating ideas), and more socioemotional tasks (persuasion, getting the other on one's side of an argument, resolving disagreements or conflicts, maintaining friendly relations/staying in touch, bargaining, and getting to know someone; Rice, 1993b).

Greater perceived social presence predicted greater student satisfaction in an interactive television class (Hackman & Walker, 1990). Bretz (1983) summarized a study of two audio conferencing systems and two video conferencing systems by Hough and Panko (1977). The video systems were rated on average as 20% more satisfactory for six personal (the socioemotional ones listed previously) activities than were the audio systems (48% vs. 40%), whereas only 3% more so for six impersonal (the more task-oriented ones listed previously) activities. Rice and Case (1983) found that upper-level university administrators rated e-mail as less appropriate for tasks requiring greater social presence—bargaining, negotiating, managing conflict. However, technical managers rated e-mail as somewhat more appropriate for those tasks, indicating that familiarity and social context can affect perceptions and effects of social presence. In another study, Gunawardena and Zittle (1997) analyzed a graduate course in distance education involving 50 students from five universities. They found that student satisfaction with the conference was primarily (58%) explained by social presence, followed by perception of equal opportunity to participate (12%), and somewhat by technical skills and experience with CMC, and attitude toward CMC.

Similarly, media richness theory proposes that the relation between media use and performance is influenced by task equivocality, media richness, and users' "media awareness" of the suitability of new media to these tasks. Media richness is the extent to which a medium can support language variety, feedback, nonverbal cues, and learning. Proposed rankings of media on social presence or richness scales are generally consistent across studies, although proposed associations of those perceptions with outcomes of usage of new organizational media for high or low task equivocality are weakly supported and inconsistent across studies (Rice, 1993b; Rice, D'Ambra, & More, 1998; Rice et al., 1992; Rice, Hughes, & Love, 1989). For example, managers in many studies use e-mail contrary to media richness predictions, CMC can support considerable socioemotional content, and media use does not have to be nor is necessarily intentional (Lea, 1991; Rice, 1987, 1993b; Rice et al., 1992; Rice & Love, 1987; Trevino, Lengel, & Daft, 1987). The negative effects associated with using media low in information richness or social presence for equivocal contexts may be limited to a narrow set of situations including laboratory experiments, zero-history groups, and short initial usage periods (Walther, 1992).

A text-based ALN would theoretically be classified as low on social presence. However, studies have shown that a sense of both personality and community can be generated in such a communication environment, often using a variety of communication conventions (e.g., keywords, shorthand, nonverbal cues in text, playfulness and humor, emoticons, and smilies), to increase social presence (Murphy & Collins, 1997; Rovai, 2002). Rice and Love (1987) found that one third of messages in a CMC forum contained socioemotional content, indicating that a medium with supposed low social presence can support quite social communication. Participants in the Gunawardena and Zittle (1997) study who perceived a high level of social presence wanted to enhance their experience (and satisfaction) by utilizing alternative forms of social-emotional expression, such as emoticons (e.g., the "smiley" or "winky" ;=)—i.e., punctuation and alphanumeric characters used to represent emotions).

Paradoxically, precisely because cues that ordinarily regulate speaking, turn taking, and attention are reduced or absent (e.g., physical appearance, voice, dress, gender, status, etc.; Rice, 1984), CMC may foster greater participation from and among students, especially those who are shy or anxious, are minorities or have speech or sight disabilities, or are not typically dominant in face-to-face settings. Discussion via CMC may include more diversity of viewpoints, egalitarian participation, interpretative risk taking, and challenges to textual authority than in traditional face-to-face settings. Furthermore, the relative lack of social presence in online settings can foster relationships with people who have more diverse social characteristics than might normally be encountered in person. CMC's very lack of forced immediate feedback (as in face-to-face interaction) gives participants more control over the timing and content of their self-disclosures.

Swan (2002) reported one of the most comprehensive comparisons of online media, assessing 22 course design factors and student perceptions across 73 online courses offered by the State University of New York (SUNY) Learning Network in spring 1999. The three most important influences on student perceptions were course design consistency and clarity, feedback and contact from course instructors, and valued and active discussion. Other studies have also discerned that computer-mediated communication can be conceptualized as a way to increase individual and dyadic interaction in the traditional large lecture course, thus taking a computer-assisted personalized approach (Thoennessen, Kashy, Tsai, & Davis, 1999). For example, students can identify with and work in groups via listservs, and poorly performing students can be individually contacted by personalized e-mail from the instructor to encourage better performance. Additionally, chat can be used as part of an examination support medium (Witfelt, Philipsen, & Kaiser, 2002).

The potential for more equal participation, however, does not necessarily mean equal attention from others (especially in noncooperative social contexts), because

it is far easier to be selectively attentive in CMC than in face-to-face communication. For example, some argue that the use of CMC in traditional ways may just reinforce existing gender and power inequities (Brail, 1996; Collins-Jarvis, 1996; Ebben, 1993; Frissen, 1992; Selfe & Meyer, 1991; Sparks & van Zoonen, 1992). Precisely because context may be depersonalized due to anonymity and weak social feedback, online communication may be more disinhibited and critical, and lessen public awareness of social sanctions.

The general argument would be that for educational goals that involve more socioemotional or equivocal aspects, media with greater social presence or richness are more appropriate. Thus, an initial synchronous online meeting of class members, arriving with different backgrounds, might generate equivocality-reducing information in the minds of the students. Conversely, a print and/or online medium would be appropriate for reducing uncertainty by providing easy access to the syllabus and course schedule. The completely asynchronous online class and the completely face-to-face class *both* leave the students and teacher with only one communication medium.

OTHER CHARACTERISTICS AND INFLUENCES

Other theoretical approaches extend both the range of media characteristics as well as the influences on perceptions and use of media, including:

- *Social contexts and influences:* Usage contexts (Moore & Jovanis, 1988), social influences (Fulk, 1993; Rice & Aydin, 1991; Rice, Grant, Schmitz, & Torobin, 1990), and symbolic aspects (Bozeman, 1993; Sitkin, Sutcliffe, & Barrios-Choplin, 1992; Trevino et al., 1987).
- *Differences in users' status or role:* Status differences across lines of authority and organizational boundaries (D'Ambra & Rice, 1994), and distinctions between initiator and responder (Zmud, Lind, & Young, 1990).
- *Changes in usage and understanding of a medium over time:* The ability to process social information in CMC content (in order to convey socioemotional content and to develop personal relationships with others) increases over time (Walther, 1992), experience with the medium and communication partners (Carlson & Zmud, 1994), the extent to which problem solving becomes routinized over time (Dawson, 1995; McKenney, Zack, & Doherty, 1992), and timeliness and sequential patterns in using different media (Valacich, Paranka, George, & Nunamaker, 1993).

Media synchronicity theory (MST) extends media richness theory to give a dynamic time-changing value to the richness of the media (Valacich, Paranka, George, & Nunamaker, 1993). MST proposes five significant media characteristics: *immediacy of feedback, symbol variety* (use more than one representation of the information or to match the symbol to the type of information), *parallelism* (number of channels that can simultaneously be in use in the medium), *rehearsability* (ability to read and edit messages before transmission or after reception), and *reprocessibility* (receiver may read, watch, or listen to the message more than once). Rich, synchronous media at one period may not be optimal at another period. When information *conveyance* is the task, media providing low synchronicity (low feedback and high parallelism) will be of benefit, whereas when information *convergence* is the goal (or task) of the users, media providing high synchronicity (high feedback and low parallelism) will be most appropriate. One can presume that the need of newly formed online classes to resolve ambiguity in group well-being and individual support can be served by high media synchronicity. The class needs for information such as what is provided by the syllabus (that can resolve uncertainty about the schedule and assignments) may be best communicated with low synchronicity media that allow reprocessibility.

Another extension of the media characteristics approach is Smith and Dillon's (1999) classification based on research related to *learning and motivation*. The authors proposed that the essential distinction in media attributes is the extent of support for learners' *cognitive* or *social* processing (to some extent related to conveyance and convergence). For example, text-based databases or organizers can support cognitive processing, whereas real-time video can help distant groups improve their social interactions. Smith and Dillon suggested three primary attributes of media that should differentially support these learning processes: *realism/bandwidth, feedback/interactivity,* and *branching/interface*. Greater bandwidth supports greater realism (images, motion) but may also make it more difficult to identify and ignore irrelevant information, swamping the abstract concepts communicated through word or sound. Feedback and interaction (via video, audio, and text) improve cognitive processing and learner motivation. Branching (or contingent response) provides instruction based on prior responses, thus tailoring the content to the user. Branching can also be simultaneous, as part of an interface providing contingent access to multiple resources.

Computer-based media have intrinsic advantages over traditional mass media for instruction, because interactive media can provide channels for interpersonal communication to reinforce and extend the learning. According to Lieberman (2001), particular characteristics possible through interactive media include: *network interconnectivity* (to diverse and updateable content), *interactivity, personalized content* (and format based on users' characteristics and choices), *user control* (over timing, format, and content), *communication* (asynchronous and synchronous, private or public), *multiple input and presentation modes* (providing greater entertainment and motivation), and *portability* (smaller, wireless, continuous access, in diverse environments). Kozma (2001a) identified five other media attributes that could facilitate learning: *present moving objects* onscreen, allow user to *manipulate objects,* present *complex contexts that in turn stimulate dynamic mental images, search and display information,* and provide *visual and social context.* Thus, for example, a multimedia computer-based approach may be better at conveying rich and complex social situations than may a face-to-face class, so that students can better understand and act in those environments.

Another significant technical and social factor is *critical mass,* which means enough initial users to stimulate rapid later adoption by others (Markus, 1990; Rice, 1982, 1990; Rice et al., 1990). The value of a communication network rises, and the relative cost of each person's potential adoption of the network decreases, more and more users engage through the system, as the number of possible interactions rises much faster than the number of additional participants. Eventually a critical mass

develops, where there are sufficient users and interactions to sustain the social system and generate additional value to each participant. A critical mass of users also fosters initial and adaptive uses of the new medium to become shared with and accepted by subsequent users. Local critical masses (e.g., course teams or project groups) are especially crucial to the successful diffusion of a new communication medium, because members are more likely to share similar benefits and costs.

THEORIES OF EDUCATIONAL MEDIA

Some educational theories specifically consider the interaction of media characteristics with students' cognitive processes and abilities (as well as teaching methods, tasks, etc.; Clark & Salomon, 2001). These include:

- *Symbol systems theory* (Goodman, 1968) proposes specific dimensions of symbol systems (e.g., the extent to which a symbol system has explicit notations), so that each symbol system has different biases, or would foster different informational or behavioral aspects of learning.
- Olson's (1976) *theory of instructional means* asserts that media and techniques influence the development of relevant cognitive skills, because they influence how environmental information is perceived, converted, stored, and retrieved. The content of a medium affects the acquisition of knowledge through rules and principles, whereas message codes affect the development of skills and strategies. Hence, for example, text-based instruction may emphasize (be biased toward) analytic, scientific, and philosophical knowledge, whereas oral-based instruction may emphasize negotiation, social relations, and context.
- Salomon's (1979) *media attributes theory* argues that the mind as well as media uses symbols, and these mental symbol systems may be influenced by or acquired from media symbol systems. The more unique a medium's symbol system is, the more distinctive the required mental skills must be. Alternatively, the more the symbol system of the particular medium matches the student's learning style and mental representations, the easier the student can process and understand the message. Some cognitive skills can be improved through experiencing their use in media, whereas others can be inhibited by being dominated by various media symbol systems.
- *Dual coding theory* (Paivio, 1985) claims that recall scores are greater when a learner processes both words and pictures, because visual and verbal information are separately cognitively coded. Visuals can be recalled from various relative positions, but text can only be processed sequentially. Thus, perceiving and storing material in two coding systems improves recall and understanding.

The fundamental assumption of these theories—that the medium per se can influence learning outcomes—is subject to several critiques. Clark (2001a), as did Bretz (1970), argued that any media system can provide most types of symbols, and thus effects are not logically necessarily due to a particular medium. Some symbolic modes may serve no instructional purpose, and many modes may serve the same cognitive processing purpose. Another question Clark raised is whether images or propositions are the more fundamental cognitive representations, thus invoking visual/audio or textual media codes. Or, if most content is processed through propositional rules, then the original image or textual form may not matter much, except in the initial stages of decoding (Clark & Salomon, 2001), which at least would affect learning speed. Hence, different media modes may support different cognitive functions, rather than having specific cognitive effects. That is, sequential logic could be fostered through computer programming but could also be developed through personal tutoring.

Additionally, does a skill developed through use of a particular medium transfer to other situations? Media symbol systems may cultivate particular cognitive skills, but those may well not be especially useful, unique, or transferable. Clark and Salomon (2001) asserted that the active learner affects how any of these stimuli are experienced, anyway—so anticipations, assumptions, or expectations about a particular medium, including expected levels of effort required as well as student self-efficacy, may be the most significant influences, often affecting learning positively, whereas satisfaction and enjoyment are less associated with learning. Subsequent tests of dual coding theory concluded that visual and verbal forms of instruction do not by themselves affect memory activation.

SOME STUDIES OF THE EFFECTS OF EDUCATIONAL MEDIA MIXES

As should be clear from the previous review, no one medium has all of the characteristics that perfectly match the needs of ALN users through all phases of a course. Furthermore, any medium might be sufficient to accomplish some or even many of the needs of teachers and learners, depending on the pedagogical approach and the social context. In combination, the sufficiency of any medium may be increased by judicious use of complementary media, or even the same medium, in various time periods or phases. The following sections review studies that may provide some evidence related to the supposition that combinations of media with different sets of characteristics will result in better outcomes than relying on text-based ALN alone.

Video and Audio Content

By the late 1960s, there was enough experience with educational uses of radio and video instructional technologies to allow a comprehensive review by Chu and Schramm (1967; see also Schramm, 1977). These instructional media studies showed that, about 75% of the time, there was no significant difference between video/television and face-to-face instruction; the other 25% of the time was about evenly split between improved and decreased learning. However, video had certain advantages: enriches audiovisual content, puts more effort into lessons/program, can raise average lesson quality, permits access by multiple audiences over multiple time periods, and can allow the instructor do other important activities (e.g., "interaction, understanding, encouragement and informal progress appraisal ... group leader ... adult model to emulate"; Bretz, 1970, p. 50).

On the other hand, there were also several sources of communication failure associated with video and radio instruction: transmission or recording, program display subsystem, program production, and message origination. Applying Bretz's (1970) notion of higher-level media constraints, video is not good for a large amount of print, or for high-resolution, print. Also, full motion, although transmittable through both streaming video or full-motion video, is not usually needed for instructional presentations and can be a distraction (Bretz, 1970). The added realism or dynamic quality doesn't seem to have much of an effect on learning outcomes, although it may affect some aspect of the learner's affective domain (or, as noted earlier, even create sensory overload and distraction). Indeed, Matarazzo and Selen (2000) found that students in distributed work groups in a narrowband video condition reported higher satisfaction and lower task completion time compared to those in a broadband video condition.

Kelsey (2000)—who studied 73 students and 5 site facilitators in an animal science course delivered to five locations by interactive compressed video (ICV) technology—also highlighted some of the obstacles to interaction. Very little interaction occurred in any of the types of course communication forms (face-to-face interactions among students and facilitator within each site, question-and-answer sessions at the end of each class, a web-based discussion board, e-mailing of content-related questions, and informal luncheon discussions with guest speakers at the originating site). In general, interactive compressed video did not foster much interaction among participants, especially with participants at other sites. The primary barriers to interactions included social concerns, technology failures, time, content, camera shyness, site facilitator's role, and additional time for processing content. However, knowing that they could be seen through the system did increase students' sensory awareness, their attention, and their modeling of appropriate behavior, compared to students working with delayed videotape.

Machtmes and Asher (2000) analyzed 11 experiments that used video and either one-way or two-way audio compared to traditional instruction. There was little average difference, although there was considerable variation. Of the 10 factors evaluated, the only positive effect was due to the presence of two-way interaction. A study of a two-way audio/two-way video system of delivery (Hilgenberg & Tolone, 2000) found no difference in students' satisfaction levels or ratings of the instructor between main site and remote site participants, nor in opportunities for critical thinking between students in general in the two sites. However, education students in the main site perceived greater critical thinking opportunities than did education students at the remote site, or nursing students in either site. Thus, it's possible that familiarity with pedagogical processes is necessary to take advantage of those complex approaches, regardless of medium.

One of the most rigorous designs testing for effects of educational video media compared three forms of video—videoconference and one-frame webcasting across a LAN, a two-frame webcast across a LAN, and a three-frame webcast across the Internet, while applying the same presenter and teaching material in each condition—on three aspects: presentational, technical, and educational (Reynolds & Mason, 2002). There were no differences in presenter and teaching material across the media conditions. However, videoconferencing was deemed more suitable for major lectures whereas webcasting was better for a one-to-one situation. In terms of technical aspects, webcasting demands, setup time, and audio were better than for videoconferencing, but suffered from bandwidth congestion. The three-frame Internet webcasting benefited from the use of a chat box that allowed students to consider their comments before responding.

Audio combined with (tele)graphics is a less frequently used instructional medium, but does provide the two primary communication modes of sound and text/images. Oliver and McLoughlin (1997) studied the role of interactivity in this mixed medium through analysis of videotapes of six teachers providing audiographics lessons to remote schools in Western Australia. Although various kinds of classroom interactions were possible within the same technological media combination, the teachers tended to use didactic instructional approaches that limited learner-initiated communication and collaborative activity. There was little communication between teacher and students on equal terms, to pursue meaning, or to construct personal ideas, and the teachers tended to use the communication feature to "control" the remote classroom. Partially this was due to an incomplete understanding by the teachers of the possible types and forms of interactivity available through computer conferencing, but such results warn of the more general issue that instructor pedagogy can be the most constraining and limiting influence on student learning, regardless of medium.

When using or assessing video conferencing, one must consider the interaction of video characteristics with the social context. Bretz (1983) used the example of video conferencing to show that different design, image size, perspective, and depth of field characteristics of different video conferencing systems represent different kinds of social distance, which may or may not be appropriate for the kinds of learning situation desired (e.g., group discussion vs. public lecture). As a related example, an exploratory study by Steeples (2002) of a course involving learning technology professionals concluded that both digital video clips (of the "talking head" variety) and audio clips could be rapidly created. The participants were initially uneasy with the video clips, and found that it was much more engaging to have an interviewer–interviewee clip than a single talking head. The participants felt that the use of video or audio clips did help create a sense of social presence, and that the video clips were helpful in enabling the learning community to exchange and explain aspects of their professional practice. Note that the medium is not the crucial factor here: It was the ability of students to adapt the medium (i.e., conceptualizing that there were different formats and display approaches within the larger media system) that allowed a more effective use to emerge.

Adding Additional Media to Text-Based Asynchronous Learning

Text-based communication may not create an optimal learning environment for some learners, given that learners have different learning styles and preferences in terms of type or medium of information (Kim, Hiltz, Scher, & Turoff, 2003). For example, nonverbal learners are likely to learn better with nonverbal materials, such as images (Monaghan & Stenning, 1988). ALN based on text-only communication, by which information is organized sequentially, may not be an optimal communication mode for random learners (Leuthold, 1999). Thus, at least for some students, combining one or more other media with text-based asynchronous text may improve learning.

ncorporating Synchronous Chat

Spencer (2002; Spencer & Hiltz, 2003) studied the effect of mixed-media modes on teachers' and students' satisfaction with the learning process in 29 course sections. Media mode, the independent variable, had four levels derived from the mixture of asynchronous discussion forums with various levels of synchronous media use: ALN only, ALN plus face to face, ALN with one synchronous session, and ALN plus multiple synchronous chats. Instructors reported during interviews that (synchronous) chat sessions were hard to schedule because of students' time commitments, thus making it very difficult to achieve critical mass. The hypothesis that social presence would be higher in courses that included chat than in ALN-only courses was not supported. Nevertheless, many instructors reported some small success in their first chat session and felt that the experience led to better facilitation in subsequent sessions. Significantly, students found chat more "rewarding" and less "complex" in classes that scheduled chat sessions two or more times than did students in ALN-only classes, meaning that student familiarity or experience with a particular (here, computer-based) medium can improve their perceptions of that medium's social presence.

Lantz (2001) similarly found that, over time, ratings for chat meetings rose for four participants who had three meetings using chat, one using a collaborative virtual environment (CVE), and one using face to face. However, although task-oriented work was rated higher in the chat and CVE meetings (indeed, the face-to-face meeting encountered excessive social communication—i.e., it was too rich a medium), the range of topics discussed was narrower. Veerman, Andriessen, and Kanselaar (2000) noted that the kinds of argumentation, focusing, and production of constructive activities among pairs of students using synchronous CMC (NetMeeting) varied according to different discourse facilitation (i.e., the teacher's pedagogical style). Haythornthwaite's (2000) study of four multimedia distance learning classes found that those students who use the system more for communication also communicated more frequently with others in general and had more socially supportive relations. The closer ties helped foster a stronger sense of belonging to the class, and perceptions of greater social interaction among other students. Furthermore, pairs who had strong ties used more media to interact and to maintain their ties, including the development of greater "virtual proximity" by using chat (IRC) during synchronous classes and by exchanging e-mails late at night.

Adding Pictures, Graphics, or Video

Media richness theory and social presence theory predict that having a digital (online) photo of other students available to class members should result in stronger, faster feelings of affection and attraction among the members of a virtual team or class than having text only. However, media synchronicity theory or social information processing (SIP) theory assume that in some ways text-only asynchronous communication may be superior to face-to-face meetings or other supposedly "richer" media, allowing users to construct idealized impressions of the members of the class over time, and thus to form strong feelings of group identity.

Walther, Slovacek, and Tidwell (2001) conducted a study of eight cross-national student teams working together, some with text-only CMC, and some with a digital photo gallery of the team members. In new, unacquainted teams, seeing one's partners' pictures promoted the swift formation of feelings of affection and attraction. In long-term online groups, however, introducing photographs after group members had developed a sense of bonding "dampened affinity." Indeed, participants in groups with no photographs reported the highest levels of intimacy and affection and felt the CMC system was the most helpful in achieving a good impression! Thus, when it comes to media richness, more is not necessarily better, and sequencing or timing can make a difference.

In many disciplines, graphics can be very valuable for representing a complex set of relationships (e.g., flow charts or conceptual/causal diagrams). Suthers, Hundhausen, and Girardeau (2003) reported an exploratory comparison in one course that compared synchronous online communication using a graph that students could build together, with face-to-face communication in which a similar graphing tool was present. Suthers et al. found that the visual knowledge representation played a greater role in supporting discourse among the dispersed learners than among the face-to-face learners, and it seemed to benefit their task communication in such areas as evidential relation and epistemic classification. These researchers plan to focus in the future on using such representational graphics for collaborative interaction in the asynchronous condition.

In one study of adding video to ALN, Matarrazzo and Selen (2000) had participants use two screens, one with shared task-oriented documents displayed and one with either high- or low-bandwidth video of participants' faces; all participants also had an audio channel. Subjects in the narrowband video condition focused more on their task, completed it faster, and were more satisfied than those in a wideband video condition, who seem to have been distracted by the streaming video, especially with larger numbers of participants (4 vs. 2).

On the other hand, Nancy Mundorf, director of the Early Childhood Learning Community distance learning program at the University of Cincinnati, related a case of the successful use of video clips plus conference calls to supplement the use of their Blackboard® ALN system for the student teaching segment of the curriculum. She described their experiences as follows (personal communication, 2002):

> We had 13 students from around the country ready to student teach this fall.... We created four "best practice videos" of 30–45 minutes of raw footage focusing on a master teacher that became a part of the student teaching seminar. It was further decided that having student teachers have themselves videotaped and then discussing the videotape on a conference call with the student teacher, mentor teacher, and university supervisor would be acceptable in assessing the student's teaching....
>
> The student was asked to write a journal entry the day of the taping and send it to the mentor and university supervisor as a lead in to the video. Approximately one week later, the student teacher, mentor teacher, and university professor had a conference call while all three watched the video on their own computers. The conferences were quite reflective and not defensive. Student teachers were able to pick up on habits, things they missed, expressions on a child's face, and other subtle things because we were watching them together. They could remember what they were thinking and why

they did something and explain their reasoning while we watched. I felt the conferences were more reflective and reached a greater depth than the traditional face-to-face meeting.

Adding Audio

There are now several software packages that allow digitized audio to be posted for playback as part of asynchronous computer-mediated communication. This became of particular interest at the New Jersey Institute of Technology in 2001–2002 when an external accrediting team ruled that students in online programs had to have courses in which they made "oral presentations" to the class, not just written ones. In a class on computers and society, students were told of the new requirement and asked to share their knowledge and tips about how to best and most easily produce a 3- to 5-minute oral presentation to be posted in an online class conference. All the students managed to do it, and expressed some enthusiasm about how this made them feel that they knew one another better. Several suggested that this be made a mandatory addition to the self-introduction that each student must make at the beginning of the online course.

However, in the few studies analyzing adding a digital audio capability to asynchronous communication, the results were mixed. Bargeron et al. (2002) found that when given a choice of text versus audio in threaded discussions, subjects were more likely to choose text and reply to text messages, because they found it faster to read text than to listen to audio, and easier to edit text inputs than to edit audio comments. On the other hand, as summarized previously, Steeples (2000) found some promise for the use of audio annotations for video clips, for researchers presenting to one another about professional practice issues. However, Steeples' subjects reported that it was more difficult to pay attention to conter in the video-only condition. The participants did report that adding voice annotations to the video clips was useful for providing background or contextual information.

SUMMARY

One rather broad conclusion to these kinds of studies is that there probably is no necessary (at least not simple or linear) causal relationship between the use of any particular new medium and success in teaching or learning. Thus, teachers and students will have to understand the possible new roles and responsibilities that come with these technological developments (Gibson, 1996). Furthermore, as Alavi and Leidner (2001) state, "It is important to conceptualize technology features and attributes in a manner directly relevant to instructional and learning processes" (p. 5). For example, constructivist approaches to student learning should understand how ALNs can foster greater participation, collaboration, feedback, and involvement by course members. Also needed is extensive and creative professional development, for both instructors and learners, to develop new strategies that emphasize collaboration, critical thinking, and lifelong learning, and how new media (including "simple" text-based ALNs) may help to support these processes.

As part of that development, administrators, teachers, and learners need to become more familiar with the array and implications of the primary media characteristics discussed or identified by this review of theories and research on media in general and newer ALN media in particular. Each of these media has a learning curve and some difficult challenges. It is probable that an instructor would do best to select only one of these supplementary modes of interaction, and foster multiple uses of that medium and the development of a critical mass of contributions and participants, while emphasizing the primary use of text-based asynchronous exchanges, structured in various ways (e.g., conversational threads or topic-based forums). In terms of media choice for online learning, the data tend to support the point of view that many different media can be sufficient to support teaching and learning. Adding the "newest" medium, such as full-motion video, may be distracting and counterproductive. Use of synchronous chat, a picture gallery of class members, or asynchronous audio clips may increase the sense of social presence and help a class to form a virtual learning community more quickly.

It is important to distinguish between the effects of the *delivery (conveyance) technology* versus those of the *instructional (convergence) technology*. Often, instructional approaches are confounded empirically or conceptually with the delivery medium or process (Clark, 2001b). For example, Clark and Craig (2001) pointed out that "interactivity" is really an instructional method (functionality)—feedback and content based on student response—and not a characteristic intrinsic to select media. There may be different evaluation criteria and possibly even data and analysis for each (cost, time, number of students, etc. for the delivery technology; learning, socialization, etc. for the instructional technology). Therefore, Simonson, Schlosser, and Hanson (1999) advocated developing a set of equivalent learning experiences that would be available to both distance and local students. Sometimes, a particular criterion learning goal requires longer or most costly instructional technology, and there may be different evaluations for different stakeholders across delivery and instructional technologies (i.e., teachers, administrators, students). Swan (2002) proposed that the most significant role of technology is to foster opportunities for interaction among the participants, which emphasizes the convergence aspect.

Our own position is that you can do many, if not most, things in face-to-face classrooms that you can do with online media. However, CMC can also support new, different class processes, that, if not impossible, would at least be very difficult and require a lot of intentionality to accomplish in face-to-face settings. This includes in-process interactivity and cross-student and even out-of-class communication.

Of course, the most important variables are still how the instructor applies these various media characteristics in combination with a pedagogical strategy to lead the students to engage in fruitful discussion and collaboration, student learning styles, and desired course outcomes (ranging from cognitive to affective to behavioral; Alavi & Leidner, 2001). Media, teachers, administrators, learners, and their family and friends may all interact to foster or impede different kinds of cognitive and social understandings. The best implementation strategy is to identify what instructional technologies (methods) are suitable for what goals, and find the media functionalities (available in a variety of communication media) that best support those methods, in order to lower cost and time while increasing access (Clark & Craig, 2001). Much remains to be understood about various media characteristics in ALNs, and their relative advantages and disadvantages.

QUESTIONS FOR DISCUSSION AND RESEARCH

1. Clark's famous "delivery truck" statement at the beginning of this chapter was originally made before the Internet and online education existed. Do you think it is true that ALN no more shapes the content of a course than a delivery truck changes the contents of the packages inside it? What theories or evidence can you cite to support your position?

2. How do you think that the spread of handhelds, tablet PCs, and high-bandwidth wireless Internet connections will affect the practicality of combining various other digital media with text-based asynchronous communication in courses? What kinds of studies should be conducted to identify problems and possibilities for online learning that have been introduced by such new technologies?

3. Can you provide an example from your own experience in which a medium that was supposedly low in social presence or media richness, or otherwise supposedly insufficient for the education purpose, was used in such a way as to foster significant learning or innovation? Alternatively, can you provide an example in which one or more media with high social presence or media richness were used in such a way as to limit learning and creativity?

4. Select five of the media characteristics provided in the section on "Other Characteristics and Influences" to analyze and compare a very traditional learning context—a large lecture class scheduled twice a week—and a new learning context—an ALN with links to multimedia Internet pages and dyadic "chat."

5. Which courses or departments in your college or university use multiple media to enhance student learning? Which seems to be the most successful? Using the theories and research in this chapter, suggest why this is the case.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Research commentary: Technology-mediated learning—a call for greater depth and breadth of research. *Information Systems Research, 12*(1), 1–10.

Bargeron, D., Grudin, J., Gupta, A., Sanocki, E., Li, F., & Leetiernan, S. (2002). Asynchronous collaboration around multimedia applied to on-demand education. *Journal of Management Information Systems, 18*(4), 117–145.

Berge, Z., & Mrozowski, S. (2001). Review of research in distance education, 1990 to 1999. *American Journal of Distance Education, 15*(3), 5–19.

Bozeman, D. (1993). Toward a limited rationality perspective of managerial media selection in organizations. In D. Moore (Ed.), *Academy of Management best papers proceedings* (pp. 278–282). Madison, WI: Omni.

Brail, S. (1996). The price of admission: Harassment and free speech in the wild, wild west. In I. L. Cherny & E. Weise (Eds.), *Wired-women: Gender and new realities in cyberspace* (pp. 157–182). Seattle, WA: Seal.

Bretz, R. (1970). *A taxonomy of communication media.* Englewood Cliffs, NJ: Educational Technology Publications.

Bretz, R. (1983). *Media for interactive communication.* Beverly Hills, CA: Sage.

Carlson, J., & Zmud, R. (1994). Channel expansion theory: A dynamic view of media and information richness perceptions. In D. Moore (Ed.), *Best papers Proceedings of the Academy of Management* (pp. 280–284). Madison, WI: Omni.

Chu, G., & Schramm, W. (1967). *Learning from television: What the research says.* Washington, DC: National Association of Educational Broadcasters.

Clark, R. E. (2000). Evaluating distance education: Strategies and cautions. *Quarterly Review of Distance Education, 1*(3), 16.

Clark, R. E. (Ed.). (2001a). *Learning from media: Arguments, analysis, and evidence.* Greenwich, CT: Information Age Publishing.

Clark, R. E. (2001b). Media are "mere vehicles": The opening argument. In R. E. Clark (Ed.), *Learning from media: Arguments, analysis, and evidence* (pp. 1–12). Greenwich, CT: Information Age Publishing.

Clark, R. (2001c). New directions: Evaluating distance education technologies. In R. E. Clark (Ed.), *Learning from media: Arguments, analysis, and evidence* (pp. 299–317). Greenwich, CT: Information Age Publishing.

Clark, R., & Craig, T. (2001). What about multimedia effects on learning? In R. E. Clark (Ed.), *Learning from media: Arguments, analysis, and evidence* (pp. 89–101). Greenwich, CT: Information Age Publishing.

Clark, R. E., & Salomon, G. (2001). Why should we expect media to teach anyone anything? In R. E. Clark (Ed.), *Learning from media: Arguments, analysis, and evidence* (pp. 37–70). Greenwich, CT: Information Age Publishing.

Collins-Jarvis, L. (1996, May). *Discriminatory messages in on-line discussion groups: The role of gender identity and social context.* Paper presented at the International Communication Association, Chicago, IL.

Culnan, M. J., & Markus, M. L. (1987). Information technologies. In F. Jablin, L. Putnam, K. Roberts, & L. Porter (Eds.), *Handbook of organizational communication* (pp. 420–443). Newbury Hills, CA: Sage.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science, 32*(5), 554–571.

D'Ambra, J., & Rice, R. E. (1994). The equivocality of media richness: A multi-method approach to analyzing selection of voice mail for equivocal tasks. *IEEE Transactions on Professional Communication, 37*(4), 231–239.

Dawson, K. (1995). Comments on "Read me what it says on your screen...." *Technology Studies, 2*, 80–85.

Dede, C. (1996). The evolution of distance education: Emerging technologies and distributed learning. *American Journal of Distance Education, 10*(2), 4–36.

Eastmond, D. (1993). Adult distance study through computer conferencing. *Distance Education, 15*(1), 129–151.

Ebben, M. (1993, October). *Women on the net: An exploratory study of gender dynamics on the Soc.women computer network.* Paper presented at the Organization for the Study of Communication, Language and Gender 16th Annual Conference, Tempe, AZ.

Frissen, V. (1992). Trapped in electronic cages? Gender and new information technologies in the public and private domain: An overview of research. *Media, Culture & Society, 14*, 31–39.

Fulk, J. (1993). Social construction of communication technology. *Academy of Management Journal, 36*(5), 921–950.

Gibson, C. (1996). Toward emerging technologies and distributed learning: Challenges and change. *American Journal of Distance Education, 10*(2), 47–49.

Goodman, N. (1968). *Language of art.* Indianapolis, IN: Hackett.

Gunawardena, C., & Zittle, F. (1997). Social presence as a predictor of satisfaction within a computer-mediated conferencing environment. *American Journal of Distance Education, 11*(3), 8–26.

Hackman, M., & Walker, K. (1990). Instructional communication in the televised classroom: The effects of system design and teacher immediacy on student learning and satisfaction. *Communication Education, 39*(3), 196–209.

Harasim, L. (Ed.). (1990). *Online education: Perspectives on a new environment.* New York: Praeger.

Haythornthwaite, C. (2000). Online personal networks: Size, composition and media use among distance learners. *New Media & Society, 2*(2), 195–226.

Hilgenberg, C., & Tolone, N. (2000). Student perceptions of satisfaction and opportunities for critical thinking in distance education by interactive video. *American Journal of Distance Education, 14*(3), 59–74.

Hiltz, S. R. (1986). The "vitrual classroom": Using comptuer-mediated communication for university teaching. *Journal of Communication, 36*(2), 95–104.

Hiltz, S. R. (1994). *The virtual classroom: Learning without limits via computer networks.* Norwood, NJ: Ablex.

Holmberg, B. (1989). *Theory and practice of distance education.* London: Routledge.

Hough, R., & Panko, R. (1977). *Teleconferencing systems: A state of the art survey and preliminary analysis.* Menlo Park, CA: Stanford Research Institute.

Keegan, D. (1986). *The foundations of distance education.* London: Croom Helm.

Kelsey, K. D. (2000). Participant interaction in a course delivered by interactive compressed video technology. *American Journal of Distance Education, 14*(1), 63–74.

Kim, E., Hiltz, S. R., Scher, J., & Turoff, M. (2003, August). *Multimedia diversification of the ALN learning environment.* Paper presented at the Americas Conference on Information Systems, Tampa, FL.

Kozma, R. (2001a). Kozma reframes and extends his counter argument. In R. E. Clark (Ed.), *Learning from media: Arguments, analysis, and evidence* (pp. 179–198). Greenwich, CT: Information Age Publishing.

Kozma, R. (2001b). Learning with media. In R. E. Clark (Ed.), *Learning from media: Arguments, analysis, and evidence.* Greenwich, CT: Information Age Publishing.

Lantz, A. (2001). Meetings in a distributed group of experts: Comparing face-to-face, chat and collaborative virtual environments. *Behaviour & Information Technology, 20*(2), 111–117.

Lea, M. (1991). Rationalist assumptions in cross-media comparisons of computer-mediated communication. *Behaviour and Information Technology, 10*(1), 153–172.

Leuthold, J. H. (1999). Is computer-based learning right for everyone? In *Proceedings of 32nd Hawaii International Conference on Systems Sciences* (CD-Rom ed.). Washington, DC: IEEE Computer Society.

Lieberman, D. (2001). Using interactive media in communication campaigns for children and adolescents. In R. E. Rice & C. K. Atkin (Eds.), *Public communication campaigns* (3rd ed., pp. 373–388). Thousand Oaks, CA: Sage.

Lombard, M., Ditton, T., & Reich, R. (1997). The role of screen size in viewer responses to television fare. *Communication Reports, 10*(1), 95–106.

Machtmes, K., & Asher, J. (2000). A meta-analysis of the effectiveness of telecourses in distance education. *American Journal of Distance Education, 14*(1), 27–46.

Markus, M. L. (1990). Toward a critical mass theory of interactive media: Universal access, interdependence and diffusion. In J. Fulk & C. Steinfield (Eds.), *Organizations and communication technology* (pp. 194–218). Newbury Park, CA: Sage.

Matarazzo, G., & Selen, G. (2000). The value of video in work at a distance: Addition or distraction? *Behavior & Information Technology, 19*(5), 339–348.

McKenney, J., Zack, M., & Doherty, V. (1992). Complementary communication media: A comparison of electronic mail and face-to-face communication in a programming team. In N. N. R. Eccles (Ed.), *Networks and organizations: Structure, form and action* (pp. 262–287). Boston, MA: Harvard Business School Press.

Monaghan, P., & Stenning, K. (1998, August). *Effects of representation modality and thinking style on learning to solve reasoning problems.* Paper presented at the 20th Annual Meeting of the Cognitive Science Society, Madison, WI.

Moore, A., & Jovanis, P. (1988). Modeling media choices in business organizations: Implications for analyzing telecommunications-transportation interactions. *Transportation Research, 22A*, 257–273.

Murphy, K. L., & Collins, M. P. (1997). Development of communication conventions in instructional electronic chats. *FirstMonday, 2*(11). Retrieved October 15, 2003, from http://www.firstmonday.dk/issues/issue2_11/murphy

Oliver, R., & McLoughlin, C. (1997). Interactions in audiographics teaching and learning environments. *American Journal of Distance Education, 11*(1), 34–54.

Olson, D. (1976). Towards a theory of instructional means. *Educational Psychologist, 12*, 14–35.

Orr, B. (1997). *A Significant Difference.* Retrieved October 15, 2003, from http://teleeducation.nb.ca/english/article.cfm

Paivio, A. (1985). *Mental representations: A dual approach*: New York: Oxford University Press.

Peters, O. (1988). Distance teaching and industrial production: A comparative interpretation in outline. In D. Sewart, D. Keegan, & B. Holmberg (Eds.), *Distance education: International perspectives* (pp. 95–113). New York: Routledge.

Quinn, C., Mehan, H., Levin, J., & Black, S. (1983). Real education in non-real time: The use of electronic message systems for instruction. *Instructional Science, 11*, 313–327.

Reynolds, P. A., & Mason, R. (2002). On-line video media for continuing professional development in dentistry. *Computers and Education, 39*(1), 65–98.

Rice, R. E. (1982). Communication networking in computer conferencing systems: A longitudinal study of group roles and system structure. In M. Burgoon (Ed.), *Communication yearbook* (Vol. 6, pp. 925–944). Newbury Park, CA: Sage.

Rice, R. E. (1984). Mediated group communication. In R. E. Rice et al. (Eds.), *The new media: Communication, research and technology* (pp. 129–154). Newbury Park, CA: Sage.

Rice, R. E. (1987). Computer-mediated communication and organizational innovation. *Journal of Communication, 37*(4), 65–94.

Rice, R. E. (1990). Computer-mediated communication system network data. Theoretical concerns and empirical examples. *International Journal of Man–Machine Studies, 32*(6), 627–647.

Rice, R. E. (1992). Contexts of research on organizational computer-mediated communication: A recursive review. In M. Lea (Ed.), *Contexts of computer-mediated communication* (pp. 113–144). London: Harvester-Wheatsheaf.

Rice, R. E. (1993a). Artifacts, freedoms, paradoxes and inquiries: Some ways new media challenge traditional mass media and interpersonal effects paradigms. *MultiMedia Review/Virtual Reality World, 4*(2), 30–35.

Rice, R. E. (1993b). Media appropriateness: Using social presence theory to compare traditional and new organizational media. *Human Communication Research, 19*(4), 451–484.

Rice, R. E. (1999). What's new about new media? Artifacts and paradoxes. *New Media and Society, 1*(1), 24–32.

Rice, R. E., & Aydin, C. (1991). Attitudes towards new organizational technology: Network proximity as a mechanism for social information processing. *Administrative Science Quarterly, 36*, 219–244.

Rice, R. E., & Case, D. (1983). Computer-based messaging in the university: A description of use and utility. *Journal of Communication, 33*(1), 131–152.

Rice, R. E., D'Ambra, J., & More, E. (1998). Cross-cultural comparison of organizational media evaluation and choice. *Journal of Communication, 48*(3), 3–26.

Rice, R. E., & Gattiker, U. (2000). New meonal structuring. In F. Jablin & L. Putnam (Eds.), *New handbook of mmunication* (pp. 544–581). Newbury Park, CA: Sage.
Rice, R. E., Grant, A., Schmitz, J., & Torolvidual and network influences on the adoption and perceived outcor messaging. *Social Networks, 12*(1), 27–55.
Rice, R. E., Hart, P., Torobin, J., Shook, nning, L., et al. (1992). Task analyzability, use of new media, and ulti-site exploration of media richness. *Organization Science, 3*(4), 4
Rice, R. E., Hughes, D., & Love, G. (1989)mes of electronic messaging at an R&D organization: Situational con:and media awareness. *Office: Technology and People, 5*(2), 141–161
Rice, R. E., & Love, G. (1987). Electron-emotional content in a computer-mediated communication netwon *Research, 14*(1), 85–105.
Rovai, A. A. P. (2002). A preliminary lookifferences of higher education classroom communities in traditionales. *Journal of Asynchronous Learning Networks, 6*(1). Retrieved ', from www.aln.org/publications/jaln/v6n1_rovai.asp
Rumble, G. (2001). Re-inventing distance2001. *International Journal of Lifelong Education, 20*(½), 31–43.
Russell, T. (1999). *The no significance diffn*. Chapel Hill: North Carolina State University Office of Instructionalons.
Salomon, G. (1979). *Interaction of mend learning*. San Francisco: Jossey-Bass.
Salomon, G. (1981). *Communication and* y Hills, CA: Sage.
Schramm, W. (1977). *Big media, little me* CA: Sage.
Selfe, C., & Meyer, P. (1991). Testing clairerences. *Written Communication, 8*(2), 163–192.
Short, J., Williams, E., & Christie, B. (197*hology of telecommunications*. London: Wiley.
Simonson, M., Schlosser, C., & Hanson, Lnd distance education: A new discussion. *American Journal of Dista*(1), 60–75.
Sitkin, S., Sutcliffe, K., & Barrios-Choplin,apacity model of communication media choice in organizations. *Hu:ion Research, 18*(4), 563–598.
Smith, P. L., & Dillon, C. L. (1999). Comprning and classroom learning: Conceptual considerations. *American .e Education, 13*(2), 6–23.
Sparks, C., & van Zoonen, L. (1992). Geny. *Media, Culture and Society, 14*, 5–7.
Spencer, D. (2002). *A field study of the use mputer-mediated communication in asynchronous learning networks*:oral dissertation, Rutgers University, Newark, NJ.
Spencer, D., & Hiltz, S. R. (2003). A field shronous chat in online courses. In *35th Annual Hawaii International stem Sciences* (CD-Rom ed.). Washington DC: : IEEE Computer Soc
Steeples, C. (2002). Voice annotation of muleflective learning in distributed professional communities. In *ProceeaAnnual Hawaii International Conference on System Sciences* (CD Ron, DC: IEEE Computer Society.
Suthers, D., Hundhausen, C., & Giradeau, Ing the roles of representations in face-to-face and online computer sutive learning. *Computers and Education, 41*(4), 335–351.

Swan, K. (2002). Building communities in online courses: the importance of interaction. *Education, Communication and Information, 2*(1), 23–49
Thoennessen, M., Kashy, E., Tsai, Y., & Davis, N. E. (1999). Impact of asynchronous learning networks in large lecture classes. *Group Decision and Negotiation, 8*(5), 371–384.
Trevino, L. K., Lengel, R. H., & Daft, R. L. (1987). Media symbolism, media richness and media choice in organizations: A symbolic interactionist perspective. *Communication Research, 14*(5), 553–575.
Valacich, J., Paranka, D., George, J., & Nunamaker, J. (1993). Communication concurrency and the new media. *Communication Research, 20*(2), 249–276.
Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (2000). Learning through synchronous electronic discussion. *Computers & Education, 34*, 269–290.
Walther, J. (1992). Interpersonal effects in computer-mediated interaction: A relational perspective. *Communication Research, 19*(1), 52–90.
Walther, J. B., Slovacek, C. L., & Tidwell, L. C. (2001). Is a picture worth a thousand words? Photographic images in long-term and short-term computer-mediated communication. *Communication Research, 28*(1), 105–134.
Witfelt, C., Philipsen, P. E., & Kaiser, B. (2002). Chat as media in exams. *Education and Information Technologies, 7*(4), 343–349.
Zmud, R., Lind, M., & Young, F. (1990). An attribute space for organizational communication channels. *Information Systems Research, 1*(4), 440–457.