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WEB-BASED VIRTUAL LEARNING ENVIRONMENTS: A RESEARCH FRAMEWORK AND A PRELIMINARY ASSESSMENT OF EFFECTIVENESS IN BASIC IT SKILLS TRAINING[1]

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Abstract

Internet technologies are having a significant impact on the learning industry. For-profit organizations and traditional institutions of higher education have developed and are using web-based courses, but little is known about their effectiveness compared to traditional classroom education. Our work focuses on the effectiveness of a web-based virtual learning environment (VLE) in the context of basic information technology skills training.

This article provides three main contributions. First, it introduces and defines the concept of VLE, discussing how a VLE differs from the traditional classroom and differentiating it from the related, but narrower, concept of computer aided instruction (CAI). Second, it presents a framework of VLE effectiveness, grounded in the technology-mediated learning literature, which frames the VLE research domain, and addresses the relationship between the main constructs. Finally, it focuses on one essential VLE design variable, learner control, and compares a web-based VLE to a traditional classroom through a longitudinal experimental design.

Our results indicate that, in the context of IT basic skills training in undergraduate education, there are no significant differences in performance

between students enrolled in the two environments. However, the VLE leads to higher reported computer self-efficacy, while participants report being less satisfied with the learning process.

Keywords: Virtual learning environments, Web-based training, experimental research, basic skills training, information technology training, computer self-efficacy.

ISRL Categories: GA03, HB08, IA02.

Introduction ■■■■■■■■■

Since the commercialization of the Internet, Internet technologies have had profound impacts on a number of industries (Evans and Wurster 1997) and have allowed small entrants to compete with established dominant incumbents (Yoffe and Cusumano 1999). While in the learning industry, the pace of transformation may not have been as dramatic, education has not been immune to Internet-driven change (Beller and Or 1998; Kiser 1999). Traditional institutions of higher education, universities and colleges, have been somewhat slow to realize the potential impact of these technologies, but many of them are now beginning to develop and deliver web-based courses (McCormick 2000). Researchers as well as practitioners have suggested that "nothing will protect the business school from being swept into the current of technologically driven change" (Ives and Jarvenpaa 1996, p. 39; Lenzner and Johnson 1997).

In this article we define the virtual learning environment (VLE) concept and, drawing on technology-mediated learning theory, develop a conceptual framework that identifies the primary dimensions of a VLE and their relationship to learning effectiveness. We then report the results of a preliminary test of a subset of the relationships identified by the framework. We limit our inquiry to basic information technology (IT) skills, although the conceptual framework proposed has broader utility. Employing a longitudinal experimental design, we compare a VLE to a traditional classroom-based course designed to introduce students to computing principles and basic end-

user skills (i.e., proficiency with the Microsoft Office suite of productivity tools).

We focus on basic IT skills for several reasons. Technology savvy students and instructors are early adopters of technology and represent a high proportion of users of web-based courses. Technology courses were among the first to appear on the web and are still among the most popular online offerings. An important motivation for teaching web-based courses in many universities, particularly those funded by public sources, often arises from the search for an efficient delivery vehicle for introductory courses. Particularly in information systems education, with its shortage of faculty and growing student demand, web-based courses may help relieve the pressure. As faculty and administrators become more familiar with the potential applications of Internet technologies in education, their use in higher-level courses will likely increase. We chose to focus on basic IT skills because of their fast obsolescence and because of the growing need for training in both academic and business environments.

Our conceptual framework will be most useful to researchers investigating VLE effectiveness. The immediate findings of our experiment will be most useful to universities considering the transfer of basic IT skill courses to the Internet and to organizations seeking effective methods to continuously upgrade the IT skill sets required of their employees.

The article is organized as follows. In the next two sections, we define the VLE concept and present the conceptual framework. We then focus on one dimension, learner control, and develop the study hypotheses, followed by a description of the research design. Analysis and discussion of the results, the study limitations, implications for research, and our conclusions follow.

Virtual Learning Environment ■

Virtual learning environments (VLEs) are defined as "computer-based environments that are relatively open systems, allowing interactions and

encounters with other participants" and providing access to a wide range of resources (Wilson 1996, p. 8). VLEs are distinguished from *computer microworlds*, where the students individually enter a self-contained computer-based learning environment, and *classroom-based learning environments*, where various technologies are used as tools in support of classroom activities (Wilson 1996).

VLEs share many similarities with computer aided instruction (CAI), or computer microworlds. For example, learners can access the material independently, individuals can follow different paths through it, and can utilize different material displays. But the VLE concept is broader than CAI and adds the communication dimension to a previously individualized learning experience. Because VLEs are built to take advantage of the now widely available network infrastructure, VLEs can foster communities of learners and encourage electronic interaction and discussion (Wilson 1996). In a VLE, the learning process is no longer an individual endeavor, but can incorporate and leverage the many-to-many relations among learners and with instructors.

Traditionally, learning environments are defined in terms of *time*, *place*, and *space*. We expand the traditional definition of learning environment to include three further dimensions: *technology*, *interaction*, and *control*. Table 1 contains definitions of each dimension and examples that clarify how a VLE differs from traditional classroom education on each of them.

Traditionally, technology has not significantly altered educational environments. Electronic mail has been adopted, to varying degrees, for one-to-one student-teacher communication, but most communication is still carried out during classroom meetings or through broadcast electronic mail messages sent from a faculty member to all students. Some courses rely on the use of videotaped lectures or CAI modules that students can use at their own convenience, but these arrangements don't allow for interaction among students and with the instructor. Conversely, VLEs provide high levels of student control, support participant contact and interaction throughout the learning

process, and provide an opportunity to restructure the learning experience in ways not feasible with CAI alone. In the next section, we develop a framework outlining the theoretical constructs and relationships that shape the domain of VLEs. The framework aims at identifying the key determinants of VLE effectiveness, broadly explaining the underlying processes linking these variables and clarifying how VLEs differ from CAI and other technology-mediated learning environments.

Theoretical Development ■■■■

Recent research suggests that technology-mediated learning environments may improve students' achievement (Alavi 1994; Hiltz 1995; Maki et al. 2000; Schutte 1997; Wetzel et al. 1994), their attitudes toward learning (Schutte 1997), and their evaluation of the learning experience (Alavi 1994; Hiltz 1995). Technology may also help to increase teacher/student interaction (Cradler 1997; Hiltz 1995; Schutte 1997), and to make learning more student-centered (Cradler 1997). Proponents of VLEs suggest that they can potentially eliminate geographical barriers while providing increased convenience, flexibility, currency of material, student retention, individualized learning, and feedback over traditional classrooms (Hackbarth 1996; Kiser 1999; Massy and Zemsky 1995).

While much of the literature emphasizes the value, or potential value, of technology in education, others highlight its drawbacks (Hara and Kling 2000). Students in VLEs may experience feelings of isolation (Brown 1996), frustration, anxiety, and confusion (Hara and Kling 2000), or reduced interest in the subject matter (Maki et al. 2000). Learner achievement has also been questioned. Some authors suggest that there is generally no significant difference between technology supported environments and traditional face-to-face instruction. Most notable is a compilation of over 350 comparative studies, dating back to studies of instructional radio, reporting no significant difference in performance (Russell 1999). While this work mainly focuses on audio/video technology, it incorporates other technologies, including computer microworlds and VLEs. These

Table 1. Classification of Dimension of Learning Environments		
Dimension	**Definition**	**Comparison**
Time	The timing of instruction. VLEs free participant from time constraints.	When instruction is delivered asynchronously in a VLE, participants retain control as to when they engage in the learning experience. Learners determine the time and pace of instruction.
Place	The physical location of instruction. VLEs free participants from geo-graphical constraints.	Participants access the learning material and communi-cate with classmates and instructors through networked resources and a computer-based interface, rather than face-to-face in a classroom.
Space	The collection of materials and resources available to the learner. VLEs provide access to a wide array of resources.	While it is feasible to expand the traditional model of classroom-based instruction to include the variety of resources available in VLEs (Leidner and Jarvenpaa 1993, 1995), generally these materials remain only a secondary resource in instructor-led classroom education.
Technology	The collection of tools used to deliver learning material and to facilitate communication among participants.	In VLEs technology is used to deliver learning material and to facilitate many-to-many communication among distributed participants. Text, hypertext, graphics, streaming audio and video, computer animations and simulations, embedded tests, and dynamic content are some examples of delivery technology. Electronic mail, online threaded discussion boards, synchronous chat, and desktop videoconferencing are some examples of communication technology.
Interaction	The degree of contact and educational exchange among learners and between learners and instructors.	VLEs rely on information and communication technology to create the venue of knowledge transfer and learning progress. Unlike computer microworlds, VLEs are open systems that allow for communication and interaction among the participants. Unlike traditional classroom edu-cation, VLEs support student-to-student and student-to-instructor connectivity throughout the learning experience in a technology-mediated setting.
Control	The extent to which the learner can control the instructional presentation. Control is a continuum enabling the design of varying degrees of learner control (Newkirk 1973).	A certain degree of learner control can be built into tradi-tional classroom instruction, but VLEs have the potential to provide far greater personalization of instruction and a much higher degree of learner control than traditional classroom education. Traditional learning environments do allow students, when outside of the classroom, to control the pace and sequence of material, and the time and place of their study. VLEs, however, provide this flexibility *during* instruction as well.

authors suggest that, "if learning occurs as a result of exposure to any media, the learning is caused by the instructional method embedded in the media presentation" (Clark 1994, p. 26). They conclude that "the instructional implementation of the technology," not the technology itself, determines learning outcomes (Collins 1995 p. 146).

We share these views and believe that technology alone does not "cause" learning to occur. Indeed, some of the inconclusive findings regarding the effectiveness of technology in the classroom have been attributed to the failure to control emerging learning model differences in comparing traditional instruction to technology-mediated education (Leidner and Jarvenpaa 1995). While technology itself does not determine learning outcomes, technologies differ significantly with respect to the learning environments they foster. For example, while it is impossible to accommodate learners with different preferences for time of instruction in traditional classroom education, this objective is quite simple to achieve in an asynchronous VLE. Therefore, when technology enables the development of a different learning environment, different learning outcomes should be expected (Leidner and Jarvenpaa 1995).[2]

Research on technology enhanced learning environments dates back to the beginning of the last century (De Vaney and Butler 1996), but very little attention has as yet been devoted to web-based courses and training (Beller and Or 1998). This paucity of research is surprising and is partly due to the relative novelty of networked technology use in education. It is perhaps even more surprising given the magnitude of the available market for web-based education, and the potentially devastating effects that emerging for-profit online education alternatives can have on traditional institutions of higher education (Lenzner and Johnson 1997). As high bandwidth rapidly becomes available and access costs decline, a number of VLEs are being developed and research attention is increasing in response to

calls for the study of VLE effectiveness (Hiltz 1993)

While interest in web-based training and VLEs is growing rapidly, a broad framework identifying the theoretical constructs and relationships in this domain has yet to be developed. Drawing on previous research in technology-mediated education, we contribute an initial conceptualization of the determinants of learning effectiveness in VLEs. We identify two classes of determinants: human dimension and design dimension. The framework is portrayed in Figure 1 and is followed by a discussion of the relevant constructs and their relation to learning effectiveness.

Human Dimension ■■■■■■

Students

Students are the primary participants in any learning environment. The dominant learning environment today is the classroom and students are generally comfortable with it. From this dominant model, VLEs depart noticeably due to their use of technology and the shift of control and responsibility to the learners that they promote. Maturity and motivation have been linked to academic success in VLEs (Leidner and Jarvenpaa 1995). For example, effective learning in a VLE, compared to traditional classrooms, has been observed for mature and motivated learners while less motivated and mature students tend to suffer (Hiltz 1993). The high levels of flexibility in terms of time, place, and space offered by VLEs may be a further source of motivation for mature non-traditional students who have work or family constraints.

VLEs require all participants to interact extensively with computers. In such a learning environment, individuals who are comfortable with technology and who have positive attitudes toward it should thrive due to low levels of anxiety and likely excitement with the learning environment. Previous experience with a VLE may also be an antecedent of success. As students' experience with the VLE increases, they should develop and fine-tune learning strategies (Jonassen 1985) that are appropriate for this environment. Moreover, if the

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[2]Proponents of the thesis of no significant difference recognize the logic of this argument but cite the quantity of contradictory research in support of their view (Russell, personal communication to authors).
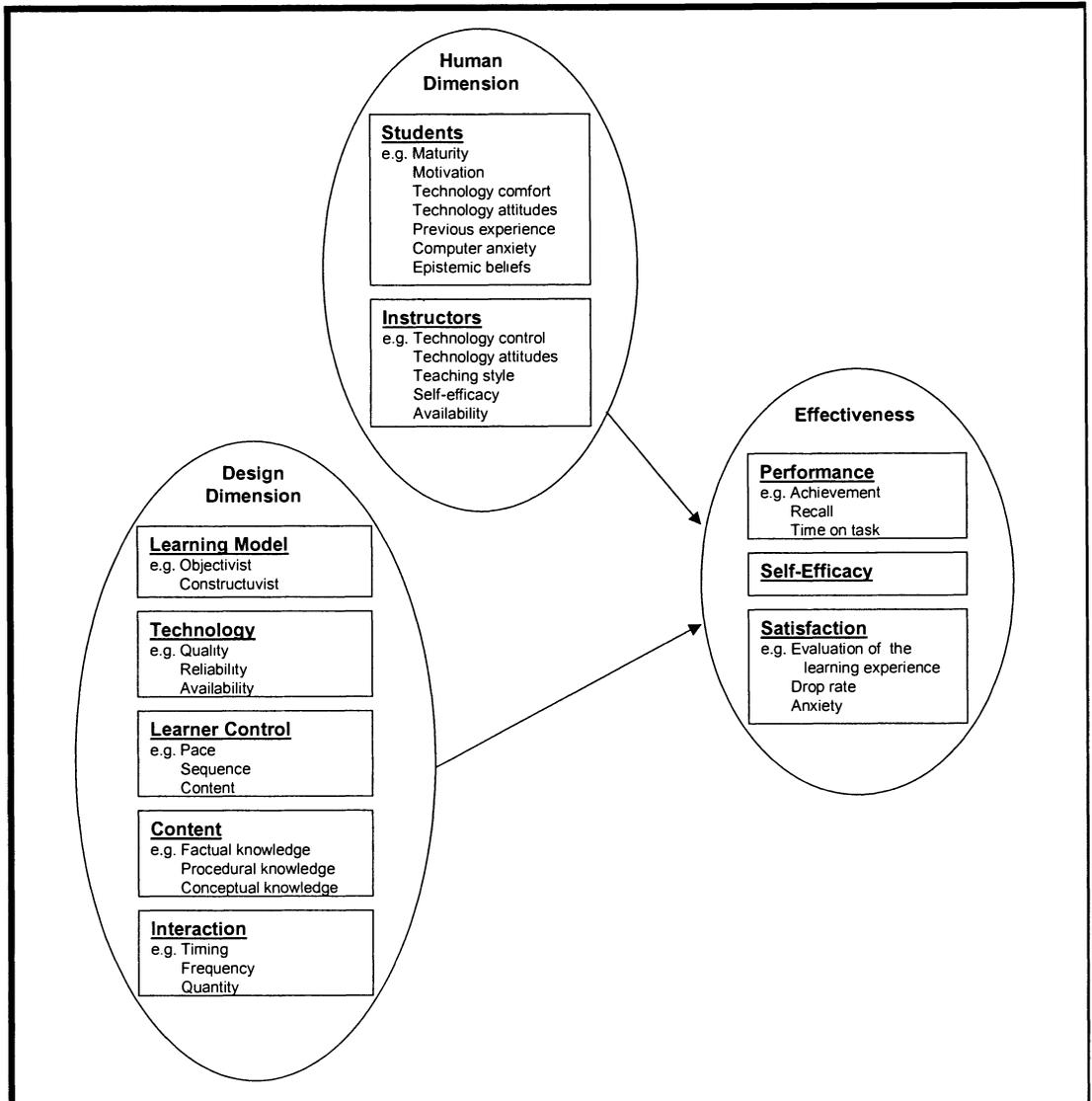
Figure 1. Dimensions and Antecedents of VLE Effectiveness

experience has been positive, learners' positive attitudes toward technology-mediated learning environments should be strengthened and their anxiety reduced. Individual epistemic beliefs, beliefs about the nature of learning and the structure of knowledge, may also influence students' ability to learn effectively in a VLE (Jacobson and Spiro 1995). If student's conscious or unconscious epistemic beliefs do not fit a given VLE, we can anticipate their failure to learn in that environment.

Instructor

Instructors are principal actors in any learning environment (Webster and Hackley 1997). Previous research in technology-intensive learning environments has highlighted several characteristics of instructors that relate to effective learning in such environments. Webster and Hackley found that an instructor's positive attitude toward technology, the instructor's interactive teaching

style, and the instructor's control over the technology related to a number of attitudinal measures of learning effectiveness. These results, obtained in the context of videoconferencing distance education, suggest that an instructor's own behavior conveys cues that shape students' evaluation of the experience. Others have reported that the instructor's self-efficacy contributes to learning effectiveness (Cavanaugh et al. 2000; Mathieu et al. 1993).

Hiltz (1993) noted that teachers in VLEs are perceived to be constantly "on duty" with a consequent substantial increase in time and energy requirements. This heightened level of obligation stems from the lengthier nature of the communication and interaction in the virtual environments (Walther 1992). Students may feel isolated and may, therefore, more often seek contact with the instructor (Hara and Kling 2000). Moreover, when students are not constrained to the typical class meeting schedule, they may perceive the class to be "in session" whenever they connect to it. It is arguable that courses where the instructor is unwilling and/or unable to adjust to the higher time and energy demands of the virtual environment will not be effective. VLEs are computer-based systems that permeate every aspect of the students' learning experience. Instructor behavior, as surfaced through attitudes and actions, can have an important influence on students' own reactions to the learning environment.

Design Dimension ■■■■■■

Learning Model

At the heart of the learning process is an implicit or explicit learning model (Leidner and Jarvenpaa 1995). The objectivist, or traditional, learning model assumes an agreed upon reality that can be represented and communicated (Jonassen 1993). Proponents of this model view learning as the transfer of knowledge to the learner. Conversely, the constructivist model considers reality as constructed either socially or by individuals (Jonassen 1993). Therefore, learning consists of the development of abstract models to represent reality (O'Loughlin 1992). A thorough discussion

of learning models and their underlying assumptions is beyond the scope of our work (see Leidner and Jarvenpaa 1995). These models of learning influence the design of a learning environment and ultimately its effectiveness. From a methodological standpoint, it is important to reiterate that research on the effectiveness of instruction, whether in VLEs, in the traditional classroom, or in any technology-mediated environment, must explicitly acknowledge the role of the learning model (Leidner and Jarvenpaa 1995). The researcher must either control it or evaluate its effects. Failure to do so leads to the inability to compare different learning environments, contributing to a proliferation of inconsistent research results (Leidner and Jarvenpaa 1995).

Technology

Technology quality and reliability, as well as easy access to appropriate hardware and software equipment, are important determinants of learning effectiveness, particularly students' affective reaction to the learning experience (Hiltz 1993; Webster and Hackley 1997). Leidner and Jarvenpaa (1995) suggest that some technologies are best suited to support specific theoretical models of learning (e.g., objectivist, constructivist). For example, self-paced, individual CAI seems best suited to support an objectivist approach while classes based on computer-mediated discussion may be aligned with a constructivist philosophy (Romiszowski and Mason 1996). Electronic teaching technologies can generally be deployed in support of different philosophies, and the same technology can be used to support different learning models depending upon its implementation and use (Clark 1994; Collins 1995). An electronic forum with discussion board technology presents an apt example. If the instructor uses it to quickly and publicly answer student questions, as is done during in-class lectures, the behavior is consistent with an objectivist model. Conversely, if the instructor fosters asynchronous discussion through the medium, facilitating the students' exploration of the subject, and engaging them in discourse and construction of meaning, the behavior is consistent with the constructivist model.

Learner Control

Learner control refers to "instructional designs where learners make their own decisions regarding some aspects of the 'path,' 'flow,' or 'events' of instruction" (Williams 1996, p. 957). More precisely, learner control is the degree of discretion that students can exert over the *pace*, *sequence*, and *content* of instruction in a learning environment (Milheim and Martin 1991). Content refers to the instructional material presented to the learner; pace refers to the rate of presentation of the instructional material and the time spent on each instructional component; sequence refers to the order of presentation of the material (Milheim and Martin 1991).

Proponents of learner control argue that higher degrees of learner control lead to better student performance, measured as a lower number of errors on tests, and a more positive student affect, measured by self reports of satisfaction (Merrill 1994). Motivation theory (Keller 1983), attribution theory (Martin and Briggs 1986), and information processing theory (Gagné 1985) provide the underpinning of learner control (see Milheim and Martin 1991). Positive results are hypothesized because "learner control is a way of allowing individual differences to exert a positive influence without trainer control" (Williams 1996, p. 997).

The appeal of the general positive effect of learner control notwithstanding, empirical findings remain inconclusive with some research reports showing either the superiority or inferiority of learner control to program control, but with the majority of the literature reporting no significant difference (Reeves 1993; Williams 1996). Duchastel (1986) warns that

> the research leads one to be cautious about the general learner control hypothesis, namely, that the student is the best judge of the instructional strategy to be adopted (p. 391).

More precisely, when confronted with high degrees of learner control, individuals are called upon to make instructional decisions. Individuals differ in their ability to make appropriate educational decisions and thus to take advantage of increased control (Reeves 1993). Two cognitive traits, prior knowledge and ability, explain some of the negative findings on learner control (Williams 1996). For example, there is some evidence that learners who have higher control tend to over-estimate their ability (Lee and Wong 1989) and, as a result, may view less material and skip important instructional components (Lepper 1985). Individuals with prior specific knowledge are better able to gauge their learning needs and benefit from high degrees of learner control (Lee and Lee 1991).

To increase the successful implementation of learner control arrangements for a wide range of students, instruction should be designed to aide learners in gauging their progress and instructional needs (Milheim and Martin 1991; Steinberg 1989). Strategies for meeting this goal include informing learners directly, instructing them to continuously gauge their progress, or training them to monitor their learning more effectively (Williams 1996). Considerable empirical support for these techniques is reported in the literature (Holmes et al. 1985; Schloss et al. 1988; Tennyson 1981; 1980).

Content

Due to the novelty of VLEs, considerable uncertainty remains regarding the subject matter and content type best suited to delivery in the virtual environment. CAI is generally thought to be an effective means for transferring factual and procedural knowledge when employing the objectivist learning model. Technologies that promote communication and interaction can be effectively used to develop higher-order thinking skills and build conceptual knowledge when following a constructivist or collaborative learning model (Leidner and Jarvenpaa 1995). Technologies that promote participant communication are best suited for subject matter or course designs that emphasize discussion, brainstorming, problem-solving, collaboration, and reflection (Wells 1990). VLEs mirror characteristics of CAI, but with the addition of facilities supporting extensive participant interaction. Therefore, VLEs appear well suited for a wide range of topics and content.

Interaction

VLEs are by definition open systems that allow for participant interaction through synchronous or asynchronous electronic communication. Communication media enable interactivity, but the degree to which a course is interactive depends largely on participants' behavior. Timely contribution and high participation frequency are necessary prerequisites (Romiszowski and Mason 1996). Few studies have evaluated learning outcomes as a function of participant interaction in VLEs (Romiszowski and Mason 1996). Early research suggests that interaction through electronic media in VLEs is most appropriate in support of learning rather than as the primary delivery medium (Vaverek and Saunders 1993). This is likely due to information overload that can quickly dilute valuable contributions with trivial information, and to the typically asynchronous nature of electronic communication that may make discussions hard to follow (Grint 1989; Harshim 1987; Hiltz 1986). With respect to the affective dimension, high levels of interaction may ease the feelings of isolation, anxiety, and confusion.

In the context of VLEs, participant interaction and electronic communication can play an important role in fostering effective learning by enabling students to evaluate their progress and instructional needs, thus complementing the high degree of learner control. When given the ability to ask and answer questions, to post comments, and to generally engage in an intellectual exchange with peers and the instructor, students verbalize their current understanding of the material. This verbalization process is similar to self-explanation and to articulation of cognitive processes. When engaging in self-explanation, learners comment on problems and examples that they are currently working on and articulate their current understanding (Chi and VanLehn 1991). Articulation processes, such as "think aloud" protocols, encourage learners to evaluate their understanding by making their decisions and problem solving strategies explicit (Collins 1991). Both self-explanation and articulation processes promote the expression of tacit knowledge and its reinterpretation into explicit statements. This verbalization activity is hypothesized to improve

learning directly, by making tacit knowledge more explicit and available for use (Chi and VanLehn 1991; Collins 1991), as well as indirectly, by revealing knowledge gaps and lack of comprehension. Participants in a VLE not only post their questions and comments, but also monitor contributions by others and can in turn reply. This monitoring process further serves as a mechanism for progress evaluation. While students may or may not reply, the initial contribution is likely to stimulate a cognitive response by the readers, who will evaluate their understanding of the topic. Therefore, electronic communication provides learners with a tool to gauge their progress and their instructional needs during self-paced instruction.

We have developed a general framework of the antecedents of effectiveness in the VLE encompassing both human and design variables. Given the number of constructs and the complexity of the relationships described above, an evaluative comparison of VLEs and traditional classroom instruction, or other technology-mediated learning environments (Alavi and Leidner 2001; Leidner and Jarvenpaa 1995), can only be achieved through programmatic research. In the remainder of the paper, we present early results of such a program of research.

Development of Hypotheses ■■

We built a web-based VLE to teach introductory IT skills, explicitly leveraging the unique structural characteristics of the underlying technology. Networked computer technologies, such as the Web, allow course designers to break the time and place boundaries of the traditional classroom, while maintaining a high level of connectivity and interaction among participants. The VLE provides a level of learner control, complemented by progress evaluation tools, not attainable in the traditional classroom setting. Echoing recent calls for greater depth and attention to the underlying structure of learning environments (Alavi and Leidner 2001), we focused on the construct of learner control and its relationship to learning effectiveness. Drawing upon the conceptual

framework presented above, we developed testable hypotheses comparing the two environments on measures of learning effectiveness. Effectiveness has historically been measured in terms of students' achievement and satisfaction. We add computer self-efficacy as a learning effectiveness dimension due to its relevance to IT skills development.

Component display theory (CDT; Merrill 1983) provides the foundation for the design of both the VLE and the traditional classroom. CDT is a theory of instructional design that introduces the notion of presentation forms as the basic components of a lesson. Merrill (1983; 1994) identifies four primary presentation forms: (1) rule: the expository presentation of a generality (i.e., a teaching module); (2) example: expository presentation of an instance (i.e., specific illustration of a rule); (3) recall: inquisitory generality (i.e., practice questions); (4) practice: inquisitory instance (i.e., practice tasks). According to CDT, a segment of instruction should include all of the above principal presentation forms in order to provide the learner with a full range of instructional tools. Learners should then be allowed to control the learning pace, the sequence of presentation, and which forms to employ or skip (i.e., control over content).

When a course is designed according to the tenets of CDT and all of the primary presentation forms are incorporated in each lesson, higher levels of learner control are hypothesized to generate higher student performance, as measured by number of errors on an achievement test following instruction (Merrill 1983, 1994). Because learners vary in their ability to gauge their progress and take advantage of a high level of control (Milheim and Martin 1991), learner control should be coupled with aids for self-monitoring of progress (Williams 1996). The VLE provides superior learner control while enabling self-monitoring of progress through practice assignments and discussion. Thus, we hypothesize:

> H1: *Students in the virtual learning environment achieve higher test scores than their counterparts in the traditional learning environment.*

We recognize the importance of performance as a learning outcome, but broaden the notion of effectiveness to include self-efficacy. Self-efficacy represents

> people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with skills one has but with judgments of what one can do with whatever one possesses (Bandura 1986, p. 391).

As such, self-efficacy refers to individuals' own belief in their ability to successfully perform a specific behavior.

In the context of IT basic skills training, it is very important to evaluate the learners' propensity to actually apply what they have learned and the confidence they have developed in their ability. Computer self-efficacy, defined as one's judgment of his or her ability to complete a task using computers (Compeau and Higgins 1995a), influences not only the decision to enroll in computer courses (Hill et al. 1987) but also successful performance (Gist et al. 1989; Webster and Martocchio 1992). However, performance alone offers no indication regarding behavior that learners will exhibit when they are confronted with a new task that requires them to apply their newly acquired skills. By coupling the performance indicator with a measure of what the learners perceive their skill level to be and their confidence in their ability to perform, we provide a more complete assessment of effectiveness.

While an explicit link between learner control and self-efficacy has not been established empirically, Keller's (1983) model of motivational instructional design indicates that providing learners with learner control enhances their self-efficacy. Learner control theorists, building on attribution theory (Martin and Briggs 1986), have suggested that students who have more control over their learning experience ascribe the learning outcome to their own ability (Williams 1996). Thus, learners exerting control tend to make more internal and stable attributions about their learning (Williams 1996). Having learned "independently"

once in a given topic area, they feel that they can do so in the future (i.e., develop high self-efficacy). We hypothesize:

H2: *Students in the virtual learning environment will report higher levels of computer self-efficacy than their counterparts in the traditional learning environment.*

Satisfaction has been a widely used parameter to evaluate the effectiveness of learning environments both in academic (Alavi 1994; Alavi et al. 1995) and business settings (Wolfram 1994). VLEs differ substantially from traditional, class-room-based, learning environments and their success may depend heavily on learners' acceptance of this new training format. Particularly, as previous experience is a critical determinant of future attitudes (Eagly and Chaiken 1993), it is important to evaluate students' satisfaction with this novel class of learning environments. CDT, as well as the general learner control research, link higher degrees of learner control with increased student satisfaction (Merrill 1983; Williams 1996). Allowing students to engage in the learning activity when and where they prefer, to learn at their own pace, and to focus on the material that they deem important tend to engender positive responses. But the positive effects of learner control must be weighted against potential feelings of frustration students may experience when unable to make effective instructional decisions (Williams 1996).

Generally, computer-mediated environments are still foreign to the general population that, when using them, typically reports low levels of satisfaction with the experience. For example, recent research on student satisfaction in VLEs indicates that the students in the traditional classroom reported higher scores on this dimension (Maki et al. 2000). The authors ascribe this result to the perception by students in the VLE that they had to work harder than usual. In general, when individuals are confronted with a new technology-intensive learning environment, they tend to have negative attitudes that lessen, but don't entirely disappear, over time (Wetzel et al. 1994). This dynamic is not idiosyncratic to VLEs, but it is also common in other computer-mediated environ-

ments. For example, a recent review of 280 GSS laboratory experiments where satisfaction was measured shows that only 10% of them yielded positive results (Fjermestad and Hiltz 1999). The general student population is accustomed to traditional classroom education (Simon et al. 1996). VLEs depart considerably from the traditional model and shift much of the responsibility for learning to the students. In light of these competing predictions, our third hypothesis is exploratory and non-directional.

H3: Students in the virtual learning environment will report different levels of satisfaction than students in the traditional learning environment.

Research Design ▬▬▬▬▬

We employed a longitudinal field experiment adopting a two group repeated measure design varying the learning environment (web-based, traditional).

The Course

The course is an introductory course in management information systems for undergraduate business students. The course is required of all students enrolled in the College of Business, but it attracts students from many non-business curricula. The purpose of this course is hands-on computer training. It covers a brief introduction to computers and the basic concepts of word processing, presentation software, spreadsheets, and database management systems using Microsoft Office. The first half of the semester focuses on word processing and presentation software. The second half of the semester concentrates on spreadsheet and database management applications.

The Subjects

A total of 146 undergraduates participated in the experiment. Subjects had no prior knowledge of

Table 2. Subject Participation by Section

Learning Environment	Section	Data Collection			Usable Data
		Preliminary	Midterm	Final	
Virtual	Sect. V1	47	38	34	34
	Sect. V2	47	43	36	36
Subtotal		*94*	*81*	*70*	*70*
Traditional	Sect. T1	46	48	45	42
	Sect. T2	41	37	37	34
Subtotal		*87*	*85*	*82*	*76*
Total		**181**	**166**	**152**	**146**

the experimental character of the selected sections and signed up based on personal reasons and schedule fit. Further, they were not aware of the identity of the instructors prior to enrollment. At the beginning of the semester, students in the VLE were informed that they would be taking the course online rather than coming to class. The experiment began with an initial pool of 192 subjects (48 per section). However, complete records were only available for 146 subjects (see Table 2).

The subjects were representative of the traditional business undergraduate population. They were young (age ≤ 22, 91%), and fairly evenly distributed by gender (56.8% males, 43.2% females). The distribution by classification is typical of the population of the over 800 students who take the course: freshman (18.5%), sophomore (52.1%), junior (17.8%), and senior (11%). In a preliminary survey, completed during the first week of class, we measured demographics, attitudes toward computer use, previous experience with computers, expectation for the course, and self-reported knowledge of course material. We also administered an objective skill assessment quiz covering core course material. A series of t-tests revealed no significant difference between the treatment and control group on these dimensions, with the exception of self-reported previous experience with spreadsheets. However, the t-test of spreadsheet knowledge scores measured by way of the objective skill assessment revealed no statistical difference. Given the preponderance

of the evidence, we assume homogeneity of pre-treatment skills, attitudes, and experience.

Procedure and Learning Environments

Seventeen sections of the target course were offered during the semester; four sections were included in the experiment. Two instructors participated in the experiment, and they were assigned to course sections based on departmental requirements during the preparation of the class schedule. Each instructor taught one section in the traditional classroom and one section in the VLE. In the traditional classroom, the instructor lectured and demonstrated specific software features using standard practice assignments and an overhead projector. One half of the class time was spent in a computer laboratory where each student had access to a computer and completed the practice assignment along with the instructor. Each week, students were assigned homework projects.

The VLE was developed using Lotus Learning Space, a curriculum delivery application that facilitates the creation and administration of online courses delivered through a Lotus Notes client or a Web browser. The core instructional material is organized in online teaching modules grouped in tutorials. Each module describes a command in the target application (e.g., Microsoft Word) and, through step-by-step instructions mirroring in-

class lectures, illustrates how to effectively use it. Each module also links to an animation that depicts visually how each task is carried out. Materials in logically connected instructional modules are cross-linked, thus allowing the students to control the path through the modules. Each module is also accessible directly through menus, thus allowing students to instantaneously retrieve information as they are confronted with assignments and problems. Through JavaScript routines, the material is presented on screen along with the target application, allowing students to practice skills as they acquire them. The VLE is an open system, allowing participants to interact through an electronic forum. Students and the instructor can participate with comments, questions, and responses at any time, in asynchronous fashion, in the class electronic discussion. The forum is publicly available to all participants in the VLE and discussion can be threaded, thus allowing students to easily access and read interactions on different subjects. The threading of public communication also enables students to selectively access topics of interest to them while skipping the others (for further information on the VLE's characteristics and development see Ahmad and Piccoli 1998; Piccoli et al. 2000).

Both versions of the course, traditional and web-based, were designed following the tenets of CDT and included all four primary presentation forms. Each segment of instruction contained a general explanation of a command. The command was then demonstrated either by the instructor in class or through animations online. Each segment of instruction also offered a practice task that the students were required to complete. We explicitly addressed the potential for researcher bias. The primary investigator did not teach, but monitored the teaching activities. One of the authors was also an instructor but he, as well as the second instructor, was not informed of the research details (hypothesis, dependent variables, instruments) prior to the completion of the course.

Many studies in the learner control tradition have used a single lesson as the unit of analysis (Reeves 1993). Consequently, the limited duration of the treatment may be partially responsible for the lack of convergent findings (Reeves 1993). To mitigate this problem, we increased the dura-

tion of the experiment to one semester. The considerable length of the experiment enabled students in the VLE to adjust to the web-based instruction delivery system, and should reduce concerns based on confounding novelty effects while being representative of a standard semester-long course. In order to clarify the distinction between the traditional learning environment and the VLE used in our study, we contrast them on the six defining dimensions introduced earlier (Table 3).

Participants' interaction represents one of the defining characteristics of a VLE. Thus, we performed a *post hoc* categorization and analysis of the electronic forum logs to ensure that our course represents an accurate operationalization of a VLE. We subdivided messages into three categories: administrative, content related, and social. The first category refers to general announcements and questions (e.g., due dates, scope of exams). The second category refers to questions, answers, or comments directly referring to the learning material. The third category refers to social messages (e.g., interesting new movies or Web sites). A total of 698 messages were recorded in the one section we analyzed. The second section had comparable interaction and we deemed it unnecessary to repeat the analysis. Results, showing an adequate level of interaction, are presented in Table 4. Most students participated in the on-line activities with some being more active than others but with no students dominating the interaction.

Experimental Manipulation

During the first week of class, the students in the treatment group were taught how to navigate the online modules and how to access and use the available communication tools. During the second week of training, the students convened for three hours in a computer lab on campus and covered introductory material using the VLE. Both instructors were available to provide guidance and answer questions during the training sessions. For the remainder of the semester, class meetings occurred only for testing purposes (midterm and final). Students accessed the VLE via a Web browser either from home, the workplace, or any

Table 3. Differences between the Traditional Learning Environment and the VLE

	Traditional Environment	VLE
Time	• Students and instructor convene twice a week for 90 minutes • Students work independently on their assigned homework	• Students connect to the online classroom when they choose • Students work independently on their assigned homework
Place	• Students and instructor convene in a physical classroom • Students complete their homework at home, work, or a school computer laboratory	• Students connect to the online course from home, work, or a school computer laboratory • Students complete their homework at home, work, or a school computer laboratory
Space	• The instructor lectures during class time • Students use their notes when completing assignments outside of class	• Students use online teaching modules • Students use the same online teaching modules to complete assignments
Interaction	• Students are able to interact face-to-face with the instructor during bi-weekly lectures • Students receive immediate responses to questions asked during class meeting • Limited interaction between the instructor and some students (individually) occurs via e-mail	• Communication occurs exclusively through electronic media (e-mail, discussion board) • Students post questions to the online discussion; responses are generally not immediate • Communication among all participants is ongoing
Technology	• An overhead projector allows the instructor to demonstrate the operation of the applications • Students sit at workstations during instruction and repeat the tasks shown by the instructor	• Students access the online material through a Web browser • Students access the communication technology through a Web browser
Learner Control	• Students cannot control the pace or order in which the material is presented • Students cannot skip over topics during the lecture • Students can ask for repetition of concepts or topics but do so rarely and almost never is there more than one repetition	• Students control the pace and order in which the material is accessed • Students are free to review or skip any lecture or components of it • Students can repeat entire lectures, or any component of them, at will and repeatedly

Table 4. Total Number of Messages Exchanged during the Semester in One VLE Section		
Interaction Type	**Total**	**Percentage**
Administrative (by instructor)	29	4%
Administrative (by students)	110	16%
Subtotal: Administrative	**139**	**20%**
Content (by instructor)		
Replies by the instructor	112	16%
Initiation of conceptual threads	21	3%
Content (by students)	392	56%
Subtotal: Content	**525**	**75%**
Social	34	5%
Total	**698**	**100%**

school lab. Interaction with instructors and class-mates occurred by means of private electronic mail and the class asynchronous electronic discussion. A set of identical teaching procedures was devised to ensure consistency between instructors and between treatments. The learning model employed in both learning environments was carefully controlled. Through a set of proce-dures, developed and monitored by the primary researcher, consistency of learning models between instructors and between treatments was assured. The primary researcher also monitored interaction both in the VLE and in the classroom and provided direction and suggestions to correct behaviors when necessary. Assignments, exams, and deadlines were standardized as well.

The primary structural difference between the two learning environments is the higher level of learner control provided by the VLE. The VLE allowed the students to access the teaching material at any time and from any location equipped with a computer and an Internet connec-tion. Conversely, students in the traditional learning environment had to attend class at specified times. Students taking the course online were able to customize the teaching material. They could briefly review or skip topics with which they were familiar, or they could repeat at will topics that they did not comprehend. They could also limit their attention to presentation forms they found useful and skip those that they did not. For example, one student might only use animations

while another might rely exclusively on textual instructions or a mix of the two. The VLE provided a higher level of learner control than was available to the students in the control group,[3] and enabled students to evaluate their progress and instruc-tional needs through practice assignments and interaction with other participants.

To corroborate the above arguments with perceptual data, we asked all subjects involved in the experiment to evaluate their control over the learning pace. They were asked to agree or disagree, on a five-point Likert scale, with the following statement: "In this class I was able to learn at my own pace." Individuals in the VLE, on average, felt that they had more control over the learning pace ($p = 0.000$). While we only measured control over pace quantitatively, student comments provide evidence that they also enjoyed the other forms of control: "I like to be able to work at my own pace and on my own

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[3]While it could be argued that students in traditional classroom education are commonly provided with handouts, and they can flip through them at their own pace, in the VLE, the learner has access to the full range of instructional material and presentations. These can be accessed at will and at random; a student could repeat many times only the few modules of interest in a given lesson. This is clearly impossible in a traditional classroom, as it would equate to asking the instructor to repeat the same concepts many times and subsequently skip the following *n* topics, or to quit using animations and visual demonstrations to only focus on verbal explanations.

time"; "I liked the way you could choose to complete assignments wherever you chose"; "I really liked the structure of this class because it was at your own pace; if you understand, you could go do other projects." Perhaps the most informative comment on the learner control differential is the comment of one dissatisfied student: "I would learn the material better if it were 'forced' on me by having attended class."

Variables and Measures

Grades on midterm and final exams provided a measure of achievement. A pool of six graders, blind to the research hypothesis and subjects' section membership, was created. Grading assignments were rotated among them to avoid systematic grading bias. Both self-efficacy and satisfaction were measured through validated scales (Compeau and Higgins 1995b; Green and Taber 1980).[4] The primary investigator surveyed students before the midterm and before the final exam. When factor analyzed, all items loaded on the expected construct and the psychometric characteristics of the scales were satisfactory ($\alpha > .80$).

Two control variables, gender and instructor, were included in the analysis in an attempt to control for extraneous sources of variance and to maximize the power of the statistical test. Recent research has found that perception of technology usefulness and ease of use differs between genders (Gefen and Straub 1997). These findings, albeit exploratory, suggest that controlling for gender differences may be beneficial. During our preliminary survey, female subjects reported feeling significantly more threatened by computers than their male counterparts. Thus, we included gender as a control variable in our research model. To minimize the potential influence of idio-

syncratic instructor characteristics, two instructors participated in the experiment. We included instructor as a second control variable.

Qualitative data were collected through open-ended questions in the midterm and the final surveys, analysis of messages on the electronic discussion, and debriefing of the instructors and some students. We reviewed these sources of data to triangulate our quantitative findings and to assess the plausibility of competing explanations of our results.

Data Analysis and Results

Tests of the assumptions of homoscedasticity and normality underlying repeated measure designs (Hair et al. 1995) were satisfactory and justified further analysis. Mean and standard deviations of performance, self-efficacy and satisfaction are reported for both environments in Table 5. Multivariate tests of significance are reported in Table 6.

Our results show a statistically significant main effect of learning environment. This finding lends support to the proposition that, when learning model is held constant, VLEs and traditional classrooms differ in terms of learning effectiveness. We thus performed univariate tests to understand what dimensions of effectiveness account for these results (Table 7).

Our findings did not support the first hypothesis. While, in aggregate, the students in the VLE consistently outperformed their counterparts in the traditional environment, the score differential was not statistically significant. The second hypothesis was supported. Students in the VLE reported significantly higher computer self-efficacy than those in the traditional classroom. The third hypothesis shows a significant difference in satisfaction with the direction indicating that students in the VLE were less satisfied.

In order to determine if the pattern of results differed between the first and second data collections (i.e., midterm and final), we analyzed the data separately through multivariate analysis of variance. Because the material covered during

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[4]Green and Taber's satisfaction measure was originally developed to measure individuals' satisfaction with a group decision process. We modified the instrument to focus the subjects' assessment on their satisfaction with the learning process in the course. Subjects were asked whether they felt the learning process in the course was coordinated/uncoordinated, confusing/understandable, satisfying/dissatisfying.

Table 5. Means and Standard Deviations[a] of Dependent Variables

Dependent Variables	Virtual Environment			Traditional Environment		
	Midterm Exam	Final Exam	Total	Midterm Exam	Final Exam[b]	Total
Performance	84.9 [14.4]	80.9 [16.3]	82.5 [14.0]	82.7 [10.8]	76.1 [18.4]	79.4 [13.0]
Self-Efficacy	7.118 [1.72]	7.17 [1.882]	7.17 [1.55]	6.528 [1.66]	6.546 [1.704]	6.53 [1.531]
Satisfaction	3.869 [0.999]	3.542 [1.003]	3.7 [0.833]	4.06 [0.692]	3.971 [0.634]	4.016 [0.602]

[a]Standard deviations are shown in brackets.

[b]Table 5 shows a high performance drop between the midterm and final examinations. These results are typical in the course we examined and they are due to the higher difficulty of the material taught in the second half of the semester.

Table 6. Multivariate Test of Significance

Effect	Wilks' Lambda	F	df	p	Estimated Effect Size	Observed Power
Instructor	.930	3.513	3; 139	.017	.070	.772
Gender	.933	3.306	3; 139	.022	.067	.744
Learning Environment	.838	8.944	3; 139	.000	.162	.995

Table 7. Univariate Tests of Significance: Between-Subject Variables

Source	Measure	SS	df	MS	F	p	Estimated Effect Size	Observed Power
Intercept	Performance	86834.818	1	86834.818	249.643	.000	.639	1.000
	Self-Efficacy	995.682	1	995.682	214.970	.000	.604	1.000
	Satisfaction	286.742	1	286.742	290.504	.000	.673	1.000
Instructor	Performance	2.624	1	2.624	.008	.931	.000	.051
	Self-Efficacy	13.467	1	13.467	2.908	.090	.020	.395
	Satisfaction	9.606	1	9.606	9.732	.002	.065	.873
Gender	Performance	1283.852	1	1283.852	3.691	.057	.026	.479
	Self-Efficacy	8.639	1	8.639	1.865	.174	.013	.274
	Satisfaction	.425	1	.425	.431	.513	.003	.100
Type of Environment	Performance	501.537	1	501.537	1.442	.232	.010	.222
	Self-Efficacy	34.730	1	34.730	7.498	.007	.050	.776
	Satisfaction	6.150	1	6.150	6.231	.014	.042	.698
Error	Performance	49044.819	141	347.836				
	Self-Efficacy	653.073	141	4.632				
	Satisfaction	139.174	141	.987				

Table 8. Multivariate Tests of Significance								
	First Half				**Second Half**			
Effect	**Wilks' Lambda**	**F**	**df**	**p**	**Wilks' Lambda**	**F**	**df**	**p**
Instructor	.053	2.592	3; 139	.055	.048	2.334	3; 140	.077
Gender	.068	3.376	3; 139	.020	.073	3.649	3; 140	.014
Learning Environment	.093	4.735	3; 139	.004	.158	8.787	3; 140	.000

Table 9. Univariate Tests of Significance: Between-Subject Variables							
		First Half			**Second Half**		
Source	**Measure**	**F**	**p**	**Observed Power**	**F**	**p**	**Observed Power**
Intercept	Performance	310.814	.000	1.000	126.047	.000	1.000
	Self-Efficacy	181.774	.000	1.000	159.353	.000	1.000
	Satisfaction	193.370	.000	1.000	234.163	.000	1.000
Instructor	Performance	.208	.649	.074	.020	.889	.052
	Self-Efficacy	4.217	.042	.532	1.110	.294	.182
	Satisfaction	6.816	.010	.737	7.069	.009	.752
Gender	Performance	.426	.515	.099	6.503	.012	.717
	Self-Efficacy	.958	.329	.163	2.212	.139	.315
	Satisfaction	3.349	.069	.443	.419	.518	.099
Type of Environment	Performance	.759	.385	.139	1.264	.263	.201
	Self-Efficacy	5.860	.017	.672	6.253	.014	.700
	Satisfaction	2.318	.130	.327	8.307	.005	.817

the first and second halves of the semester was different—MS Word and Power Point, and MS Excel and Access, respectively—a consistent pattern of results would indicate that this difference had no effect on learning effectiveness and that the results are robust with respect to different IT skills. The results indicate that no performance or self-efficacy differences existed between the two environments at either time, but satisfaction differences were detected only at the end of the second half of the course. While the direction of the means is consistent over time, with students in the traditional environment reporting greater satisfaction than their counterparts, the difference is statistically significant only at time

two. Table 8 and Table 9 summarize these results.

Discussion ▊

VLEs offer a number of advantages over traditional teaching environments in terms of convenience and flexibility (Kiser 1999), but their effectiveness remains an open question (Kiser 1999; Milheim and Martin 1991). Our findings indicate that undergraduate students learning basic IT skills in a VLE or in a traditional classroom achieve comparable levels of mastery. This

result, consistent with prior technology-mediated learning research (Russell1999), runs counter to our first hypothesis. The high degree of learner control that VLEs engender, coupled with progress self-monitoring aids, did not lead to higher performance. While students in the VLE did not outperform their counterparts in the traditional classroom, their mean test scores were higher and we can confidently conclude that learning in the virtual environment did not prove detrimental from a performance point of view.

VLEs are learning environments unfamiliar to most learners who need to develop appropriate learning strategies (Jonassen 1985). Most students are only familiar with the dominant model of classroom education (Simon et al. 1996) and have not developed learning strategies that allow them to take advantage of the high levels of learner control and flexibility available in VLEs. Students accustomed to the direction and structure typical of traditional classrooms often have trouble managing high degrees of learner control and different delivery methods (Gall and Hannafin 1994). Many students indicated that they felt a great shift of responsibility from the instructor to themselves and that they found it difficult to adjust. One of the participants commented that "students should not be responsible for also being 'teachers,'" and another echoed that the relative freedom "made it a lot more difficult to complete assignments because they were never taught to us." Another stated: "I found learning this way was very, very frustrating," and a classmate stated that he had difficulties because the class "was different from my experience" and he had never taken "a class like this." One student commented about asking for help through the electronic communication facility: "It was difficult relaying exactly what I wanted to know." These comments highlight the fact that some students found themselves unable to cope with the high degree of learner control they received and with the novelty of the learning environment.

According to our expectations, the VLE fostered increased computer self-efficacy. These results were consistent over time and were maintained when different software applications were taught. While students received considerable guidance and instruction in the VLE, they felt that they had

learned independently. Having learned independently once, subjects felt that they could do it again in the future. Many comments clearly indicate that students in the VLE attributed learning outcomes to their own effort and ability. For example, "I have not taken away anything that I could not have gotten myself," "I felt like I had to teach myself a lot of the times," and "It was hard to figure out how to do certain things with just the tutorials and the book."

Subjects in the VLE reported lower levels of satisfaction than their counterparts in the traditional environment. A breakdown of students' satisfaction responses shows that significant differences in reported satisfaction only occurred during the second half of the semester. Students in the traditional classroom reported a steady satisfaction level throughout the semester ($p = 0.166$). Conversely, the level of satisfaction reported by the students in the VLE declined significantly during the second half of the course ($p = 0.016$). This pattern is consistent with the hypothesis that previous experience in the learning domain is necessary to avoid frustrating learners with a high degree of learner control that they are unable to properly utilize. While students in both learning environments had significantly higher experience and familiarity with the material covered during the first half of the course ($p = 0.000$), only the students in the VLE experienced a decline in satisfaction during the second half. A higher level of learner control offered by the VLE was not well received by the students when they turned to material with which they were less familiar. Qualitative data corroborate this finding. Three comments are indicative of the common opinion that the VLE was "a good learning environment for this material because most people have a general knowledge of [Microsoft] Office," "the second half was more difficult and took more effort," and that when learning Microsoft Access, students would prefer to "be in the classroom with the professor for hands-on help and teaching."

Overall, students in the VLE reported lower levels of satisfaction. Even when they had some familiarity with the material, they were not more satisfied than students in the traditional environment. A number of comments point to the need

for technology quality and reliability in novel learning environments (Webster and Hackley 1997). Subjects reported being dissatisfied with the quality of the shell application (e.g., "I am not opposed to taking an Internet class but the interface was very inefficient and ineffective") and the reliability of the online material (e.g., "I think it was an effective class. The only frustration was LearningSpace: it was slow and not user-friendly"). A few students without a computer or the necessary software found it difficult to gain access to the needed equipment (e.g., "It was hard to always gain access to a computer, therefore I felt that I was rushing to catch up").

The frustration with technical issues may also be masking a more fundamental cause of dissatisfaction. The subjects were engaging in their first experience in a VLE using relatively unfamiliar learning and communication tools. This lack of familiarity and developed learning strategies for the new environment may lead to feelings of isolation and anxiety (Hara and Kling 2000). Some students reported feelings of frustration and inability to use effectively the communication infrastructure in the VLE. As students become more computer savvy and more accustomed to the computer as a learning tool, they will likely feel more comfortable with the technology and, overall, be more satisfied with the process. Notable in this regard are the results of a pilot study conducted in a course offered the semester before the experiment. A total of 20 students interested in taking a course in the VLE were selected from a pool of 60 applicants. These self-selected students responded enthusiastically to the VLE and reported very high levels of satisfaction with the learning process.

Limitations ████████████████

As with any study of this complexity, the reader should be mindful of limitations when interpreting the results. Power analysis indicates that, with our research design, we can detect medium and large group differences (Cohen 1988). It is possible that a small performance difference does exist between virtual and traditional learning environ-

ments but our design is not sensitive enough to detect it.

We witnessed differential drop rates between the treatments, 11 in the VLE versus five in the traditional environment. Drop rate can be considered a measure of learning effectiveness and previous research generally shows that drop rates tend to be higher in technology-mediated learning environments (Maki et al. 2000; Wetzel et al. 1994). This differential drop rate may be an indicator that students in the VLE generally felt that they had been treated unfairly and thus withdrew or lessened their efforts. While we have no conclusive evidence on this issue, it was possible to interview nine students who had dropped the course. Interviews did not offer compelling evidence of withdrawal behavior. Some subjects cited reasons independent of the learning environment (e.g., personal reasons, heavy semester loads) while two of them cited reasons specific to the treatment (e.g., need an instructor face-to-face, personal aversion to computers). An analysis of computer self-efficacy and satisfaction reported during the first half by students who later dropped shows no significant difference from the general population.

It could be argued that students in the VLE spend more time interacting with the computer and, as a consequence, develop higher computer self-efficacy. A correlation between time spent in the VLE and computer self-efficacy would provide evidence corroborating this explanation. However, while we cannot definitely rule out this possibility due to our investigation of IT-related subject matter, the available evidence does not support it. Students reported spending considerably more time on task during the second half of the semester because of widespread unfamiliarity with the material. Yet, no appreciable difference in computer self-efficacy was detected between the two halves of the semester.

The generalizability of our findings to other learning contexts is also subject to debate. The current study is limited to the attainment of basic computer skills, a subject area that is inextricably linked with the very tools employed in the VLE. Replications in other subject areas are required.

Conclusions and Implications ▮▮▮▮▮▮▮▮▮▮

Virtual learning environments (VLEs) have recently become a viable education alternative. In this article, we defined the VLE concept and identified its main dimensions. We then developed a framework of the determinants of learning effectiveness and reported the results of a first study to empirically test it. Our study provides results of interest to universities that are migrating part of their basic skills courses to the Internet and organizations seeking new and effective means to update the IT skills of their work force. We found that performance outcomes in the VLE and the traditional learning environment are similar. Learners in the VLE reported higher computer self-efficacy and lower satisfaction with the learning experience. Our results attest to the potential of VLEs to present a viable and effective alternative to the traditional classroom and highlight potential sources of concern. These preliminary results suggest a number of important avenues for future research.

Our study focused strictly on the question of effectiveness. Nonetheless, important unresolved questions deal with the efficiency of education in VLEs (Alavi, and Leidner 2001). The popular press seems to assume that VLEs are more efficient than traditional classrooms, because of cost reduction and limited reliance on instructors (Kiser 1999). Nonetheless, while VLEs make use of codified knowledge modules typical of CAI, they also enable participants' interaction. Our study did not attempt to investigate the optimal VLE class size, but its relationship with effectiveness may assume an "inverted u" form. As class size increases, so does the pool of resources and perspectives contributed by participants. Once the apex is reached, information overload and coordination difficulties depress effectiveness. Since a number of initiatives in higher education, as well as in the corporate world, are being justified based on the alleged efficiency gains brought about by VLEs, careful empirical research should verify these claims.

The investigation of individual characteristics of students and instructors, referred to as human dimension in our framework, also provides fertile ground for future research. VLEs depart from the traditional model of classroom education with which most students are familiar. They shift much of the responsibility and control of the learning experience to the learner. While we did not explicitly focus our attention on individual characteristics, many participants' comments suggest that a novel skill set, including time-management skills, the ability to monitor personal progress, and the ability to communicate effectively through electronic media, is necessary to take advantage of the unique characteristics of VLEs. These comments also point to the importance of high comfort with computers and a learning style fit with the VLE as prerequisites for student satisfaction with a learning experience in the VLE. Technological proficiency, and the ability to rely on the community of learners through electronic communication, appears critical also in light of the potential for feelings of isolation, anxiety, and confusion to emerge in the virtual environment (Brown 1996; Hara and Kling 2000).

With respect to instructors' individual characteristics, debriefing interviews lend support to the notion, advanced by earlier research, that a considerable time and energy burden is placed on teachers in the VLE (Hiltz 1993). Moreover, the ability to comfortably share control of the learning activities with students appears to be a prerequisite to satisfactory instructor adoption of the VLE. Given the importance of previous experience in shaping future attitudes (Eagly and Chaiken 1993), future research on human dimensions that verifies or dispels the above considerations through empirical investigation is highly desirable.

Many of the design dimensions that we identified in our framework also await systematic investigation in the context of VLEs. While we sought to standardize the learning model in order to tease out the unique effect of technology and learner control, many have theorized about the fit between learning models and technology (see for example Leidner and Jarvenpaa 1995). VLEs seem to be flexible tools that are amenable to the implementation of different learning models, but considerable research is still needed to evaluate how learning model, subject matter, and technology tools interact to produce desired learning outcomes (Alavi and Leidner 2001). A particularly promising avenue of future research is the

investigation of participants' interaction. Several participants in our study commented on the use of electronic communication media. These comments speak to both the potential value and current difficulties in using lean communication media. Systematic research investigating the role of different communications technologies in support of learning in VLEs is necessary as many unanswered questions remain. Is electronic communication best adopted as a support tool in VLEs, or can it take center stage, as in case discussions? What is the cognitive process by which communication in VLEs affects learning outcomes? Can interaction ease feelings of isolation and anxiety? This research agenda is particularly relevant because interaction, one significant characteristic of VLEs, will likely be impacted by the evolution of technology in the future (e.g., on-demand, high bandwidth wireless).

In conclusion, for IT basic skills in entry-level college courses, students who are trained in the new environment develop the confidence in their skills that is instrumental in making them successful computer users. Low satisfaction with the learning process, particularly when the subject matter is very new to students, is, at least in the short term, a byproduct of the experience. Educators who intend to offer training in web-based virtual learning environments should consider a number of alternative courses of action aimed at increasing learner satisfaction with the process. They can let students self-select into the learning environment they deem most appropriate to their skills and preference. They can help them develop self-management and time management skills and they can provide intensive support, especially early in the course, to remote students. Alternatively, the real benefits of the VLE, particularly for on-campus undergraduate student populations, may in fact come from blending desirable features of the VLE with the personal contact benefits of the traditional learning environment.

Acknowledgment

References

Ahmad, R., and Piccoli, G. "Virtual Learning Environments: An Information Technology Basic Skills Course on the Web," in *Proceedings of the Fourth Americas Conference on Information Systems*, E. Hoadley and I. Benbasat (eds.), Baltimore, MD, August 14-16, 1998.

Alavi, M. "Computer-Mediated Collaborative Learning: An Empirical Evaluation," *MIS Quarterly* (18:2), 1994, pp. 159-174.

Alavi M., and Leidner, D. E. "Research Commentary: Technology-Mediated Learning—A Call for Greater Depth and Breadth of Research," *Information Systems Research* (12:1), 2001, pp. 1-10.

Alavi, M., Wheeler, B., and Valacich, J. S. "Using IT to Reengineer Business Education: An Exploratory Investigation of Collaborative Telelearning," *MIS Quarterly* (19:3), 1995, pp. 293-312.

Bandura, A. *Social Foundation for Thought and Action*, Prentice Hall, Englewood Cliffs, NJ, 1986.

Beller, M., and Or, E. "The Crossroad Between Lifelong Learning and Information Technology: A Challenge Facing Leading Universities," *Journal of Computer Mediated Communication* (4:2), 1998.

Brown, K. M. "The Role of Internal and External Factors in the Discontinuation of Off-Campus Students," *Distance Education* (17:1), 1996, pp. 44-71.

Cavanaugh, M. A., Milcovich, G. T., and Tang, J. "The Human and Technical Dimensions of Multimedia Distance Learning (MDL): A Study of MDL Effectiveness in a Global Human Resource Management Class," Working Paper, Cornell University, 2000.

Chi, M. T., and VanLehn, K. A. "The Content of Physics Self-Explanations," *The Journal of the Learning Sciences* (1:1), 1991, pp. 69-105.

Clark, R. E. "Media Will Never Influence Learning," *Educational Technology Research and Development* (42:2), 1994, pp. 21-29.

Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*, Academic Press, New York, 1988.

Collins, A. "Cognitive Apprenticeship and Instructional Technology," in *Educational Values and*

Cognitive Instruction: Implications for Reform, L. Idol and B.F. Jones (eds.), Erlbaum, Hillsdale, NJ, 1991, pp. 121-138.

Collins, B. "Anticipating the Impact of Multimedia in Education: Lessons from the Literature," *Computers in Adult Education and Training* (2:2), 1995, pp. 136-149.

Compeau, D. R., and Higgins, C. A. "Application of Social Cognitive Theory to Training for Computer Skills," *Information Systems Research* (6:2), 1995a, pp. 118-143.

Compeau, D. R., and Higgins, C. A. "Computer Self-Efficacy: Development of a Measure and Initial Test," *MIS Quarterly* (19:2), 1995b, pp. 189-211.

Cradler, J. "Summary of Current Research and Evaluation of Findings on Technology in Education," Working Paper, Educational Support Systems, San Mateo, CA, 1997.

De Vaney, A., and Butler, R. P. "Voices of the Founders: Early Discourse in Technology," in *Handbook of Research for Educational Communications and Technology*, D. H. Jonassen (ed.), Simon and Schuster Macmillan, New York, 1996.

Duchastel, P. "Intelligent Computer Assisted Instruction Systems: The Nature of Learning Control," *Journal of Educational Computing Research* (2:3), 1986, pp. 379-93.

Eagly, A. H., Chaiken, S. *The Psychology of Attitudes*, Harcourt College Publishers, Fort Worth, TX, 1993.

Evans, P. B., and Wurster, T. S. "Strategy and the New Economics of Information," *Harvard Business Review* (75:5), 1997, pp. 70-93.

Fjermestad, J., and Hiltz, S. R. "An Assessment of Group Support Systems Experimental Research: Methodology and Results," *Journal of Management Information Systems* (15:3), 1999, pp. 7-149.

Gagné, R. M. *The Conditions of Learning and Theory of Instruction*, Holt, Rinehart and Winston, New York, 1985.

Gall, J. E., and Hannafin, M. J. "A Framework for the Study of Hypertext," *Instructional Science* (22), 1994, pp. 207-232.

Gefen, D., and Straub, D. W. "Gender Differences in the Perception and Use of E-Mail: An Extension to the Technology Acceptance Model," *MIS Quarterly* (21:4), 1997, pp. 389-400.

Gist, M., Schwoerer, C., and Rosen, B. "Effects of Alternative Training Methods on Self-Efficacy and Performance in Computer Software Training," *Journal of Applied Psychology* (74:6), 1989, pp. 884-891.

Green, S., and Taber, T. "The Effects of Three Social Decision Schemes on Decision Group Process," *Organizational Behavior and Human Performance* (25:1), 1980, pp. 97-106.

Grint, K. "Accounting for Failure: Participation and Non-Participation in CMC," in *Mindweave: Communication, Computers and Distance Education*, R. Mason and A. R. Kaye (eds.), Pergamon, Oxford, England, 1989.

Hackbarth, S. *The Educational Technology Handbook: A Comprehensive Guide*, Educational Technology Publications, Englewood Cliffs, NJ, 1996.

Hair, J. F., Anderson, R. E., Tatham, R. L., and Black, W. C. *Multivariate Data Analysis*, Simon and Schuster, New York, 1995.

Hara, N., and Kling, R. "Students' Distress with a Web-Based Distance Education Course: An Ethnographic Study of Participants' Experiences," *Information, Communication and Society* (3:4), 2000, pp. 557-579.

Harshim, L. M. "Teaching and Learning On-Line: Issues in Computer-Mediated Graduate Courses," *Canadian Journal of Educational Communication* (16:2), 1987, pp. 117-135.

Hill, T., Smith, N., and Mann, M. F. "Role of Efficacy Expectations in Predicting the Decision to Use Advanced Technologies: The Case of Computers," *Journal of Applied Psychology* (72:2), 1987, pp. 307-313.

Hiltz, S. R. "Teaching in a Virtual Classroom," *International Journal of Educational Telecommunications* (1:2), 1995, pp. 185-198.

Hiltz, S. R. *The Virtual Classroom: Learning Without Limits Via Computer Networks*, Ablex Publishing Corporation, Norwood, NJ, 1993.

Hiltz, S. R. "The 'Virtual Classroom:' Using Computer Mediated Communication for University Teaching," *Journal of Communication* (36:2), 1986, pp. 95-104.

Holmes, N., Robinson, E. H., and Steward, A. P. "Learner Control in Computer-Assisted Learning," *Journal of Computer Assisted Learning* (1:2), 1985, pp. 99-107.

Ives, B., and Jarvenpaa, S. L. "Will the Internet Revolutionize Business Education and Research?," *Sloan Management Review* (37:3), 1996, pp. 33-41.

Jacobson, M. J., and Spiro, R. J. "Hypertext Learning Environments, Cognitive Flexibility, and the Transfer of Complex Knowledge: An Empirical Investigation," *Journal of Education Computing Research* (12:4), 1995, pp. 301-333.

Jonassen, D. H. "Learning Strategies: A New Educational Technology," *Programmed Learning and Educational Technology* (22:1), 1985, pp. 26-34.

Jonassen, D. H. "Thinking Technology," *Educational Technology* (33:1), 1993, pp. 35-37.

Keller, J. M. "Motivational Design of Instruction," in *Instructional Design Theories and Models: An Overview of their Current Status*, C. M. Reigeluth (ed.), Lawrence Erlbaum Associates, Hillsdale, NJ, 1983.

Kiser, K. "10 Things We Know So Far About Online Training," *Training* (36:11), 1999, pp. 66-74.

Lee, S., and Lee, Y. H. K. "Effects of Learner-Control Versus Program-Control Strategies on Computer-Aided Learning of Chemistry Problems: For Acquisition or Review?," *Journal of Educational Psychology* (83:4), 1991, pp. 491-498.

Lee, S., and Wong, S. C. "Adaptive Program vs. Learner Control Strategy on Computer-Aided Learning of Gravimetric Stoichiometry Problems," *Journal of Research on Computing in Education* (21:4), 1989, pp. 367-379.

Leidner, D. E., and Jarvenpaa, S. L. "The Information Age Confronts Education: Case Studies on Electronic Classrooms," *Information Systems Research* (4:1), 1993, pp. 24-54.

Leidner, D. E., and Jarvenpaa, S. L. "The Use of Information Technology to Enhance Management School Education: A Theoretical View," *MIS Quarterly* (19:3), 1995, pp. 265-291.

Lenzner, R., and Johnson, S. S. "Seeing Things as They Really Are," *Forbes Magazine* (159:5), 1997, pp. 122-129.

Lepper, M. R. "Microcomputers in Education: Motivational and Social Issues," *American Psychologist* (40:1), 1985, pp. 1-18.

Maki, R. H., Maki, W. S., Patterson, M., and Whittaker, P. D. "Evaluation of a Web-Based Introductory Psychology Course: I. Learning and Satisfaction in On-Line Versus Lecture Courses," *Behavior Research Methods, Instruments, and Computers* (32:2), 2000, pp. 230-39.

Martin, B., and Briggs, L. J. *The Affective and Cognitive Domains: Integration for Instruction and Research*, Educational Technology Publications, Englewood Cliffs, NJ, 1986.

Massy, W. F., and Zemsky, R. *Using Information Technology to Enhance Academic Productivity*, Inter-university Communications Council, Inc., Washington, DC, 1995.

Mathieu, J. E., Martineau, J. W., and Tannenbaum, S. I. "Individual and Situational Influences on the Development of Self-Efficacy: Implications for Training Effectiveness," *Personnel Psychology* (46:1), 1993, pp. 125-147.

McCormick, J. "The New School," *Newsweek* (135:17), 2000, pp. 60-62.

Merrill, M. D. "Component Display Theory," in *Instructional Design Theories and Models*, C. M. Reigeluth (ed.), Lawrence Erlbaum Associates, Hillsdale, NJ, 1983.

Merrill, M. D. *Instructional Design Theory*, Educational Technology Publications, Englewood Cliffs, NJ, 1994.

Milheim, W. D., and Martin, B. L. "Theoretical Bases for The Use of Learner Control: Three Different Perspectives," *Journal of Computer-Based Instruction* (18:3), 1991, pp. 99-105.

Newkirk, R. L. "A Comparison of Learner Control and Machine Control Strategies for Computer-Assisted Instruction," *Programmed Learning and Educational Technology* (10:2), 1973, pp. 82-91.

O'Loughlin, M. "Rethinking Technology: Beyond Piagetian Constructivism Toward a Sociocultural Model of Teaching and Learning," *Journal of Research in Science Teaching* (29:8), 1992, pp. 791-820.

Piccoli, G., Ahmad, R., and Ives, B. "Knowledge Management in Academia: A Proposed Framework," *Information Technology and Management* (1:4), 2000, pp. 229-245.

Reeves, T. C. "Pseudoscience in Computer Based Instruction: The Case of Learner Control Research," *Journal of Computer-Based Instruction* (20:2), 1993, pp. 39-46.

Romiszowski, A. J., and Mason, R. "Computer-Mediated Communication," in *Handbook of Research for Educational Communications and*

Technology, D. H. Jonassen (ed.), Simon and Schuster Macmillan, New York, 1996.

Russell, T. L. *The No Significance Difference Phenomenon.* North Carolina State University Press, Raleigh, NC, 1999.

Schloss, P. J., Sindelar, P. T., Cartwright, G. P., and Smith, M. A. "Learner Control Over Feedback as a Variable in Computer Assisted Instruction," *Journal of Research on Computing in Education* (20:4), 1988, pp. 310-320.

Schutte, J. G. "Virtual Teaching in Higher Education: The New Intellectual Superhighway or Just Another Traffic Jam?," California State University, Northridge, CA, 1997 (available at http://www.csun.edu/sociology/virexp.htm; accessed on September 9, 2001).

Simon, S. J., Grover, V., Teng, J. T., and Whitcomb, K. "The Relationship of Information Systems Training Methods and Cognitive Ability to End-User Satisfaction, Comprehension, and Skill Transfer: A Longitudinal Field Study," *Information Systems Research* (7:4), 1996, pp. 466-490.

Steinberg, E. R. "Cognition and Learner Control: A Literature Review, 1977-88," *Journal of Computer Based Instruction* (16:4), 1989, pp. 117-124.

Tennyson, R. D. "Instructional Control Strategies and Content Structure as Design Variables in Concept Acquisition Using Computer-Based Instruction," *Journal of Educational Psychology* (72:4), 1980, pp. 524-532.

Tennyson, R. D. "Use of Adaptive Information for Advisement in Learning Concepts and Rules Using Computer-Assisted Instruction," *American Educational Research Journal* (18:4), 1981, pp. 425-438.

Vaverek, K. A., and Saunders C. "Computerspeak: Message Content and Perceived Appropriateness in an Educational Setting," *Journal of Educational Technology Systems* (22:2), 1993, pp. 23-139.

Walther, J. B. "Interpersonal Effects in Computer-Mediated Interaction: A Relational Perspective," *Communication Research* (19:1), 1992, pp. 52-90.

Webster, J., and Hackley, P. "Teaching Effectiveness in Technology-Mediated Distance Learning," *Academy of Management Review* (40:6), 1997, pp. 1282-1309.

Webster, J., and Martocchio, J. "Microcomputer Playfulness: Development of a Measure With Workforce Implications," *MIS Quarterly* (15:1), 1992, pp. 201-226.

Wells, R. A. *Computer-Mediated Communication for Distance Education and Training: Literature review and International Resources*, U.S. Army Research Institute, Boise, ID, 1990.

Wetzel, C. D., Radtke, P. H., and Stern, H. W. *Instructional Effectiveness of Video Media* Lawrence Erlbaum Associates, Hillsdale, NJ, 1994.

Williams, M. D. "Learner-Control and Instructional Technologies," in *Handbook of Research for Educational Communications and Technology*, D. H. Jonassen (ed.), Simon and Schuster Macmillan, New York, 1996.

Wilson, B. G. *Constructivist Learning Environments: Case Studies in Instructional Design*, Educational Technology Publications, Englewood Cliffs, NJ, 1996.

Wolfram, D. "Audio-Graphics for Distance Education: A Case Study in Students Attitudes and Perceptions," *Journal of Education for Library and Information Science* (35:3), 1994, pp. 179-186.

Yoffe, D. B., and Cusumano, M. A. "Judo Strategy: The Competitive Dynamics of Internet Time," *Harvard Business Review* (77:1), 1999, pp. 71-81.

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