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Interaction in distance education and online learning: using evidence and theory to improve practice

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Abstract In a recent meta-analysis of distance and online learning, Bernard et al. (2009) quantitatively verified the importance of three types of interaction: among students, between the instructor and students, and between students and course content. In this paper we explore these findings further, discuss methodological issues in research and suggest how these results may foster instructional improvement. We highlight several evidence-based approaches that may be useful in the next generation of distance and online learning. These include principles and applications stemming from the theories of self-regulation and multimedia learning, research-based motivational principles and collaborative learning principles. We also discuss the pedagogical challenges inherent in distance and online learning that need to be considered in instructional design and software development.

Keywords Distance education · Online learning · Self-regulation · Multimedia learning · Motivation · Collaboration · Instructional design · Cooperative learning · Metacognition

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Introduction

This paper provides us with an opportunity to look backward as a way of looking forward. As reviewers of evidence, we constantly use the past record of evidence to summarize what is known, to offer new insights about the existing evidence and then to suggest what may lie ahead in theorizing, researching and applying new knowledge. Distance and online learning provide exciting opportunities for not only increasing the reach of education and reducing its cost, but, most important to us, for increasing the quality of teaching and learning. In looking forward, we combine the results of our latest distance education review with summaries of evidence from other areas to suggest directions for the future.

Thus, this paper has two intertwined foci. One is at the level of research, where we will argue that distance education (DE) and online learning (OL) has evolved beyond simple comparisons with classroom instruction. The other is at the level of design, where we will suggest how theory and new forms of evidence may improve instructional practice.

The research paradigm of the past

An examination of the quantitative/experimental research literature of DE and OL reveals an inordinately large proportion of comparisons with classroom instruction (CI). Bernard et al. (2004a) found that 232 such studies were conducted between 1985 and 2003. Many others have been done since 2003. Why is this form of primary study so popular? The most cynical answer to this question is that they are easy to conduct, given that many universities and colleges have routinely run parallel forms of courses, one as a conventional classroom-based section and the other as a DE section. From a less cynical perspective, they are sometimes used to justify the viability of DE as an alternative to classroom instruction to administrators and policymakers. If asked a second question, whether researchers interested in improving classroom instruction would make similar comparisons with DE and OL, the resounding answer would be "no."

Since 2000, there have been more that 15 meta-analyses of this literature. Some have focused on particular populations, such as K-12 students (e.g., Cavanaugh et al. 2004), postsecondary students (e.g., Jahng et al. 2007) and health care professionals (e.g., Cook et al. 2008). Some have addressed particular forms of DE (telecourses, Machtmes and Asher 2000; online learning, U.S. DOE, 2009; and Web-based instruction, Sitzmann et al. 2006) and some have looked at specific outcome measures besides achievement (satisfaction, Allen et al. 2002). The meta-analysis by Bernard et al. (2004a, b) looked at all of these population features and also examined studies reporting dropout statistics. What has been the overall outcome of all of this primary research and meta-analytic activity based upon it?

1. There is general consensus of the effectiveness of all forms of DE (including online learning and Web-based instruction) compared with classroom instruction.

2. There is wide variability among studies, from those strongly favoring DE to those favoring CI, thereby bringing into question the unqualified interpretation of point 1.
3. There is a tendency for researchers to describe the DE/OL condition in great detail while characterizing the CI condition as “traditional classroom instruction,” thereby diminishing the opportunity to describe and compare salient study features.
4. Comparative primary research is plagued with a variety of methodological problems and confounds that make them very hard to interpret (Bernard et al. 2004b).
5. There is little else to learn about the nature of DE or CI from comparative studies.

The next generation of research

More recent advances in technology have increased the power, flexibility, ubiquity and ease of learning online and at a distance. As one consequence, there is literature in DE and OL, albeit small by comparison to the DE vs. CI literature, that compares DE treatments “head-to-head.” Bernard et al. (2009) examined this literature from the perspective of interaction treatments (i.e., conditions of media and/or instructional design that are intended to enable and/or increase student–student, student-instructor and student-content interaction). According to Cook (2009), it is studies such as these that will help us understand “… when to use e-learning (studies exploring strengths and weaknesses) and how to use it effectively (head-to-head comparisons of e-learning interventions)” (p. 158). Similarly, Bernard et al. (2009) argue that it is through direct studies of DE and OL that “… progress to advance theory and practice will be made as researchers begin to examine how instructional and technological treatments differ between DE conditions, not between DE and CI” (p. 1262). As early as 2000, Clark (2000) was arguing the same point, “All evaluations [of DE] should explicitly investigate the relative benefits of two different but compatible types of DE technologies found in every DE program” (p. 4).

Prior to Bernard et al. (2009), other reviews, and the studies on which they were based, explored only indirect comparisons of pedagogical features across studies by contrasting DE with CI. However, differentiating among critical DE features is never certain in such contrasts and may be explained by a host of alternative factors. In contrast, more recent DE vs. DE studies allow for the direct comparison of pedagogical features, such that differentiating among critical features is more certain and may be explained by fewer alternative factors.

Furthermore, as Bernard et al. (2009) demonstrated, it is not always necessary for primary studies of DE and OL to directly address instructional variables such as interaction, flexibility, technology affordance, etc. in order for a systematic review to be conducted. It is necessary, however, that a conceptual structure be devised into which primary studies can be reasonably integrated. That is, one or more underlying constructs must be identified allowing for different study-by-study operationalizations to be classed together by the reviewer.

But these studies, especially high quality studies, still represent the minority. A fundamental shift in the culture of research practices and the quality of reporting needs to occur to enable systematic reviewers and meta-analysts to come to broader and more comprehensive generalizations about the processes and conditions under which learning is best supported in DE and OL course designs. These include:

- *more research* that compares at least one DE/OL treatment to another DE/OL treatment with an emphasis on learning and motivational processes;
- *better research designs* (if not RCTs, designs that at least control for selection bias);
- *more studies* across the grade levels (k-12) and in higher education settings of all types;
- *better-quality descriptions of all treatment levels* and how well they were implemented;
- *better-quality measures,* particularly measures of student learning, higher order thinking and engagement; and
- *better-quality reporting*, preferably the inclusion of full descriptive statistics.

This is a hope, perhaps more like a plea, for the future. But there is much to be learned already from studies that do compare DE/OL conditions directly. In order to do so, Bernard et al. (2009) used Moore's (1989) tripartite conception of interaction in DE and Anderson's (2003) more recent expansion on the conditions that encourage student–student, student-instructor, and student-content interaction to examine both the magnitude and the strength of interaction treatments.

Interaction in DE and OL

The DE/OL literature is largely univocal about the importance of interaction (Lou et al. 2006; Anderson 2003; Sutton 2001; Muirhead 2001a, b; Sims 1999; Wagner 1994; Fulford and Zhang 1993; Jaspers 1991; Bates 1990; Juler 1990; Moore 1989; Daniel and Marquis 1979, 1988; Laurillard 1997). This is because of the integral role that interaction between students, teachers and content is presumed to play in all of formal education (e.g., Garrison and Shale 1990; Chickering and Gamson 1987) and because interaction was largely absent during so much of the early history of DE (Nipper 1989). But is there empirical evidence that interaction is important and what forms of interaction are best? Bernard et al. (2009) were able to synthesize the evidence in support of this belief in a meta-analysis that summarized findings from 74 empirical studies comparing different modes of DE to one another. They found the overall positive weighted average effect size of 0.38 for achievement outcomes favoring more interactive treatments over less interactive ones. The results supported the importance of three types of interaction: among students, between the instructor and students and between students and course content.

Types of interaction

An interaction is commonly understood as actions among individuals, but this meaning is extended here to include individual interactions with curricular content. Moore (1989) distinguished among three forms of interaction in DE: (1) student–student interaction, (2) student-instructor interaction; and (3) student-content interaction.

Student–student interaction refers to interaction among individual students or among students working in small groups (Moore 1989). In correspondence courses, this interaction is often absent; in fact, correspondence students may not even be aware that other students are taking the same course. In later generations of DE, including two-way video- and audio-conferencing and Web-based courses, student–student interaction could be synchronous, as in videoconferencing and chatting, or asynchronous, as in discussion boards or e-mail messaging.

Student-instructor interaction focuses on dialogue between students and the instructor. According to Moore (1989), during student-instructor interaction, the instructor seeks “to stimulate or at least maintain the student’s interest in what is to be taught, to motivate the student to learn, to enhance and maintain the learner’s interest, including self-direction and self-motivation” (p. 2). In DE environments, student-instructor interaction may be synchronous such as through the telephone, videoconferencing and chats, or asynchronous such as through correspondence, e-mail and discussion boards.

Student-content interaction refers to students interacting with the subject matter under study to construct meaning, relate it to personal knowledge, and apply it to problem solving. Moore (1989) described student-content interaction as “… the process of intellectually interacting with the content that results in changes in the learner’s understanding, the learner’s perspective, or the cognitive structures of the learner’s mind” (p. 2). Student-content interaction may include reading informational texts for meaning, using study guides, watching instructional videos, interacting with multimedia, participating in simulations, or using cognitive support software (e.g., statistical software), as well as searching for information, completing assignments and working on projects.

The positive impacts of interaction

The results of Bernard et al. (2009) confirmed the importance of each type of interaction on student learning. See Table 1 for a summary of the results. Each type of interaction had a significantly positive average effect size ranging from +0.32 for student-instructor interaction to +0.49 for student–student interaction. Both student–student and student-content interaction was significantly higher than student-instructor interaction.

Not surprisingly, the major conclusion from Bernard et al. (2009) was that designing interaction treatments into DE courses, whether to increase interaction with the material to be learned, with the course instructor, or with peers impacts positively on student learning. But are even larger and more consistently positive

Table 1 Weighted average achievement effect sizes for categories of interaction

Interaction categories	*k*	*g* + (adj.)	*SE*
Student–student (SS)	10	0.49	0.08
Student-instructor (SI)	44	0.32	0.04
Student-content (SC)	20	0.46	0.05
Total	74	0.38	0.03
(*Q*) Between-class		7.05*	

effects possible? It may be that the presence of the interaction conditions in the reviewed studies functioned in exactly the way they were intended, so that the estimates of the effects were fairly accurate. But just because opportunities for interaction were offered to students does not mean that students availed themselves of them, or if they did interact, that they did so effectively. The latter case is the more likely event, so the achievement effects resulting from well-implemented interaction conditions may be underestimated in our review.

Therefore, we believe that what we identified in Bernard et al. (2009) is the impact of the first generation of interactive distance education (IDE1), where online learning instructional design and technology treatments allowed or enabled some degree of interaction to occur. In other words, in IDE1 learners were able to interact but may not have done so optimally given the quality and quantity of interactions that occurred. These interactions may have been limited by how the courses used in the research were designed and delivered and limited by how technology mediated learning and instruction.

Consequently, the next generation of interactive distance education (IDE2), or purposeful, interactive distance education, should be better designed to facilitate interactions that are more targeted, intentional and engaging. Not only will we need knowledge tools and instructional designs that do this effectively, but we will also need research that validates both the underlying processes (e.g., using implementation checks and measures of treatment integrity) as well as the outcomes of IDE2 (e.g., especially measures of student learning).

The next generation of interactive distance education (IDE2)

One way to advance this new, more interactive DE, largely possible because of Web 2.0 features, is via the development of specialized knowledge tools or customized instructional designs that take advantage of these new features. A knowledge tool is educational software that scaffolds and supports student learning. Instructional design is the practice of maximizing the effectiveness, efficiency and appeal of instruction and other learning experiences. Effective knowledge tools for IDE2 should be based on sound instructional design or allow instructional design templates to be added to them.

Beldarrain (2006) notes that although emerging technologies offer a vast range of opportunities for promoting collaboration in learning environments, distance education programs around the globe face challenges that may limit or deter implementation of these technologies. Beldarrain (2008), like Moore (1989), believes that instructional design models must be adapted to integrate various types of interactions, each with a specific purpose and intended outcome. It is also necessary to choose the appropriate technology tools that foster collaboration, communication and cognition. Furthermore, instructional design models must anchor student interaction in the instructional objectives and strategies that create, support and enhance learning environments. Beldarrain (2008) explores five instructional design frameworks and assesses their effectiveness in integrating interaction as part of the design and development phase of DE. She also provides literature-based suggestions for enhancing the ability of these design frameworks to foster student interaction.

Guided, focused and purposeful interaction goes beyond whether opportunities for interaction exist to consider especially why and how interaction occurs. When students consider *why* they engage in learning activities they are reflecting on their motivation (from the Latin word "movere" meaning to move) for learning including the energy of activity and the direction of that energy towards a goal. When students consider *how* they engage in learning they are addressing the strategies and techniques for knowledge acquisition.

Evidence-based approaches to IDE2

We highlight below several evidence-based approaches useful in the next generation of IDE2. These include application of: (1) theories of self-regulation, (2) multimedia learning principles, (3) motivational design principles and (4) collaborative and cooperative learning principles. We also discuss challenges in integrating these principles in IDE2 and the instructional designs and learning tools best suited for its success.

Self-regulation principles

One important interpretation of purposeful interaction in IDE2 means learners will be self-regulated; they will set clear goals and develop strategies for achieving those goals, monitor their activity and reflect on their accomplishments using both self and peer or teacher feedback (Zimmerman 2000). Self-regulated learners are individuals who are metacognitively, motivationally and behaviorally active participants in their own learning and consequently are learners whose academic performance is higher than others (Zimmerman 2000). A main feature of self-regulated learning is metacognition, which refers to the awareness, knowledge and control of cognition. The three processes that make up metacognitive self-regulation are planning, monitoring and regulating. Proponents of socio-cognitive models emphasize that to develop effective self-regulated learning strategies, "students need to be involved in complex meaningful tasks, choosing the products and processes that will be evaluated, modifying tasks and assessment criteria to attain an optimal challenge, obtaining support from peers and evaluating their own work" (Perry 1998, p. 716).

The three cyclical phases of self-regulation include both metacognitive and motivational components, providing the foundation for better sustainability of learning and skill development. The forethought phase includes task analysis (goal setting and strategic planning) and consideration of self-motivation beliefs (self-efficacy, outcome expectations, intrinsic interest/value and goal orientation). Learners need to set goals and make plans to engage successfully in the task as well as take stock of their own motivation toward the task. The next phase, the performance phase, includes self-control (self-instruction, imagery, attention focusing and task strategies) and self-observation (self-recording and self-experimentation). Learners need to engage in the activity, controlling their processes and observe their own performance. Finally, the self-reflection phase includes self-judgment (self-evaluation and casual attribution) and self-reaction (self-satisfaction/affect and adaptive-defensive responses) (Zimmerman 2000). Here learners examine themselves and develop motivational 'responses' or reactions (See Fig. 1). Zimmerman (2008) emphasizes the importance of directing further research at the motivational aspects of self-regulation and Zimmerman and Tsikalas (2005) discuss how student motivational beliefs need to be an integral part of the design of educational software.

Though the terms are different, distance education has emphasized the need for students to be self-directed and to learn how to learn; historically this emphasis comes from the adult learning literature as early models of distance education largely catered to older learners. There is an emphasis on adults directing their own

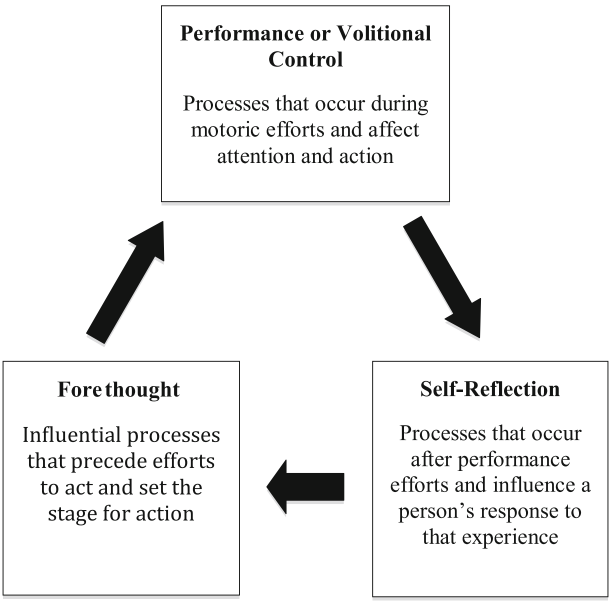

Fig. 1 Zimmerman's (2000) cyclical model of self-regulation

learning in a myriad of ways from monitoring their progress to setting their own learning goals. Knowles (1980) outlined six key principles of his adult learning theory, two of which address adult learners' self-regulation: learners need to be aware of the learning process to be undertaken, where that process leads (the learning which will be achieved) and why the learning is important; they also need to be self-directed in their learning, taking ownership over the methods and goals of learning. Similarly, Brookfield (1995) discusses adult learners' needs to be self-directed, as illustrated by setting up goals, finding relevant resources and evaluating their own progress and the importance of supporting adults in learning how to learn. Such approaches have been criticized for placing too much emphasis on the individual, as has the concept of self-regulation. Hickey and McCaslin (2001) suggest that reconciliation with more of a socio-constructivist perspective would not necessarily prohibit the concept of self-regulation, but it would be framed within the context of learners increasing their engagement in communities of practice.

It is possible to create instructional designs with many of the features of self-regulation and to embed these designs as templates into existing tools for distance and online learning, especially those that are intended to support computer conferencing (e.g., FirstClass). But knowledge tools are emerging, designed specifically to promote student self-regulation in blended, online and distance learning contexts. ePEARL, an electronic portfolio software that serves to support learning processes and encourage self-regulated learning, is one such tool (Abrami et al. 2008; Meyer et al. 2010).

Multimedia learning principles

Research on learning from multimedia has lead to the development of instructional design principles by Mayer (2001, 2008) that have applications to IDE2. In a classic experiment, Paivio (1969) found that subjects who were shown a rapid sequence of pictures as well as a rapid sequence of words and later asked to recall the words and pictures, either in order of appearance or in any order they wanted, were better at recalling images when allowed to do so in any order. Participants, however, more readily recalled the sequential order of the words, rather than the sequence of pictures. These results supported Paivio's hypothesis that verbal information is processed differently than visual information.

Paivio's dual coding theory of information processing (1971, 1986) gives weight to both verbal and non-verbal processing. The theory posits that there are two cognitive subsystems, one specialized for the representation and processing of nonverbal objects/events (i.e., imagery) and the other specialized for dealing with language.

Following from this pioneering work, Mayer (2001, 2008) describes a cognitive theory of multimedia learning organized around three core principles: (a) dual channels—the idea that humans possess separate channels for processing visual and verbal material; (b) limited capacity—the idea that each channel can process only a limited amount of material at any one time; and (c) active processing—the idea that deep learning depends on the learner's cognitive processing during learning (e.g., selecting, organizing and integrating).

According to Mayer (2001, 2008), the central challenge of instructional design for multimedia learning is to encourage learners to engage in appropriate cognitive processing during learning while not overloading the processing capacity of the verbal or visual channel. Accordingly, Mayer (2001, 2008) summarizes a series of evidence-based principles for the design of multimedia learning tools that are relevant to IDE2.

There are five principles for reducing extraneous processing and the waste of cognitive capacity, three principles for managing essential processing and reducing complexity and two principles for fostering generative processing and encouraging the use of cognitive capacity. These evidence-based principles are listed in Table 2. For example, the five principles for reducing extraneous processing include coherence, signaling, redundancy, spatial contiguity and temporal contiguity. All of these principles are intended to focus the learner's attention and processing of information and avoid distractions or spurious mental activity leading to cognitive overload.

By using the evidence-based principles of multimedia learning, interaction between students and the course content, in particular, will be enhanced by going beyond the mere inclusion of interactive multimedia in DE and OL courses. These evidence-based principles help insure that learning from multimedia will be meaningful, maximizing the storage or construction of knowledge and its retrieval.

Motivational design principles

Beyond self-regulation, motivational principles in general are also important in IDE2 to insure the active and directed engagement of learners. In an enlightening article, Fishman et al. (2004) acknowledged that far too few cognitively-based or constructively-oriented knowledge tools are in wide use in school systems. The primary uses of educational technology remain drill and practice, word processing

Table 2 Mayer's (2001, 2008) multimedia learning design principles

Principle	Definition
Five evidence-based and theoretically grounded principles for reducing extraneous processing	
Coherence	Reduce extraneous material
Signaling	Highlight essential material
Redundancy	Do not add on-screen text to narrated animation
Spatial contiguity	Place printed words next to corresponding graphics
Temporal contiguity	Present corresponding narration and animation at the same time.
Three evidence-based and theoretically grounded principles for managing essential processing	
Segmenting	Present animation in learner-paced segments
Pre-training	Provide pre-training in the name, location and characteristics of key components
Modality	Present words as spoken text rather than printed text
Two evidence-based and theoretically grounded principles for fostering generative processing	
Multimedia	Present words and pictures rather than words alone
Personalization	Present words in conversational style rather than formal style

and web surfing (Burns and Ungerleider 2003), whereas the most helpful for learning appear to be technologies that offer students various forms of cognitive support (e.g., Schmid et al. 2009). Fishman et al. (2004) claim that we need to understand ways to encourage instructor and student “buy in” or accept the value and purpose of the innovation. For example, Wozney et al. (2006) used expectancy theory to explain teacher integration of technology. Expectations of success, the perceived value of outcomes, versus the costs of adoption were key factors in explaining teacher adoption and persistence. Finally, Moos and Azevedo (2009) summarized evidence on the positive association between students’ computer self-efficacy beliefs and learning with educational software.

These perspectives and findings about student and educator motivation and the use of educational software overlap with motivational principles for instructional design in general. Pintrich (2003) provided five motivational generalizations and 14 instructional design principles that are evidence-based. The motivational generalizations are: (1) adaptive self-efficacy and competence beliefs motivate students, (2) adaptive attributions and control beliefs motivate students, (3) higher levels of interest and intrinsic motivation motivate students, (4) higher levels of value motivate students and (5) goals motivate and direct students (see Table 3).

For example, to encourage self-efficacy and student competency beliefs means distance and online courses need to be structured to: (a) provide clear and accurate feedback regarding competence and self-efficacy, focusing on the development of competence, expertise and skill; and (b) offer opportunities to be successful but also challenge students. To maximize students’ values for learning course content requires: (a) tasks, material and activities that are relevant and useful to students, allowing for some personal identification with school and the content to be learned; and (b) discourse that focuses on the importance and utility of content and activities.

An important reason to use a knowledge tool occurs when learners are undertaking large, novel or difficult tasks rather than trivial or routine ones. Knowledge tools may be best suited to situations when learners have to be conscientiously engaged in learning, when the outcome is important and/or when the process is being judged or evaluated. Knowledge tools are also suited to situations when the outcome is uncertain and especially when student effort matters and/or when failure has occurred previously. One ideal situation is where a knowledge tool is integrated into instruction, where the task is complex and novel, where the learner wants to do well and doing well is important and when the student is not certain how well s/he will do but believes that personal efforts to learn will lead to success.

Collaborative and cooperative learning principles

When student-to-student interaction becomes truly collaborative and learners work together to help each other learn, the benefits of interactivity may be largest. Lou et al. (2001) examined the effects of learning in small groups with technology and reached similar conclusions.

Lou et al.’s (2001) study quantitatively synthesized the empirical research on the effects of social context (i.e., small group versus individual learning) when students

Table 3 Motivational generalizations and design principles (Pintrich 2003)

Motivational generalization	Design principle
Adaptive self-efficacy and competence beliefs motivate students	Provide clear and accurate feedback regarding competence and self-efficacy, focusing on the development of competence, expertise and skill
	Design tasks that offer opportunities to be successful but also challenge students
Adaptive attributions and control beliefs motivate students	Provide feedback that stresses process nature of learning, including importance of effort, strategies and potential self-control of learning
	Provide opportunities to exercise some choice and control
	Build supportive and caring personal relationships in the community of learners in the classroom
Higher levels of interest and intrinsic motivation motivate students	Provide stimulating and interesting tasks, activities and materials, including some novelty and variety in tasks and activities
	Provide content material and tasks that are personally meaningful and interesting to students
	Display and model interest and involvement in the content and activities.
Higher levels of value motivate students	Provide tasks, material and activities that are relevant and useful to students, allowing for some personal identification with school
	Classroom discourse should focus on importance and utility of content and activities
Goals motivate and direct students	Use organizational and management structures that encourage personal and social responsibility and provide a safe, comfortable and predictable environment
	Use cooperative and collaborative groups to allow for opportunities to attain both social and academic goals
	Classroom discourse should focus on mastery, learning and understanding course and lesson content
	Use task, reward and evaluation structures that promote mastery, learning, effort, progress and self-improvement standards and less reliance on social comparison or norm-referenced standards

learn using computer technology. In total, 486 independent findings were extracted from 122 studies involving 11,317 learners. The results indicated that, on average, small group learning had significantly more positive effects than individual learning on student individual achievement (average $ES = +0.15$), group task performance (average $ES = +0.31$) and several process and affective outcomes. The effects of small group learning were significantly enhanced when: (a) students had group work experience or instruction; (b) specific cooperative learning strategies were employed; (c) group size was small; (d) using tutorials or practice software or programming languages; (e) learning computer skills, social sciences and other subjects such as management and social studies; and (f) students were either relatively low in ability or relatively high in ability.

Lou et al. (2001) suggested that prior group learning experience and the teacher's use of cooperative learning strategies are important pedagogical factors that may influence how much students learn when working in small groups using technology. Explanations of group dynamics suggest that not all groups function well; for example, groups often do not function well when some members exert only minimal effort. Students need practice working together on group activities and training in how to work collaboratively. In IDE2, this training can be done in numerous ways including via the incorporation of multimedia vignettes. Experience in IDE2 group work may also enable members to use acquired strategies for effective group work more effectively.

Specific instruction for cooperative learning in IDE2 ensures that students learning in small groups will have positive interdependence as well as individual accountability (Abrami et al. 1995). Positive interdependence among outcomes, means, or interpersonal factors exists when one student's success positively influences the chances of other students' successes. According to Abrami et al. (1995) positive interdependence develops along a continuum from teacher-structured interdependence, followed by student perceptions of interdependence, leading to student interdependence behaviors and culminating in student interdependence values.

Individual accountability among outcomes, means and interpersonal factors involves two components: (1) each student is responsible for his or her own learning and (2) each student is responsible for helping the other group members learn. Like positive interdependence, individual accountability develops along a continuum from teacher-imposed structure to accountability as a student value.

Recently, Johnson and Johnson (2009) updated their review of the evidence on cooperative learning noting that the research in the area has been voluminous numbering in excess of 1,200 studies. They elaborated on the importance of positive interdependence and individual accountability but also promotive interactions. Promotive interactions occur as individuals encourage and facilitate each other's efforts to accomplish the group's goals. Promotive interaction is characterized by individuals: (1) acting in trusting and trustworthy ways; (2) exchanging needed resources, such as information and materials and processing information more efficiently and effectively; (3) providing efficient and effective help and assistance to group mates; (4) being motivated to strive for mutual benefit; (5) advocating exerting effort to achieve mutual goals; (6) having a moderate level of arousal, characterized by low anxiety and stress; (7) influencing each other's efforts to achieve the group's goals; (8) providing group mates with feedback in order to improve their subsequent performance of assigned tasks and responsibilities; (9) challenging each other's reasoning and conclusions in order to promote higher quality decision making and greater creativity; and (10) taking the perspectives of others more accurately and thus being better able to explore different points of view.

Noreen Webb (Webb 1989, 2008; Webb and Mastergeorge 2006; Webb and Palincsar 1996) has examined extensively what constitutes effective collaboration in terms of how meaningful learning is exchanged. Ineffective collaboration includes providing correct answers without explanation. Effective collaboration includes giving and receiving elaborated explanations with a focus on encouraging understanding in others.

When designing online and distance learning, instructional designers should consider these four principles—(1) positive interdependence, (2) individual accountability, (3) promotive interactions, and (4) elaborated explanations. There are knowledge tools that can be designed to better scaffold and support aspects of collaborative and cooperative learning or more generally, student-to-student interaction. And they may also be used to support student-to-content interaction and student-to-teacher interaction as well.

Challenges to IDE2

Abrami (2010) considered several reasons why learners do not better utilize some knowledge tools. The first is based on the principle of least effort. Even the best strategic learners need to balance efficiency concerns with effectiveness concerns, as well as balance proximal goals with distal ones. Strategic learners need to find the middle ground between how much they can learn and how well they can learn, or between the quantity of learning and the quality of learning.

Second, strategic learners often have to find the balance between intrinsic interests and extrinsic requirements. Frankly, the postsecondary learning system imposes its own restrictions on students (e.g., course requirements) that may not make effortful strategies uniformly appropriate.

Third, decades ago, McClelland et al. (1953) illustrated the impact not only of individual differences in achievement strivings but the importance of perceived outcome to learners' task choices and persistence. Years later, Weiner (1980) showed how causal attributions for task outcomes varied among learners, that these attributions affected thinking, behavior and feelings and that attributions varied depending on subjective estimates of the likelihood of future success and later, perceived outcome.

When we ask students to take personal responsibility for their own learning, we may create an internal conflict for students. First, does a student believe s/he can succeed at this learning task? Second, does a student believe that this tool will help him/her succeed? Third, does a student want to take responsibility for his/her own learning? While McClelland and Atkinson (e.g., McClelland et al. 1953) showed that high need achievers are drawn to moderately challenging tasks, we know that high need achievers tend to avoid tasks which are low in the probability of success. Weiner and others (e.g., Weiner 1980) showed that there are marked differences in causal attributions when learners perceive they have succeeded versus failed. Attributional bias means learners attribute success to internal causes and failure to external ones. Defensive attributions for failure (e.g., I failed because the exam was too hard or my teacher did not help) help protect a learner's sense of self-efficacy (i.e., keep a learner from concluding s/he failed because of lack of ability).

Therefore, there may be situations where increased personal responsibility for learning is not always beneficial to a learner's achievement strivings, causal attributions and self-efficacy. These situations have mostly to do with the learner's perception of the likelihood of future success and/or perceived outcome. For example, in novel or very demanding situations, especially ones that are high in importance, learners may want to avoid taking responsibility for their learning (and the learning of others) until such time as they are confident of a positive outcome. In other words, it is likely that some learners will return the responsibility for learning to the instructor or, more generally, the instructional delivery system, as accept it themselves.

Fourth, related to the above is the importance of effort-outcome covariation. Productive learners come to believe that their efforts at learning lead to successful learning outcomes. These learners come to believe that "the harder and more that I try, the more likely I am to achieve a positive learning outcome." The opposite belief is when a learner believes that their efforts bear little, if any, relationship to learning outcomes. In behavioral terms, this is learning that outcomes are non-contingent on actions, called learned helplessness by Seligman (1975). Seligman demonstrated that after experiencing these non-contingencies learners made almost no effort to act even when the contingencies were changed. This passivity, even in the face of aversive stimuli, is difficult to reverse.

Fifth, in order to encourage active collaboration among learners, it is often necessary at the outset to impose external structures including individual accountability and positive interdependence. These structures insure that each learner knows that s/he is responsible for his/her own learning within a group and that s/he is also responsible for the learning of others, respectively. Eventually, the meaning and value of these structures become internalized and are no longer necessary to impose (Abrami et al. 1995).

However, not all tasks lend themselves equally well to collaboration or require team activity in the same fashion. Steiner's typology of tasks (1972) presents four major task types—additive, compensatory, disjunctive and conjunctive. For example, Steiner claims that certain types of disjunctive tasks (e.g., questions involving yes/no or either/or answers) provide group performances that are only equal to or are less than the performance of the most capable group member. In contrast, additive tasks, where individual inputs are combined, provide group performances that are always better than the most capable group member. Cohen (1994) noted that true group tasks require resources that no single individual possesses so that no one is likely to solve the problem without input from others. In the absence of true group tasks and when individual accountability and positive interdependence are ill-structured, learning in groups may see a reduction in individual effort, not an increase, colorfully referred to as "social loafing" (Latane et al. 1979). Indeed, Abrami et al. (1995) summarized ten factors that research showed are related to social loafing: size, equality of efforts, identifiability, responsibility, redundancy, involvement, cohesiveness, goals, heterogeneity and time. Creating activities that accounts for the influence of these factors on group productivity and individual learning is a tall order. And it may be more difficult in an electronic learning environment where, for example, there is less identifiability (i.e., individual contributions that are clearly identified) and tasks where there is more redundancy (i.e., individuals who believe their contributions are not unique).

To summarize, the following factors may be at work in preventing more pervasive and persistent use of knowledge tools by students:

- learners do not value the outcome(s) of learning sufficiently to increase their efforts to learn—it is not so important to do well;
- learners believe that gains in learning from increased effort are inefficient—it takes too much effort to do a little bit better;
- learners do not want to become more responsible for their own learning—it is too risky unless the perceived chances of a positive outcome are increased; and
- learners believe that novel approaches to learning (use of unfamiliar knowledge tools) increase the likelihood of poor outcomes, not increase them—it is not of interest or too risky because they do not believe the tool will help them learn.

There are ways to overcome these challenges. Several suggestions for future research and development follow.

First, knowledge tools must be structured so they increase the efficiency of learning as well as the effectiveness of learning. As such, instructional designers should pay more attention to *ease of use* as an overall design objective, where learners need even more guidance as to which features to use, how and when. Time is one critical factor and it may be dealt with in numerous ways including structuring how tool activities are carried out (e.g., weekly) or making them part of the evaluation scheme. Simplicity of use may be important; avoiding the addition of time to learn how to use technology at the expense of time needed to learn the content. It would be interesting to know not only whether use of each tool resulted in increased achievement but also whether the quality and quantity of use related to learning gains—a form of cost/benefit ratio.

Second, students need more guidance about *when to use* the tool and not only whether to use it. That is, the tool should be used when a learning task is both difficult and important. Advice and feedback from instructors may help, as well as queries and suggestions embedded in the tool. Not every learning task requires the use of a knowledge tool and its use probably varies according to the skills and interests of each learner. Furthermore, even when a task warrants the use of a tool, not all features of the tool may need to be used. Some explanation, embedded within the tool, regarding when to use which feature would also be useful. As such, additional features should be designed to be used flexibly when appropriate to the learning task.

Third, like any tool, physical or cognitive, users need *practice* to use the tool well and wisely. You don't license a driver after 1 day's practice or ask a carpenter apprentice to build a cabinet after a single time using a band saw. Asking students to use a tool voluntarily where performance and grades matter is stacking the deck against enthusiastic use. Requiring use may ameliorate the problem because it is fair to everyone. Nevertheless, learners may now face the dual challenge of not only learning complex and challenging material but doing so in a novel and effortful way. Use of the tool should be "well-learned" and second nature before it becomes a required part of a course or program of study. And learners must be convinced that the tool helps them learn. In the latter regard, careful attention should be paid to feedback from students and instructors on success and failure stories, including the former as testimonials embedded in the tool.

Fourth, cognitive tools and learning strategies may work best when they are an integral feature of a course or program of study and not an add-on. This is the true meaning of *technology integration* or when the use of technology is not separate from the content to be learned but embedded in it. This integration may require the same degree of forethought, planning and goal setting on the part of instructors to insure effective and efficient student use. And instructors need training and experience with the use of tools to encourage scalability and sustainability.

Summary

In this paper, we argued for changes to primary quantitative/experimental research designs in DE/OL to examine alternative instructional treatments "head-to-head." We can see limited future improvements to DE/OL if comparisons to CI continue to prevail. How far would our understanding of automotive technology have progressed, for instance, if cars (i.e., "horseless carriages") were still designed as alternatives to horses? Secondly, we believe that DE/OL research and development is still in its infancy with regards to our ability to engineer successful interaction among students, between teachers and students and between students and content.

The results of Bernard et al. (2009) confirmed the importance of student–student, student-content and student-instructor interaction for student learning. The next generation of interactive distance education (IDE2) should be better designed to facilitate more purposeful interaction. Guided, focused and purposeful interaction goes beyond whether opportunities for interaction exist to consider especially why and how interaction occurs. When students consider how they engage in learning they consider, or are provided with, the strategies and techniques for knowledge acquisition. We highlighted several evidence-based approaches useful in the next generation IDE2. These include principles and applications from the theories of self-regulation and multimedia learning, research-based motivational principles and collaborative learning principles.

Self-regulated learning principles:

1. Include a forethought phase that involves task analysis (goal setting and strategic planning) and self-motivation beliefs (self-efficacy, outcome expectations, intrinsic interest/value and goal orientation).
2. Provide a performance phase that includes self-control (self-instruction, imagery, attention focusing and task strategies) and self-observation (self-recording and self-experimentation).
3. Integrate a self-reflection phase that includes self-judgment (self-evaluation and casual attribution) and self-reaction (self-satisfaction/affect and adaptive-defensive responses).

Multimedia Learning Principles:

1. Reduce extraneous processing and the waste of cognitive capacity.
2. Manage essential processing and reducing complexity.

3. Foster generative processing and encourage the use of cognitive capacity.

Motivational design principles:

1. Encourage adaptive self-efficacy and competence beliefs.
2. Promote adaptive attributions and control beliefs.
3. Stimulate higher levels of interest and intrinsic motivation.
4. Insure higher levels of task value.
5. Encourage the identification of goals that motivate and direct students.
6. Participate in a context where knowledge is valued and used motivates students.

Collaborative and cooperative learning principles:

1. Structure positive interdependence such that one student's success positively influences the chances of other students' successes.
2. Highlight individual accountability in ways that each student is responsible for: (a) his or her own learning; and (b) helping the other group members learn.
3. Insure promotive interactions occur allowing individuals to encourage and facilitate each other's efforts to accomplish the group's goals.
4. Maximize the likelihood that students give and receive elaborated explanations with a focus on encouraging understanding in others.

Overcoming Challenges to IDE2

1. Instructional designers should pay more attention to ease of use as an overall design objective.
2. Students need more guidance about when, under what circumstances and for what purposes, to use the tool.
3. Users need practice to use the tool well and wisely.
4. Cognitive tools and learning strategies may work best when they are an integral feature of a course.

Finally, in this paper we addressed several theoretical and empirical perspectives that should be explored more fully, but we have not specified in complete detail how instructional design and technology applications should converge to achieve a more interactive environment for teaching and learning at a distance. Achieving that goal is left to the creative and collaborative efforts of future researchers, designers, software engineers and teachers.

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