

Impact of Positive Interdependence During Electronic Quizzes on Discourse and Achievement

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ABSTRACT The authors examined the effects of positive interdependence vs. no interdependence on students' academic achievement. Participants included 151 U.S. college students who took weekly electronic quizzes on which they could interact with group mates in a chat room. In the positive interdependence condition, 1 member was chosen at random, and his or her score was given to all members of the group. In the no-interdependence condition, each group member received his or her own score on each quiz. Achievement was measured by biweekly examinations that students took by themselves and that produced their own independent scores. Students in the positive-interdependence condition engaged in significantly more interaction and more promotive interaction while taking the electronic quizzes and achieved higher scores on the subsequent examinations taken individually.

Key words: achievement, cooperation, electronic quizzes

In 1949, Morton Deutsch published a theory of cooperation and competition that has served as the basis for social interdependence theory ever since. This landmark work has resulted in hundreds of studies comparing the relative efficacy of cooperative, competitive, and individualistic efforts on a wide variety of variables (Johnson & Johnson, 1989, 1999). The basic premise of social interdependence theory is that the way in which the goals in a situation are structured determines the interaction patterns among participants, which, in turn, determines the situational outcomes (Deutsch, 1949; Johnson & Johnson, 1989). Thus, positive interdependence should promote higher achievement by group members than no interdependence because it creates interaction patterns in which group members encourage and assist each other to do well.

Despite the centrality of this premise to social interdependence theory, there has been surprisingly little research that directly tests the relationship among the three variables (positive interdependence, interaction patterns, and outcomes). Although there are numerous research studies that link positive and negative interdependence with certain interaction patterns, as well as numerous studies linking

positive and negative interdependence with a wide variety of outcomes, there are almost no studies that include both interaction patterns and outcomes. The first purpose of this study, therefore, was to compare the impact of positive interdependence with no interdependence (i.e., independence) on interaction patterns among participants and their resulting individual achievement.

One focus of the research on social interdependence theory is the relative impact of positive versus no interdependence. There is considerable evidence from studies from many different countries that cooperation promotes higher achievement than individualistic efforts do (Johnson & Johnson, 1989). When positive interdependence is structured in a learning situation, a student perceives that he or she can achieve his or her learning goal only if the other students with whom he or she is cooperatively linked achieve their learning goals (Deutsch, 1962). When no interdependence is structured in a learning situation, a student perceives that the achievement of his or her learning goal is unrelated and independent from the goal attainment of other students. These research studies primarily compared individuals working in groups within which positive interdependence is structured with individuals working alone with no interdependence structured. The investigations open the possibility that membership in a group, rather than positive interdependence, promotes higher achievement.

Theoretically, positive interdependence motivates group members to strive to do their best and to ensure that other group members do the same. However, just being a member of a group may motivate members to strive to achieve. To determine whether positive interdependence or group membership creates higher achievement than do individuals working independently, researchers need to compare positive interdependence structured among group members with no interdependence structured among group members. The

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second purpose of this study, therefore, was to hold group membership constant while comparing the relative efficacy of positive and no interdependence.

Within learning groups, interaction among group members may promote the achievement of members or it may be irrelevant social interaction. *Promotive interaction* may be defined as individuals encouraging and facilitating each other's efforts to achieve in order to reach the group's goals. There are two questions, therefore, that need to be answered concerning the interaction patterns among group members working to complete assignments. The questions are, "Will positive compared to no interdependence create more interaction among group members?" and "Will the interaction be promotive of higher achievement (as opposed to social interaction or interaction inhibiting higher achievement) of group members?" It is possible for group members to (a) remain silent and engage in little interaction or (b) interact socially on topics irrelevant to the assignments they are completing and thereby inhibit each other's achievement. It is also possible for group members to promote each other's achievement by providing assistance, giving each other feedback, and encouraging each other to achieve. The third purpose of this study, therefore, was to measure the amount of interaction among group members and to determine whether the interaction was aimed at increasing each other's achievement or if it was irrelevant to, or inhibiting of, each other's achievement.

The setting for this study was a web-based education course in which group members communicated by computer. This environment eliminated all nonverbal cues from the interaction among group members during the quizzes. Although web-based education and corresponding web-class discussions are becoming more common, research demonstrating the conditions under which they may or may not increase achievement is relatively new. This study is one of the first experimental investigations into the use of chat-room discussions in a web-based education class.

Method

Participants

Participants in this study were 151 undergraduate freshmen in a human anatomy and physiology lab. The labs were held in computer rooms for 2 hr per week for 9 weeks in classes of 25 to 28 students. Within each lab section, students were assigned randomly to learning groups with 4 members. The study was conducted over two academic quarters in the General College of the University of Minnesota. A coin toss randomly decided that the fall course/quarter would be the no-interdependence condition and the winter course/quarter would be the positive-interdependence condition. The same instructor taught both conditions. In the fall quarter, 72 students (33 men and 39 women) were enrolled; 12 of the students were African American, 1 was Chicano Latino, 16 were Asian, and 43 were Anglo. Six of the students were under 18 years of age, 53 were between

the ages of 18–20, 13 were 21–22, and 7 were 23–30 years of age. During the winter quarter, 79 students (38 men and 41 women) took the course; 12 of the students were African American, 19 were Asian, and 48 were Anglo.

The two conditions were run sequentially over two adjacent academic quarters. Students enrolled in this course in blocks; only one block was taught each quarter because of the limited number of instructors, computers and computer classrooms, and teaching assistants. Because two blocks were needed for the study, we conducted it over two sequential academic quarters. There is reason to believe that the participants in each condition were academically equivalent. All General College students were admitted using the same Accumulated Academic Record Scores (AAR), between 70 and 90. The AAR score was computed by doubling the student's ACT composite score and adding it to his or her high school percentile class rank. Given that the students were freshmen, their college GPAs were nonexistent for the first quarter; therefore, the student GPAs in each condition could not be compared. Jensen (1993) demonstrated in a previous study that the ACT scores of students in different General College classes do not differ significantly. One may conclude that the students in each condition were from the same population and did not differ in academic ability. This conclusion is strengthened by the fact that the students in each condition scored the same on Tests 1 and 2.

General College is a non-degree-granting college. Its mission is to provide developmental education to its students by improving basic academic skills, such as writing and test taking, to a level that will transfer and ensure success within other colleges in the university.

Independent Variable

The independent variable was group interdependence versus no interdependence. In each condition, students took nine quizzes (one per week) and were randomly assigned to 4-member groups that remained the same throughout the quarter. In the group positive-interdependence condition, members could communicate during the quiz via the computer chat room; 1 member's score was randomly selected and given to every group member. Thus, helping other students likely would improve one's own score. In the group no-interdependence condition, group members could communicate during the quiz via the chat room. Each student was given his or her own score on the quiz in this condition, and, therefore, students had no reason to help or not help each other. In both conditions, the computer program allowed students to communicate with each other through the chat room, but students did not know and could not see any of the answers that their fellow group members were entering.

Dependent Variables

There were two dependent variables—verbal interaction and achievement. Verbal interaction was measured via the

chat room dialogue. Quantity of chat was analyzed by counting the number of lines of chat produced per group. Cooperativeness of chat was analyzed by coding the lines of chat for managing the task, giving and clarifying information, asking questions, facilitating group processes, and arguing and offering an opinion. We determined the proportion of cooperativeness of chat from the combination of quantity and cooperativeness. The unit of chat to be coded was specified a priori to be the entire student entry. If a category already was present within the time demarcation, the new code category was separated by a slash to indicate a separate classification on the basis of new criteria. Within-category codes were indicated by a semicolon. The transcripts were coded by a professor, a graduate research assistant, and an undergraduate research assistant who had been trained in the procedure. Interrater reliability was determined to be 87% among the three coders. Transcript coding was done online within the chat room transcript to ensure validity and to facilitate statistical analysis. Data were coded for a group only when at least 3 members were present.

Achievement was measured via the five biweekly examinations that all students took individually, without communicating with each other. The questions were all multiple choice and directly measured students' understanding of the course content. There were 50 questions on the examinations for Weeks 2, 4, 6, and 8; tests lasted 60 min. The comprehensive examination given in Week 10 contained 100 questions and covered the content studied for the whole course. Students were given 2 hr to complete this examination. Each student's score on the final examination was divided by two in order to equalize the results of the examinations.

Procedure

The human anatomy and physiology course met for 3 hr per week in a large lecture class and for 2 hr per week in a computer lab. In the lab, the students each had their own computer and worked in assigned groups of four students. At the beginning of each lab, students took a quiz that lasted about 25 min. The quizzes all followed the same sequence. Students entered the lab, sat down at their computer, signed onto the course's web page (identification number, quiz number, group number), and selected the electronic quiz for that week. The quiz was displayed on three screens. Each screen contained a chat room that could be entered only by members of each student's group. All communication among group members during the quizzes was only in the computer chat room. The first two screens required identification answers (show a human skeleton and require the identification of the bones; show a human heart and require the identification of its parts), and the third screen required short explanations of three or four sentences of physiology phenomena and events (explain the difference between adult-onset and juvenile-onset diabetes). On each screen, each student answered the questions with the option of going to the chat room.

Once a student left a screen, he or she could not return. The student received immediate feedback on which questions were answered correctly. In the positive-interdependence condition, therefore, it was important for group members to remain at a screen until everyone agreed on the answers. At the end of the quiz, students logged off and went back to the web page. In the positive-interdependence condition, the professor then randomly selected 1 member of the group and gave that member's quiz score to all the members. Quiz grades counted for 20% of the overall course grade. During the rest of the lab, students worked on four major projects (medical terminology assignment, computer simulation involving the heart, PowerPoint presentation, and web-page construction). These projects combined to account for 10% of the overall class grade.

Every other week (Weeks 2, 4, 6, 8, and 10), an examination was given on the content and procedures studied during that 2-week period. Students took the examinations (all multiple-choice questions) individually without any interaction with other group members. There were 50 questions on the examinations for Weeks 2, 4, 6, and 8 (each examination lasted 60 min) and 100 questions on the comprehensive final examination (2 hr) given in Week 10 that covered the content studied for the whole course. Each student's score on the final examination was divided by two in order to equalize the results for the examinations. The examination grades counted for 70% of the overall course grade. We conducted two-way analyses of variance (ANOVAs) to test for the difference between the two conditions, sampled the times interaction patterns, and assigned examinations.

Results

The data for patterns of verbal interaction used in the chat rooms while students completed the quizzes appear in Tables 1, 2, 3, and 4. The weeks analyzed were 3, 6, and 9. When a two-way ANOVA was conducted on amount of chat, there was a significant main effect for condition, $F(1, 107) = 48.17, p < .001$, and a significant interaction between

Table 1.—Verbal Interaction in Computer Chat Rooms

	Independent			Interdependent		
	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>
Overall chat						
Week 3	15.94	5.36	19	19.76	4.52	22
Week 6	15.62	3.46	16	21.83	4.69	19
Week 9	14.11	4.53	18	22.81	5.27	19
Cooperative chat						
Week 3	11.03	4.19	19	16.05	4.51	22
Week 6	10.18	2.11	16	18.01	4.39	19
Week 9	9.60	3.03	18	19.40	4.55	19
Proportion cooperative chat						
Week 3	0.58	0.06	19	0.73	0.06	22
Week 6	0.57	0.09	16	0.73	0.06	19
Week 9	0.54	0.10	18	0.75	0.06	19

Table 2.—Overall Chat

Source of variation	Sum of squares	df	M^2	F	Significance of F
Main effects	1,086.088	3	362.029	16.347	.000
Treatment	1,066.824	1	1,066.824	48.172	.000
Quiz	19.505	2	9.753	0.440	.645
Interaction	115.717	2	57.858	2.61	.078
Explained	1,201.805	5	240.361	10.853	.000
Residual	2,369.657	107	22.146		
Total	3,571.462	112	31.888		

Note. 123 cases were processed; 10 cases were missing.

Table 3.—Cooperative Chat

Source of variation	Sum of squares	df	M^2	F	Significance of F
Main effects	1,581.837	3	527.279	33.485	.000
Treatment	1,563.947	1	1,563.947	99.318	.000
Quiz	23.267	2	11.633	0.739	.480
Interaction	112.168	2	56.084	3.562	.032
Explained	1,694.005	5	338.801	21.516	.000
Residual	1,684.908	107	15.747		
Total	3,378.913	112	30.169		

Note. 123 cases were processed; 10 cases were missing.

Table 4.—Proportion Cooperative Chat

Source of variation	Sum of squares	df	M^2	F	Significance of F
Main effects	0.823	3	0.274	53.334	.000
Treatment	0.821	1	0.821	159.606	.000
Quiz	0.001	2	0.000	0.073	.929
Interaction	0.18	2	0.009	1.712	.185
Explained	0.841	5	0.168	32.686	.000
Residual	0.551	107	0.005		
Total	1.392	112	0.12		

Note. 123 cases were processed; 10 cases were missing.

Table 5.—Achievement on Examinations Taken Individually

Examination	Independent			Interdependent			F	Sig
	M	SD	n	M	SD	n		
1	32.61	7.05	72	33.03	6.28	79	0.46	.498
2	33.93	6.13	72	33.90	7.90	79	1.05	.307
3	33.74	6.05	72	37.71	6.29	79	4.36	.038
4	33.36	6.20	72	36.71	7.34	79	7.26	.008
5	31.76	5.28	72	35.37	6.12	79	7.09	.008

Note. Sig = significance of F .

condition and time of quiz, $F(2, 107) = 2.61, p < .08$. There were no significant differences for time of quiz (Weeks 3, 6, and 9), $F(2, 107) = 0.44, p < .65$. The interaction data indicated that as the course progressed, students in the no-interdependence condition interacted less, whereas students in the positive-interdependence condition interacted more.

When we conducted a two-way ANOVA on amount of cooperative chat, there was a significant main effect for condition, $F(1, 107) = 99.32, p < .001$, and a significant interaction between condition and time of test, $F(2, 107) = 3.56, p < .03$. There were no significant differences for time of measurement (Weeks 3, 6, and 9), $F(2, 107) = .74, p < .48$. The interaction indicated that as the course progressed, students in the no-interdependence condition engaged in less promotive interaction, whereas students in the positive-interdependence condition engaged in more promotive interaction.

When we conducted a two-way ANOVA on proportion of cooperative chat, there was a significant main effect for condition, $F(1, 107) = 159.61, p < .001$. There were no significant differences among time of measurement (Weeks 3, 6, and 9), $F(2, 107) = 0.73, p < .93$, and no significant interaction between condition and time of test, $F(2, 107) = 1.71, p < .19$.

The second issue that we investigated was the impact of the group interdependence on individual achievement. As the students learned the system of working together on the quizzes, their individual achievement on the tests increased (see Table 5). The difference between the group interdependence and independence conditions was not significant for the first two tests, but the students in the interdependence condition had significantly higher achievement than did the students in the independence condition for Test 3, $F(1, 149) = 4.36, p < .05$; for Test 4, $F(1, 149) = 7.26, p < .01$; and for Test 5, $F(1, 149) = 7.09, p < .01$.

Discussion

For the last 50 years, the research on social interdependence theory has been based on the proposition that the way goals are structured in a situation determines how participants interact, and the interaction pattern determines the outcomes of the situation (Deutsch, 1949, 1962; Johnson & Johnson, 1989). Few studies, however, include positive interdependence, interaction patterns, as well as outcomes. The validity of this basic premise rests on three separate sets of research studies demonstrating that, compared with negative and no interdependence, (a) positive interdependence results in higher achievement and productivity, (b) positive interdependence results in promotive interaction, and (c) promotive interaction results in higher achievement and productivity. This study provides an important validation of social interdependence theory's basic premise by including all three variables and demonstrating that positive interdependence results in more promotive interaction and higher achievement than does no interdependence.

Also in this study, we measured interaction patterns by the quantity of chat room dialogue during a quiz and by the extent it was directed toward promoting achievement and success of other group members. In regard to quantity of verbal interaction during quizzes, students in the positive-interdependence condition engaged in more chat room dialogue than did students in the no-interdependence condition. Although there may have been some novelty associated with use of the chat room initially, over the duration of the course, students in the no-interdependence groups tended to be less interested in interacting with each other as they realized that little gain arose from such interaction and that it was costly in terms of time (the opposite scenario occurred in the positive-interdependence condition). These findings are an important addition to Deutsch's (1962, 1973) previous research demonstrating that positive interdependence promotes more communication among group members than does negative interdependence.

In addition to examining quantity of chat room dialogue during a quiz, we examined the nature of the dialogue to determine the degree to which group members promoted each other's success. Most of the previous research on interaction within cooperative efforts has focused on the frequency of interaction with minority members, the positive-negative aspects of interaction among members, the amount of helping among group members, and specific behaviors (such as giving explanations; Johnson & Johnson, 1989, 1999). Few studies have examined the promotive interaction that occurs when completing a task.

In this study, *promotive interaction* was defined "operationally" as group members' verbal comments that reflected managing the task, giving each other data and asking each other questions, clarifying information, providing opinions and arguing, and facilitating the group process. Students in the positive-interdependence groups, compared with students in the no-interdependence groups, engaged in significantly more promotive interaction. Over the duration of the course, students in the positive-interdependence condition tended to assist and encourage each other more, whereas students in the no-interdependence groups engaged in such interactions less. Thus, in support of Deutsch's (1949, 1962) theorizing, positive interdependence tended to result in increased amounts of promotive interaction as the learning groups matured and developed, whereas no interdependence among groups resulted in the opposite effect.

Students took the quizzes in small groups. They were tested individually five times during the 10-week course to determine how much they had learned. The higher achievement of students in the positive-interdependence condition (compared with students in the no-interdependence condition) adds further evidence of the power of cooperative learning to increase achievement (Johnson & Johnson, 1989).

A controversial issue in the literature on cooperative learning is evaluating group work by giving all group members the same grade. The cooperative quiz, in which the instructor randomly selects the score of one member and

gives that grade to all members of the group, is an example of group grading. Although the debate is filled with over-generalizations—for example, group grades are inherently unfair and undermine motivation to learn (Kagan, 1995)—the critics do not present data concerning the conditions under which group grades are effective and ineffective. The absence of data makes it difficult for one to discuss the issue rationally. Therefore, a need exists for studies that examine the impact of group grading on achievement. This study provides clear evidence that the use of group grades promotes a highly effective learning experience when clear positive interdependence is structured among group members. These results corroborate the previous findings of Jensen (1996), who found that students who participated in the cooperative quizzes, compared with students who took individual quizzes, achieved significantly higher scores on the final examination, developed more positive attitudes toward the class and the examination, and met more frequently with classmates outside of class.

The use of cooperative quizzes in which one member's answers are randomly chosen and his or her score given to all group members fulfills two of the more difficult elements of cooperative learning—positive interdependence and individual accountability. Positive interdependence was met by sharing one common quiz grade. Although the importance of the shared grades was relatively small (i.e., about 20% of the total course grade), it was large enough to ensure that students were interested in each other's learning, paid close attention to each other's progress, and engaged in considerable promotive interaction to ensure that all group members mastered the assigned information and procedures. Individual accountability was met by randomly choosing one group member to represent the group as a whole and by giving examinations on which the level of each group member's learning became apparent. The former measure ensured that each group member correctly answered each quiz question; the second action ensured that each student was responsible for learning all the course material rather than succeeding because of the favorable efforts of the group.

The use of cooperative quizzes may work best when (a) a predefined list of objectives is developed, (b) the list of objectives is initially short and becomes longer and more challenging as the course progresses (to ensure groups can be initially successful if effort is exerted), (c) the importance of the grades received is relatively low, (d) the assignment focuses on learning terms and procedures, (e) individual examinations are given to ensure that all group members are learning, and (f) the overall course grading is conducted under a criteria-referenced (rather than a norm-referenced) system.

Finally, this investigation is one of the first studies that demonstrates that the effectiveness of web-based education may be enhanced by using cooperative learning procedures such as cooperative quizzes. The use of web-based education is increasing. Yet, there is very little evidence regarding the manner in which web-based learning should be structured to maximize its effectiveness. The setting for this

study was a web-based education course in which group members communicated only by computer. Engaging in chat room dialogue to complete quizzes cooperatively did result in higher achievement on a final examination that was taken individually. These findings are an important addition to the literature on web-based education.

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