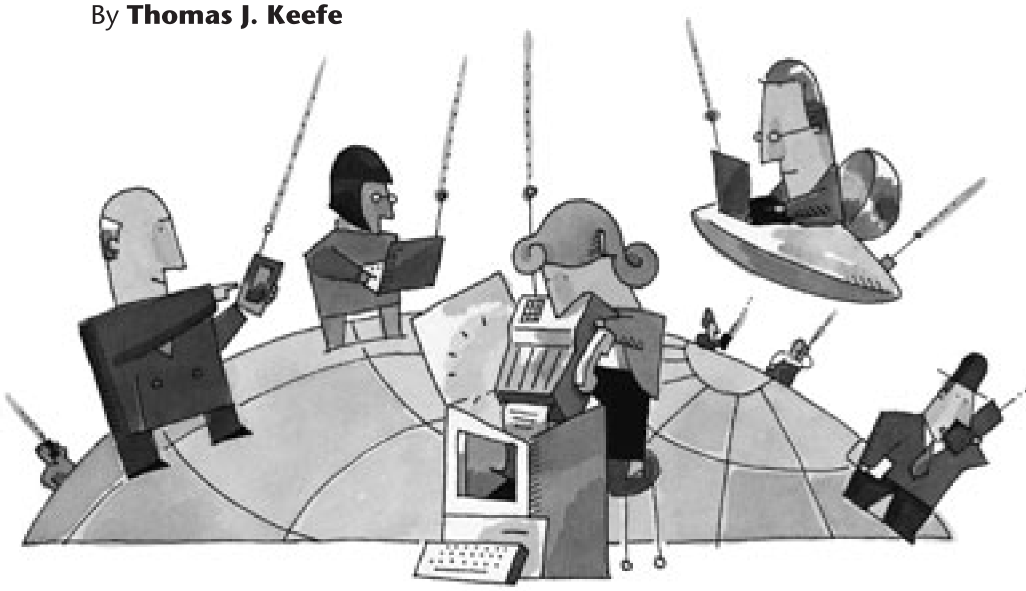
Using Technology to Enhance a Course:
The Importance of Interaction

The no-significant-difference effect did not occur when exploring the use of technology for online lectures and interaction

By **Thomas J. Keefe**



I teach the course Organizational Behavior to undergraduates in the School of Business at Indiana University Southeast, a regional campus in the IU system. In 1999, I became interested in the possibilities of using Internet technology in my courses. According to many studies, differences in media used to provide lectures make no difference in student outcomes. (See the sidebar "Some Reviews of Media Comparison Studies.") Known as the "no significant difference effect," this conclusion has been used to support more technology in education based on the logic that if it is as effective as traditional means, technology should be used when it is cheaper and more convenient.

As part of an Ameritech grant in 2000,[1] I began a systematic investigation of Internet-based classroom technology to improve my teaching. Six sections of 118 students total have participated in two studies to investigate the use of educational technology. In one study, lectures and interaction were provided online and compared to a face-to-face experience. A second study, performed the next academic year, assessed the impact of interaction apart from lecture. In the second study, after online lectures were provided to all students, interacting online was compared with interacting face-to-face in a classroom. In both studies, surveys were administered before and after each semester to gather demographic and psychological measures. Both performance and student perceptions were tracked across each semester. Results ran counter to the no-significant-difference effect, as differences in media and interactions were associated with differences in educational outcomes.

The Research Experiences

Teaching a course online involves moving lectures, interaction, or testing to the Internet. Lectures provide students with a first exposure to course content. Interaction involves students interacting with the instructor and other students to help them more deeply process course content.

Over the two years of the study, four different conditions were available for comparison. Figure 1 displays the combinations of face-to-face and online, lectures and interaction, tried out in the sections involving the study. In the spring of 2000, lecture and interaction together were compared. In the spring of 2000, students received lecture and interaction either online or face-to-face. In the fall 2000/spring 2001 study year, interaction and lecture were separated to distinguish the discrete contribution to student performance of interaction separate from lecture. This was achieved by providing all students with prerecorded narrated PowerPoint lectures, while interaction varied between online and face-to-face. In each of the fall 2000/spring 2001 semesters, the design was switched between the day and night sections to control for day/night student differences. At the start and conclusion of the course, survey information was gathered about student performance and perceptions of the course and instructor for later comparison.

Spring of 2000

In the spring of 2000, the objective was to test the no-significant-difference effect by comparing an online and a face-to-face version of the same course in a highly controlled situation. One of the primary criticisms of the no-significant-difference effect is that the lack of significant results might be attributable more to methodological errors than to the quality of null results.[2] In doing explanatory research, control is critical. In doing a study, countless other variables can be affected other than the ones of interest to a researcher. Research control refers to the ability to rule out these alternative explanations. To help ensure control, the specifics of the research plan called for using an experimental design. One version of the course served as a control group, taught in a traditional face-to-face manner, with the experimental group taught online and students randomly assigned to one of the two conditions. To eliminate other causes that might influence the results, students were treated the same as much as possible.[3]

Course Administration. Student volunteers from each of two sections of the same Organizational Behavior course taught by the same instructor using the same text were randomly assigned to take the course either face-to-face or online. All students came to class at least five times: the first day of class for orientation and training, three times for exams, and once for a presentation. In both conditions, on the first day of class students were assigned to groups. Everyone's grades were based on the same three exams; three five-page group video cases; a group Internet research project with a paper and presentation; and class participation. Instructional interactions outside of lectures were handled in the same way. Everyone had access to e-mail, online chat rooms, and threaded discussion forums. Handouts such as the syllabus, schedule, and case instructions and announcements were supplied electronically to everyone at the same time and in the same way.

Lectures. The built-in difference was that in the online condition, students

Some Reviews of Media Comparison Studies

The no-significant-difference effect may be best captured in the words of some of its strongest supporters:

- "The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition." R.E. Clark, "Reconsidering Research on Learning from Media," *Review of Research*, Vol. 53, No. 4, 1983, p. 445.
- "So, education must adopt the less expensive media—provided that learning outcomes are equivalent. Why spend more for instruction if there is a significantly less expensive way to achieve the same results?" R.E. Clark, "Bloodletting, Media, and Learning," in *The No Significant Difference Phenomena*, T.L. Russell, ed. (Raleigh, N.C.: North Carolina State University, 1999), p. x.
- "It allows us to use cheaper and simpler technologies with assurance that outcomes will be comparable with the more sophisticated and expensive ones as well as conventional teaching/learning methods." T.L. Russell, "The No Significant Difference Phenomenon," *Faculty Publication Collection* (Raleigh, N.C.: North Carolina State University, 1999), p. xii.

Reviews of the instructional effectiveness of distance education technology tend to agree with this perspective:

- Instructional television: N. Whittington, "Is Instructional Television Educationally Effective? A Research Review," *The American Journal of Distance Education*, Vol. 1, No. 1, 1987, pp. 47–57.
- Instructional video media: C.D. Wetzel, P.H. Radtke, and H.W. Stern, *Instructional Effectiveness of Video Media* (Mahwah, N.J.: Lawrence Erlbaum Associates, Inc., 1994).
- Distance education: D. Hanson et al., *Distance Education: Review of the Literature*, 2nd edition (Washington, D.C., and Ames, Iowa: Association for Educational Communications and Technology and Research Institute for Studies in Education, 1997).

A more recent review points out shortcomings of literature supporting the no-significant-difference effect:

- R. Phipps and J. Merisotis, "What's the Difference? A Review of Contemporary Research on the Effectiveness of Distance Learning in Higher Education" (Washington, D.C.: The Institute for Higher Education Policy, Council of Higher Education Accreditation, 1999), on the Web at <http://www.ihep.org/Pubs/PDF/Difference.pdf>.

Figure 1

Summary of Conditions in Course Sections

<table>
<tr><th>Study Design / Data Sets / Sections</th><th colspan="2">Day</th><th colspan="2">Night</th></tr>
<tr><td>1: Spring 2000</td><td>Online: Interaction and Lecture</td><td>Face-to-Face: Interaction and Lecture</td><td>Online: Interaction and Lecture</td><td>Face-to-Face: Interaction and Lecture</td></tr>
<tr><td>2: Fall 2000</td><td colspan="2">Online: Interaction and Lecture</td><td colspan="2">Face-to-Face: Interaction
Online: Lecture</td></tr>
<tr><td>3: Spring 2001</td><td colspan="2">Face-to-Face: Interaction
Online: Lecture</td><td colspan="2">Online: Interaction and Lecture</td></tr>
</table>

were directed to watch narrated PowerPoint slide shows[4] online or from CD-ROMs in tune with the course schedule, while in the face-to-face condition, students received lectures in a traditional manner in class. Everyone followed the same course schedule. To reduce variation in course content between the online and face-to-face versions, detailed scripts were prepared for each lecture so that material received in class or via computer would be as similar as possible. Scripts were tightly integrated with the textbook so that, at appropriate times, references could be made in class and on prerecorded lecture narrations to pages containing material, exercises, and cases. These scripts were then used to generate PowerPoint slides and brought to class for lecture. Two sets of PowerPoint slides were produced, one with narrations, one without. The visual content of both sets of slides was identical. For students receiving lectures asynchronously, narrated lectures were made available on CD-ROMs and online.

Exam Construction. Exams for both groups were handled in an identical fashion. Learning objectives that formed the basis for lectures were used to construct three essay exams given over the semester. Each time an exam was given, three versions were prepared and randomly distributed to students at the time of testing. Each of the three versions of the exam was prepared and administered in the same way. Exams included five to eight sections of essay questions that corresponded to the content of chapters in the textbook. Within each section of an exam, students had the opportunity to choose to answer one of two questions randomly selected from a chapter's learning objectives. Exams were graded in an anonymous, uniform fashion to reduce the possibility of bias and increase reliability of evaluations.

Student Perceptual Measures. To study teaching and learning, experts suggest studying a broad range of student measures.[5] Surveys were performed the first and last day of class. Data, which was gathered in a totally anonymous fashion, included perceptual measures and demographic information. Information gathered the first day of class included class rank, gender, years at IUS, self-reported GPA, experience with distance learning, hours worked per week, credit hours being taken, length of commute, stress levels, self-efficacy, and locus of control.[6] Locus of control refers to people's tendency to attribute causes of their behavior to either themselves or their environment. Students with an internal locus of control attribute outcomes to their own actions and tend to be more motivated.

Several other measures were multi-item constructs created for the purpose of the study. The approach taken here relied on factor analysis together with reliability analysis.[7] Factor analysis was used to combine the multiple items into a single set of scores for analysis purposes. A series of principal component factor analyses were run. Reliabilities were computed using the items making up each factor solution.[8] To aid interpretation, scales were coded for analysis, with lower numbers associated with negative affective responses and higher numbers associated with positive responses.

Results. Total beginning enrollment was 45 students; 10 withdrew. The remaining 35 students chose to participate in the study. The same number of students withdrew in both cases; the difference in withdrawal rates was not statistically different for the online versus face-to-face conditions.

To verify the effectiveness of the randomization process, a series of two-tailed *t*-tests were performed using the pretreatment measures mentioned above. This was done to detect the possibility of important individual psychological and demographic differences that could bias results. None were found. With statistical certainty, it could be assumed that the groups of students taking the two versions of the course were alike at the start of the course. In this way, differences in outcomes could better be ascribed to the online/face-to-face distinction and not to preexisting differences between the groups.

To test for differences at the end of the course, student perceptions of satisfaction with the course and the instructor were used as dependent variables with condition as the main factor and students' relative expected grade as a control variable in a series of univariate regression analyses.[9] Relative expected grade was used as a control variable because expected grades have been found to bias student perceptions.[10] Significant differences were found between the online and face-to-face versions of the course in terms of instructor satisfaction [factor scores instructor satisfaction: *F* (1,28) = 7.522, *p* = .011] and course satisfaction [factor scores course satisfaction: *F* (1,28) = 4.448, *p* = .044].[11] These statistical results indicate that students taking the course online rated the course and the instructor less positively than students taking the course face-to-face (see Figure 2). No significant differences were found in terms of course usefulness; students taking the course found it equally useful whether taken online or face-to-face.

Another important difference was found. Students taking the course online did worse on exams than students taking the course face-to-face. The total difference between students taking the course face-to-face versus online was 7.6 percent, favoring the face-to-face experience. The average grade of students taking the course face-to-face was 79.1 percent (*N* = 45 exams). For students taking it online, the average grade was 71.5 percent (*N* = 59 exams). Surveys to collect student perceptions were gathered anonymously, so the information could not be used in the regression to determine the impact of individual student characteristics on test performance.

To test the statistical significance of the effect, hierarchical regressions were performed.[12] To account for administrative differences in the data, a group of four variables representing each of the three different exams and the two sections were entered on step one. By entering administrative variables first, estimates of other effects are based on the residual variation left after accounting for the non-instructional administrative aspects of the course. On the second step, condition was entered as a categorical variable coded 1/0 to measure the impact of taking the course online. The sign of the coefficient for this variable indicates the direction of the effect on grades of taking the course online as opposed to face-to-face. A negative coefficient indicates that grades were lower in the online situation (hierarchical regression, spring 2000, model 2: *r*-square change = .094, *F* change 12.634, significance of *F* change = .001; online, *B* = –7.639, *t* = –3.554, p = .001).[13] The regression coefficient (*B* = –7.639) indicates that after accounting for differences in three exams and day/night sections, grades were about 7.6 percent lower among students taking the course online.

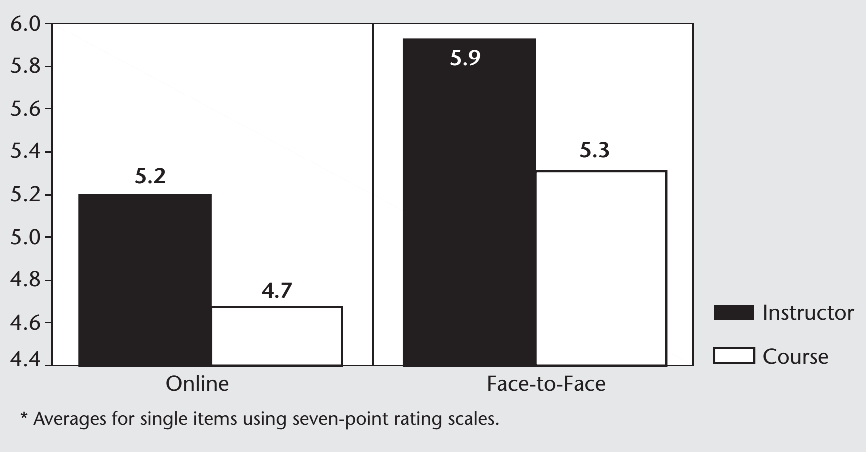
Possible Lessons. The study performed in the spring of 2000 compared online and face-to-face experiences in a highly controlled situation. In a head-to-head comparison, the online course was associated with lower grades and less satisfied students. There was no clear answer to the question of why. A possibility may lie in the lack of interaction experienced by students online. The prevailing view of traditional educators is that quality student interactions are essential to positive student outcomes. For example, Hatfield's[14] widely disseminated list of seven principles of good practice for improving undergraduate education strongly emphasized the importance of interaction. Others[15] advocate techniques like interactive learning. Collaborative learning also stresses the importance of interaction to positive student outcomes. Clearly, the traditional education literature points toward the importance of interaction. However, in the spring of 2000, by mixing lectures and interaction together in the study design, it was unknown which, if either, might have caused the difference in student performance.

At this point in the story, it might be informative to review what others have found. In general, a review of the distance education literature[16] found studies indicating that differences between online and traditional face-to-face interaction are unimportant, students did not miss it, and online instruction techniques could be adopted to compensate for the loss of face-to-face interaction. (See the sidebar "Readings about Online Student Interaction" for references to distance education literature.)

Despite what proponents of the no-significant-difference effect say about the lack of meaningful differences and the advantages of technology, recent well-publicized failures of dot-com universities[17] indicate the possibility of problems online that need to be addressed. Some supporters of technology have recognized this possibility and point toward the need for quality interaction. Burnside,[18] in writing to the corporate university community, pointed out his basic concern for students taking a course online—that they might be missing high-value classroom interactions and that electronic chat, e-mail, and bulletin boards are, as yet, not good substitutes. Phipps and Merisotis[19] reviewed the distance education literature and agreed. They concluded with

Figure 2

Instructor and Course Satisfaction, Spring 2000*



* Averages for single items using seven-point rating scales.

Readings About Online Student Interaction

Distance education literature does not support the importance of interaction, as the following entries indicate:

- More verbal interaction takes place in traditional face-to-face instruction than in distance education classes, according to J.W. Bauer and L.L. Rezabek, "The Effects of Two-Way Visual Contact on Student Verbal Interactions during Teleconferenced Instruction," 1992, retrieved June 5, 1999, from EBSCO Service.
- Differing amounts of interaction were associated with little difference in achievement by P.L. Beare, "The Comparative Effectiveness of Videotape, Audiotape, and Telelecture in Delivering Continuing Teacher Education," *The American Journal of Distance Education*, Vol. 3, No. 2, 1989, pp. 57–66.
- More interaction was not associated with student satisfaction, found S. May, "Collaborative Learning: More Is not Necessarily Better," *The American Journal of Distance Education*, Vol. 7, No. 1, 1993, pp. 39–50.
- Online students consistently had a more favorable attitude toward distance education technology than did traditional learners, as determined by D. Hanson et al., *Distance Education: Review of the Literature*, 2nd edition (Washington, D.C., and Ames, Iowa: Association for Educational Communications and Technology and Research Institute for Studies in Education, 1997).
- Perceived interaction was more important than actual time spent interacting found S. Zhang and C.P. Fulford, "Are Interaction Time and Psychological Interactivity the Same Thing in the Distance Learning Television Classroom?" *Education Technology*, Vol. 34, No. 6, 1994, pp. 58–64; and C.A. Hassenplug and D. Harnish, "The Nature and Importance of Interaction in Distance Education Credit Classes at Technical Institutes," *Community College Journal of Research & Practice*, Vol. 22, No. 6, 1998, retrieved October 1, 2002, from EBSCO Service.
- Nonverbal and verbal teacher behaviors can be used to compensate for loss of face-to-face interaction, claimed M. H. Baker, "Distance Teaching with Interactive Television: Strategies that Promote Interaction with Remote-Site Students," ed. C. Sorenson et al., *Encyclopedia of Distance Education Research in Iowa* (Ames, Iowa: Teacher Education Alliance, 1995, pp. 107–115).

A Student-Centered View of Learning—Technology Can Support Interaction

The literature dealing with interaction points toward a changing perspective. Increasingly, student interaction is seen as a complex and important topic.

The Student Side: Effects on Learning of Personal Learning/Thinking Styles

- The importance of the relationship between individual differences and educational outcome in new learning environments was explored by K. Hartley and L.D. Bendixen, "Educational Research in the Internet Age: Examining the Role of Individual Characteristics," *Educational Researcher*, Vol. 30, No. 9, 2001, pp. 22–25.
- A review of hypermedia literature indicates that the value of a technology to pedagogy may depend on interaction with a learner's ability and preferred learning style. See A. Dillon and R. Gabbard, "Hypermedia as an Educational Technology: A Review of the Quantitative Research Literature on Learner Comprehension, Control, and Style," *Review of Educational Research*, Vol. 68, No. 3, 1998, pp. 322–349.
- The interaction between learning style and the nature of a task may affect performance, wrote J. Pound and L.L. Bailey, "Cognitive Style and Learning: Performance of Adaptors and Innovators in a Novel Dynamic Task," *Applied Cognitive Psychology*, Vol. 15, 2001, pp. 547–563.
- A history of theory and research on learning styles can be found in R.J. Sternberg and L. Zhang, eds., *Perspectives on Thinking, Learning, and Cognitive Style* (Mahwah, N.J.: Erlbaum Associates, 2001).
- Current research and an up-to-date bibliography are available in L. Zhang, "Thinking Styles and Modes of Thinking: Implications for Education and Research," *The Journal of Psychology*, Vol. 136, No. 3, 2002, pp. 245–261.
- Adaptive, student-centered learning environments are covered in a review of theoretical work on user models that may enable deployment of learning systems based on interaction of a student and an information system that will tailor presentation of information to learning style of the student. See N. Ford, "Cognitive Style and Virtual Environments," *Journal of the American Society for Information Science*, Vol. 51, No. 6, 2000, pp. 543–557.

The Teacher Side: Effects on Learning of Interactive Teaching Styles and Technology

- Arguments for interaction in lectures appear in R. Murray and J.R. Brightman, "Interactive Teaching," *European Journal of Engineering Education*, Vol. 21, No. 3, 1996, pp. 295–308.
- A taxonomy of interactive strategies was created by C.P. Fulford and G. Sakaguchi, "Developing a Taxonomy of Interactive Strategies for Two-Way Interactive Distance Education Television," *International Journal of Instructional Media*, Vol. 28, No. 4, 2001, retrieved October 1, 2002, from EBSCO Service.

Social Interactions: Effects on Learning of Social Networks and Online Communities

- In emerging online communities, technical features define forms of communication and social norms define ways group members interact. See N.K. Baym, "The Emergence of Community in Computer-Mediated Communication," in *Cybersociety: Computer-Mediated Communication and Community*, S.G. Jones, ed. (Thousand Oaks, Calif.: Sage, 1995), pp. 138–168.
- The dynamic nature of online group collaboration is revealed by N.S. Contractor and E.M. Eisenberg, "Communication

Networks and New Media in Organizations," in *Organizations and Communication Technology*, J. Fulk and C.W. Steinfield, eds. (Newbury Park, Calif.: Sage, 1990), pp. 143–172.

- Online computer support is changing from supporting individuals to collaborative learning, as pointed out by L. Bannon, "Issues in Computer Supported Collaborative Learning," in *Computer Supported Collaborative Learning*, C. O'Malley, ed. (Berlin: Springer-Verlag, 1989), pp. 267–282.
- Interactions online involve both social and intellectual work-oriented exchanges that use interactive media together with traditional printed media. See L. Harasim et al., *Learning Networks: A Field Guide to Teaching and Learning Online* (Cambridge, Mass.: MIT Press, 1995).
- Computer-supported collaborative learning involves social and technical coordination, according to C. Crook, *Computers and the Collaborative Experience of Learning* (London: Routledge, 1994).
- Interactions online are increasingly student-centered and dynamic: students develop group norms, learn about each other and their work, and use technologies. See L. Chidambaram and R.P. Bostrom, "Group Development (I): A Review and Synthesis of Developmental Models," *Group Decision and Negotiation*, Vol. 6, No. 2, 1997, pp. 159–187.
- Building online learning communities was discussed by R.M. Palloff and K. Pratt, *Exploring Learning Communities in Cyberspace: Effective Strategies for the Online Classroom* (San Francisco: Jossey-Bass, 1999).
- Computer-supported social networks were evaluated by C. Haythornthwaite et al., "Community Development among Distant Learners: Temporal and Technical Dimension," *Journal of Computer-Mediated Communications*, Vol. 6, No. 1, 2000, <http://www.ascusc.org/jcmc/vol6/issue1/haythornthwaite.html>.
- How interaction takes place in computer-supported social networks was considered by C. Haythornthwaite, "Exploring Multiplexity: Social Network Structures in a Computer-Supported Distance Learning Class," *The Information Society*, Vol. 17, No. 3s, 2001, pp. 211–226.

three implications relevant to the current discussion, summarized here:

- unlike face-to-face education, interacting fully over the Internet requires special skills of students and sophisticated technical support;
- technology cannot replace the human factor; and
- many of the results indicate that technology is not nearly as important as other factors.

At the heart of these conclusions is the idea that student interaction is central to teaching and learning, and that the online use of interaction needs to develop further to be as effective as face-to-face interaction.

Authors of a review of hypermedia also appear to agree that more appropriate interaction is called for, pointing to the need for further research: "Obviously, combining the technology with innovative classroom use, discretionary collaboration, and self-paced learning may offer further advantages, but as yet such scenarios remain largely unstudied."[20] Overall, this discussion seems to indicate an opportunity for improvement online that might result from a better understanding and more appropriate use of student interaction online, which is just beginning to be understood. (See the sidebar readings on a student-centered view of learning.)

Technology also can be used to increase interaction and enhance instruction in a traditional face-to-face setting. Brown[21] assembled reports from 93 college instructors who had pioneered the use of computers in education. He used this experience to provide a picture of the effects on learning of different modes of interaction (such as collaborative learning, learning by doing, role-playing, frequent dialogue, prompt feedback, and so forth). Brown wrote, "Scholars worldwide are creating a storm of experiments. With the computer have come many new tools of the mind that are being tested at a furious pace in a myriad of learning situations." Among the examples Brown provided, William Clark of Worchester Polytechnic Institute reported using computer-aided learning tools with collaborative group techniques to teach more efficiently. Richard Shiavi and his colleagues at Vanderbilt used interactive learning that involved groups of students to employ newly learned computer presentation techniques. Stephen Loomis of Connecticut College used an Internet site that contained course information to increase communication with students. Andrew Barkley of Kansas State University used technology to perform administrative tasks, freeing up more time to pay attention to the needs of individual students. Byron Brown of Michigan State University used computer-based exercises, a help room, and shortened class meeting times to enhance his introductory economics class by increasing interactivity and hands-on learning. The central point of the instructor experiences that he reported on is the use of computers to increase the quantity and quality of interaction.

This was my approach, also, when I redesigned the Organizational Behavior course over the summer of 2000. I used Internet technology to enhance instruction by freeing up time in the classroom for quality interaction. Specifically, I removed lectures and administrative activities from the face-to-face classroom. The in-class time gained was used for interactions based on frequent dialogue and prompt feedback to students working in groups on in-class exercises.

Fall of 2000 and Spring of 2001

In the fall of 2000/spring of 2001, an attempt was made to assess the effectiveness of face-to-face versus online interaction separate from lecture. Using narrated online lectures in both versions of the course eliminated differences in lecture media as a possible explanation of differences in student outcomes.[22] In the fall of 2000 and the spring of 2001, narrated slide shows were made available to all students, streamed over the Internet and on CD-ROMs. In each semester, one section used face-to-face interaction, and the other used online interaction. Students were free to select the section of the course they wanted.

Course Administration. As in the spring semester of 2000, all students came to class at least five times. The textbook, tests, use of student groups, grading processes, and other administrative features of the course remained the same. All students were instructed to read the textbook and watch narrated lectures following the course schedule. The study involved a total of four sections of the same Organizational Behavior course. Each semester, two versions of the course were taught. One section was instructed online and the other face-to-face. The online and face-to-face versions of the course were rotated so that in the fall, the day section was taught face-to-face, and in the spring, the night section filled that role. Statistically, each semester the two sections were treated as sub-blocks. Over the two semesters, the day and night sections were complete in the sense that they contained both modes of interaction. This had the advantage of controlling for possible day student/night student difference by design.[23]

Enhanced Face-to-Face Interaction. In the enhanced face-to-face version of the course, instructional interactions occurred in person as students interacted in twice-weekly classes. More class time could be used for student interactions than when the course was taught in a traditional face-to-face lecture format. Requiring students to view lectures online before coming to class seemed to better prepare them to engage in classroom discussions.

Class sessions took the form of highly interactive meetings focused around exploring one or more learning objectives in depth. Students worked in groups on a variety of in-class discussions and assignments designed to help them process and understand learning objectives. In each class, a student was given a different role to play in the group: leader, recorder, reporter, monitor, or wildcard. Specific collaborative instructional activities varied and included discussions, cases, or exercises designed to more deeply explore the learning objective(s) for that day.

Online Interaction. In the online version of the course, instructional interactions took place online using Internet-based technology. Student interactions with other students and the instructor took place in a class chat room, in separate chat rooms for student groups, by e-mail, and in the threaded discussion groups created for each group. Students coming to class the first day of the course were instructed how to use these tools, which were also supported by the instructor and two staff members from the campus learning and teaching center. A typical week progressed as follows: Students were instructed to read the textbook and watch lectures online. Afterwards, interactions took the form of weekly class chats, e-mails, and online postings on discussion forums. The instructor monitored and facilitated interactions using all the tools.

Results.[24] Total beginning enrollment in the second year was 104 students; 19 withdrew, and 83 chose to participate in the study. Differences in withdrawal rates were not statistically significant. Table 1 presents descriptive statistics for students in the fall of 2000/spring of 2001.

Use of Analysis of Covariance (ANCOVA) with Intact Groups. Based on student outcomes in the prior year, students were not randomly assigned but could select a section to attend. Random assignment to a treatment or a control group is a key aspect of experimental research. The use of intact groups as treatment and control groups changes the research from an experimental design to a quasi-experimental design and raises the potential for a selection process that can lead to bias in the estimation of treatment effects.[25] When intact groups are used, there is a strong opportunity for a correlation between group membership and omitted relevant variables.

To detect such relationships between the face-to-face and online groups, a series of two-tailed *t*-tests were performed using demographic and individual perceptual and psychological measures. The set of variables was more extensive than in the spring of 2000, additionally including age, work ethics, and attitude toward technology. The only characteristic for which there was a difference between the two instructional groups was students' attitude toward technology

Table 1

Descriptive Statistics of Students, 2000 Academic Year

Factor	Mean*
Gender**	67% female
Rank†	3.4 years
Credit hours taken	12.5
Hours worked per week	25.9
Age	26.2 years
Commute to campus	1.5 hours per week
Commute to work	1.1 hours per week
Number who used distance learning	6
Number who used courseware	7
Self-reported GPA‡	2.91
Average grade on course exams	77%

* *N*=79, based on list-wise deletion; ** 0 = female, 1 = male; † 1 = freshman, 2 = sophomore, 3 = junior, 4 = senior; ‡ 4 = A, 3 = B, 2 = C, 1 = D, 0 = F

used in the course. Students who opted to take the course online had a more positive attitude toward technology than students who chose face-to-face interactions [Levene's test for equal variance, $F = .995$, $p = .322$; two-tailed t-tests, assuming equal variance: $T(79) = -2.812$, $p = .006$]. The finding of a positive attitude among online students is consistent with the distance education literature. For example, one of the primary findings of Hanson et al.'s review of the distance education literature[26] is that distance education students have a more favorable attitude toward distance education than traditional learners and feel they will do as well as if they were in a regular classroom.

Regression analysis is frequently used to statistically adjust post-test means. In this case, exam grades were adjusted to what they would have been if the groups had been equal on the covariate pretest scores.[27] Use of intact groups in a quasi-experimental design requires a warning because students were not randomly assigned. Although numerous potential covariates were inspected and ANCOVA seemed appropriate, the groups can still vary on some unknown important variables, and the possibility of bias always exists.

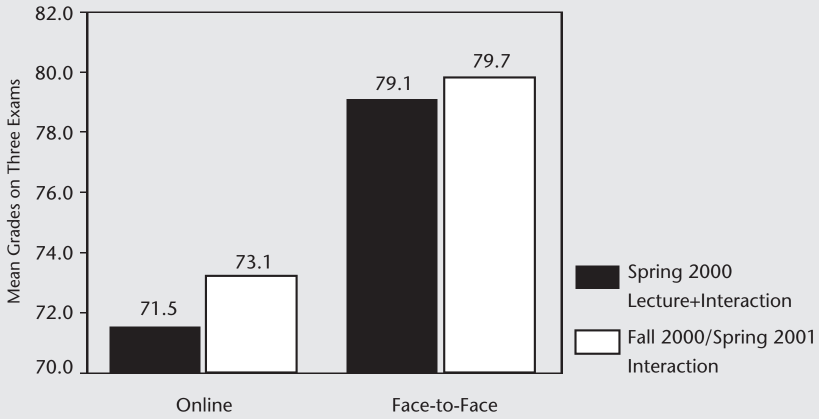
Table 2

Summary of Regression Results, Student Exam Performance

	Total Effect	Direct Effect
Lecture and interaction, spring 2000	7.6%	N.A.
Interaction, fall 2000/spring 2001	6.6%	4.8%

Figure 3

Comparison of Grades*



* Averages for single items using seven-point rating scales.

Regression Results. In this second study, online lectures provided students with their first exposure to course content. Interactions involved students with the instructor and other students to help them more deeply process course content. Interaction occurred face-to-face or online. There were no observed statistically significant differences in terms of instructor satisfaction, course satisfaction, or perceived course usefulness after controlling for relative expected grade and attitude toward technology.

For the fall of 2000/spring of 2001, putting lectures online in all sections eliminated lecture media as a possible cause of differences between sections (data set 2). The raw data indicated that, on average, students receiving interactions face-to-face scored 6.6 percent better on exams than students interacting online (see Table 2).[28] The average grade of students in the face-to-face condition was 79.7 percent ($N = 105$), and in the case of students taking the course online, it was 73.1 percent ($N = 143$). See Figure 3.

To account for non-instructional aspects of the course and important individual student differences, statistical tests were performed. A series of hierarchical regressions used the grades on exams for the fall 2000/spring 2001 period to determine the direct effect of face-to-face interaction on exam performance. Two sets of variables were used. The first set included the covariate attitude toward technology, individual characteristics, and administrative considerations. These were followed by interaction. The variables representing individual characteristics included demographics (gender, age); students' length of weekly commutes (length of commute to school, to work); and individual student academic considerations (self-reported GPA, self-efficacy, locus of control). The variables representing administrative considerations included coded variables for exam1, exam2, exam3, semester, and section to permit control for these differences by inclusion. Interaction was entered by itself on the last step to determine the discrete contribution to exam grades provided by interaction after accounting for the other sources of explanation. The Interaction variable was coded so that results indicated how much student performance was raised or lowered by face-to-face interaction.

Table 2 shows a summary of exam results for both studies presented side-by-side. Table 2 displays the results of the regression in the column Direct Effect. Results indicate that after accounting for students' attitude toward technology, individual differences, and course administrative features, interaction still associated with about a 4.8 percent difference in grades (hierarchical regression fall 2000/spring 2001, model 2: r-square change = .015, F change = 5.750, p of F change = .017; face-to-face interaction, $B = 4.762$, $t = 2.398$, $p = .017$).[29] The regression coefficient ($B = 4.762$) indicates that the students taking the course with face-to-face interaction did about 4.8 percent better than students who took the course with online interaction after accounting for the covariate, individual, and administrative differences.

Table 2 indicates that when lecture and interaction were taken together, grades were 7.6 percent better when students took the course face-to-face. In other words, the total effect was more than three-fourths of a letter grade. In the spring of 2000, because data was gathered in a totally anonymous fashion, by mixing lectures and interaction in the same study, it was not possible to calculate the separate effects of lecture and interaction. The cell in Table 2 that would correspond to Direct Effect for lecture and interaction in the spring of 2000 is blank, indicating that separate effects for lecture and interaction could not be calculated.

The problem was resolved in the fall of 2000/spring of 2001, when interaction was considered by itself; the total difference in grades was observed to be 6.6 percent, favoring face-to-face interaction. This was an observed difference without statistically controlling for other important considerations. After accounting for the covariate attitude toward technology, and two other sets of variables representing individual and administrative differences, students receiving face-to-face interaction still performed 4.8 percent better than students receiving online lectures. Note that the direct effect of interaction on student performance was nearly half of a letter grade. Results were both statistically significant and practically important.

Conclusion

In the two studies, results ran counter to the no-significant-difference effect. Differences in students' performance and perceptions were attributed to differences in lecture media and interaction. Students taking this course performed better face-to-face in both studies. In terms of student satisfaction, when differences occurred, they, too, favored the face-to-face experience. More important was the impact of interaction separate from lecture on student performance. In the spring of 2000, both lecture and interactions operated together—they were either both online or both face-to-face. In the fall 2000/spring 2001 all lectures were online, separating lecture from interaction. Results indicated that differences in the medium of interactions accounted for the bulk of differences in grades. The results are significant for several reasons.

The implication is that technology can be used to enhance a traditional class by moving lectures out of the classroom.

Design of Online Courses

Much distance education research focuses on media comparison studies dedicated to finding the best lecture format for conveying information. For designers of online courses, results point to the importance of interaction to student learning performance. If these results were replicated in other settings, the implication for designers of online courses would be to work to increase the quantity and quality of interactions as a way of improving the quality of their course offerings. Such an approach would be completely consistent with the actions taken by the instructors documented by Brown,[30] who used computers to increase levels of student interaction based on frequent dialogue and prompt feedback.

Design of Face-to-Face Courses

Even though results do not agree with the no-significant-difference effect, the results of these studies should not be seen as a repudiation of technology; rather, the appropriate use of technology to enhance education is yet to be fully understood. Again, results indicate the importance of interaction. These results raise interesting possibilities if found to be true in other settings. For example, expositive lectures are based on one-way communication that does not require the use of valuable face-to-face time. The implication is that technology can be used to enhance a traditional class by moving lectures out of the classroom to free up time for additional value-added interactions.

Observations

I hope that eventually such incremental work as the studies reported on here may make all-or-nothing arguments such as the debate over the no-significant-difference effect moot. I feel that the real contribution to education of the Internet may be as a tool for experimentation and innovation, to add value, maybe to reduce cost, and possibly to expand the availability of higher education to new groups of people. On a personal note, I have always felt a need to use class time to cover course material. I felt that if I did not cover all the material in class, I was not doing my job. At the same time, I have wanted to incorporate interesting interactive teaching techniques that I have read or heard about. An important point that I am beginning to appreciate is that a decision to use, or not to use, technology in the classroom should not be considered a trade-off between utilitarian concerns and teaching effectiveness—the value of computers is to enhance learning by encouraging interaction. In this regard, technology can be used to do new things or old things better.

In the fall 2000/spring 2001, I sought to increase interaction by using technology to free up classroom time for more face-to-face interactions. More generally, I look for opportunities to move routine tasks out of the classroom. As I do, I am finding that technology is giving me time to do those things that I have always wanted to do but did not have the time for. It is possible that in technology-enhanced courses, the flexibility of the Internet may be used to its best advantage.

Limitations of the Studies

First, the possibility of bias always exists. The study performed in the fall 2000/spring 2001 was of a quasi-experimental design that used intact groups. Even though numerous potential covariates were inspected and ANCOVA seemed appropriate, the groups still could have varied on some unknown important variables, thus the possibility of bias exists.

Second, in terms of interactions, questions remain as to what kind of interactions and how much interaction is ideal.

Third, many may criticize the results of both studies for lack of generalizability to other courses, that is, lack of external validity or the ability to be certain of what would happen in other courses doing the same things. Despite the fact that conditions were not at all unlike those in many other classrooms, the studies involved only one course. This has the advantage of increasing control by elimination, but does not allow for generalizations to be made.

Lack of external validity may not be bad, however. In a classic paper defending external invalidity, Mook[31] weighed in on the question of whether to be concerned most about internal validity (certainty of what did happen) or external validity (certainty of what would happen elsewhere). He pointed out that while internal validity is a necessary prerequisite for results to be externally valid, a study with sufficient internal validity does not need to be generalizable to be useful. Mook concluded that it depends on the purpose of the research. In this case, internal validity was most important because the purpose was to improve a course. Internal rather than external validity was critical in determining if what ought to have happened did happen. The implication is straightforward. Others are advised to replicate these studies before relying on the results in their own situations. *e*

Endnotes

1. See <http://homepages.ius.edu/tkeefe/educause_quarterly/Ameritech.htm>.
2. See L. Lewis et al., "Distance Education at Postsecondary Education Institutions: 1997–1998" (Washington, D.C.: U.S. Department of Education, National Center for Education Statistics, NCES 2000-013, 1999); and R. Phipps and J. Merisotis, "What's the Difference? A Review of Contemporary Research on the Effectiveness of Distance Learning in Higher Education" (Washington, D.C.: The Institute for Higher Education Policy, Council of Higher Education Accreditation (CHEA), 1999), on the Web at <http://www.ihep.org/Pubs/PDF/Difference.pdf>.
3. For a good review of research design issues, see E.J. Pedhazur and L. Pedhazur-Schmelkin, *Measurement, Design, and Analysis: An Integrated Approach* (Mahwah, N.J.: Lawrence Erlbaum Associates, 1991).
4. T.J. Keefe provided the supplemental online lectures for the textbook *Organizational Behavior*, 5th edition, by R. Kreitner and A. Kinicki, CD-ROM version (New Albany, Ind.: Indiana University Southeast, School of Business, 2001); available on the Web at <http://www.mhhe.com/business/management/kreitner5e/student/olc/ch01lecture.mhtml>.
5. For example, see J. Webster and P. Hackley, "Teaching Effectiveness in Technology-Mediated Distance Learning," *Academy of Management Journal*, Vol. 40, No. 6, 1997, pp. 1,282–1,309; and H.W. Marsh and L.A. Roche, "Making Students' Evaluations of Teaching Effectiveness Effective," *American Psychologist*, Vol. 52, No. 11, 1997, pp. 1,187– 1,197.
6. For a review of self-efficacy, see A. Bandura, *Social Foundations of Thought and Action: A Social-Cognitive View* (Englewood Cliffs, N.J.: Prentice-Hall, 1986). For information about measuring self-efficacy, see M.E. Gist and T.R. Mitchell, "Self-Efficacy: A Theoretical Analysis of Its Determinants and Malleability," *Academy of Management Review*, Vol. 17, No. 2, 1992, pp. 183–211. For information about locus of control, see J.W. Henry and C. Campbell, "A Comparison of the Validity, Predictiveness, and Consistency of a Trait versus Situational Measure of Attributions," in *Attribution Theory: An Organizational Perspective*, Martinko, ed. (Delray Beach, Fla.: St. Lucie Press, 1995, pp. 35–51).
7. To read about how these issues apply to test theory, see R.P. McDonald, *Test Theory: A Unified Treatment* (Mahwah, N.J.: Lawrence Erlbaum Associates, 1999).
8. For lists of items from selected measures included in the study, see Appendix A covering attitude toward the technology used in the course (attitude toward technology), course satisfaction, instructor satisfaction, and perceived course usefulness. Attitude toward technology was gathered the first day of class; the others were collected after the course had finished, to be used as student perceptual evaluations. On the Web at <http://homepages.ius.edu/tkeefe/educause_quarterly/appendix_a.htm>. For factor scores with reliabilities of measures, see Appendix B on the Web at <http://homepages.ius.edu/tkeefe/educause_quarterly/appendix_b.htm>.
9. J. Stevens, *Applied Multivariate Statistics for the Social Sciences*, 3rd edition (Mahwah, N.J.: Lawrence Erlbaum Associates, 1996).
10. A.G. Greenwald and G.M. Gillmore, "Grading Leniency Is a Removable Contaminant of Student Rating," *American Psychologist*, Vol. 52, No. 11, 1997, pp. 1,209–1,217.
11. For a full set of the regression results, see Appendix C on the Web at <http://homepages.ius.edu/tkeefe/educause_quarterly/appendix_c.htm>.
12. Regression was performed following the advice of J. Cohen and P. Cohen, *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*, 2nd edition (Mahwah, N.J.: Lawrence Erlbaum Associates, 1983), pp. 133–177, 360–366.
13. For a full set of hierarchical regression results for spring 2000, see Appendix D on the Web at <http://homepages.ius.edu/tkeefe/educause_quarterly/appendix_d.htm>.
14. S.R. Hatfield, ed., *Seven Principles in Action: Improving Undergraduate Education* (Bolton, Mass.: Anker Publishing, 1995).
15. Advocates of interactive learning include C.C. Bonwell and J.A. Eison, "Active Learning: Creating Excitement in the Classroom," *ASHE-ERIC Higher Education Report*, No. 1 (Washington, D.C.: The George Washington University, School of Education and Human Development, 1991). Advocates of collabo-

rative learning include D.W. Johnson, R.T. Johnson, and K.A. Smith, "Cooperative Learning: Increasing College Faculty Instructional Productivity," *ASHE-ERIC Higher Education Report*, No. 4 (Washington, D.C.: The George Washington University, School of Education and Human Development, 1991).

16. D. Hanson et al., *Distance Education: Review of the Literature*, 2nd edition (Washington, D.C., and Ames, Iowa: Association for Educational Communications and Technology and Research Institute for Studies in Education, 1997).
17. K. Hafner, "Lessons Learned at Dot-Com U," *The New York Times*, May 2, 2002, E4, E8.
18. R.M. Burnside, "E-Learning's Missing Ingredient," *Corporate Universities International, Your Newsletter for Research, Tools, and Best Practices*, Vol. 7, No. 5, 2001, p. 1.
19. R. Phipps and J. Merisotis, op. cit., pp. 29–32.
20. A. Dillon and R. Gabbard, "Hypermedia as an Educational Technology: A Review of the Quantitative Research Literature on Learner Comprehension, Control, and Style," *Review of Educational Research*, Vol. 68, No. 3, 1998, pp. 322–349.
21. D.G. Brown, ed., *Interactive Learning: Vignettes from America's Most Wired Campuses* (Bolton, Mass.: Anker Publishing, 2000), vignettes: pp. 5, 8, 27, 46, and 47.
22. E.J. Pedhazur and L. Pedhazur-Schmelkin, op. cit., p. 213.
23. When systematic individual differences occur that are not of primary interest to a study, there are various ways of designing studies to control for such unwanted effects. See R.E. Kirk, *Experimental Design: Procedures for the Behavioral Sciences*, 2nd edition (Belmont, Calif.: Brooks/Cole Publishing Co., 1982). Kirk called the design technique I used blocking, while Pedhazur and Pedhazur-Schmelkin (p. 214) referred to it as inclusion.
24. For a correlation matrix of selected variables, see Appendix E on the Web at <http://homepages.ius.edu/tkeefe/educause_quarterly/appendix_e.htm>.
25. D.T. Campbell and J.C. Stanley, *Experimental and Quasi-Experimental Designs for Research on Teaching* (Chicago, Ill.: Rand McNally College Publishing Co., 1963).
26. D. Hanson et al., op. cit., p. 31.
27. Some have argued strongly against using ANCOVA with intact groups, for example, N.H. Anderson, "Comparison of Different Populations: Resistance to Extinction and Transfer," *Psychological Review*, Vol. 70, 1963, pp. 162–179; and F.M. Lord, "Statistical Adjustments when Comparing Preexisting Groups," *Psychological Bulletin*, Vol. 72, 1969, pp. 336–337. Stevens did not take this position; he indicated that ANCOVA can be used with intact groups but with caution (p. 324).
28. For a full set of hierarchical regression results, fall 2000/spring 2001, see Appendix F on the Web at <http://homepages.ius.edu/tkeefe/educause_quarterly/appendix_f.htm>.
29. For discussions of analysis and of direct and indirect effects, see Cohen and Cohen, op. cit., pp. 360–366.
30. Brown, op. cit.
31. D.G. Mook, "In Defense of External Invalidity," *American Psychologist*, April 1983, pp. 379–387.

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