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Small Steps Using Cooperative Learning Techniques in the Database Management Course: Some Preliminary Results

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Abstract

We present two examples of cooperative learning techniques – paired thinking and cooperative groups. We describe the techniques, discuss how they are used in a database classroom, and offer data to demonstrate that learning benefits can be achieved through these techniques. Our preliminary evidence suggests that, contrary to recent research in information systems, these techniques are beneficial. Further, rigid adherence to the guidelines of cooperative learning group designs is not needed to reap the learning benefits.

Keywords: Cooperative learning, teaching and learning, database management

Introduction

Cooperative learning techniques are characterized by the use of small groups of students working together to facilitate each other's learning (Johnson et al. 1991). Much of the evidence regarding these techniques is positive (Hagen 2000; Lord 2001), yet research in management information systems (MIS) questions the efficacy of these techniques (Ryan et al. 2000; Wehrs 2002). This, coupled with the potential drawbacks and complexities of implementation associated with these techniques, raises additional questions regarding their use in MIS courses (Joyce 1999; Phipps et al. 2001).

Given the positive evidence in non-MIS courses, we argue that cooperative techniques can, and will, be beneficial in MIS courses. Our objective in this study is to examine the use of two different cooperative learning techniques in a database management course. We believe that learning benefits can be achieved using these techniques in MIS courses. However, in order to overcome some drawbacks, we argue that rather than attempting to fully implement cooperative learning in the course, substantial benefits can be attained through small steps toward a cooperative model of learning. We propose that instructors and students have much to gain from the use of small-scale cooperative learning initiatives in the course.

The paper is organized as follows. First, a description of cooperative learning and research that has been conducted on its effectiveness is presented. Next, the methodology of two studies examining the implementation of small-scale cooperative learning efforts is explained and empirical results showing the effectiveness of the efforts are presented. The paper concludes with a discussion of the implications of the results.

Background

Cooperative learning groups have five essential characteristics: (1) positive interdependence, (2) face-to-face promotive interaction, (3) individual accountability, (4) social skills, and (5) group processing of the effectiveness of the group (Johnson et al. 1991). These five characteristics of cooperative learning groups have become well accepted and are frequently cited in the literature on cooperative learning. The first, positive interdependence, refers to designing the group experience so that group members believe they need each other. The second, face-to-face promotive interaction, refers to students engaging in techniques that encourage each other to learn. The third characteristic, individual accountability, focuses on rewarding the group based on each individual's performance. The fourth characteristic, social skills, refers to the requirement that skills, such as leadership and conflict management, are taught to students. Finally, group processing of the effectiveness of the group means that groups are required to reflect on and openly discuss the strengths and weaknesses of the participation of each member of the group (Johnson et al. 1991).

A considerable body of evidence has accumulated demonstrating that, in general, people learn more effectively when they work with other people than when they work alone (Horn et al. 1998). This, coupled with the effectiveness of cooperative learning, has led the use of cooperative techniques to spread to elementary schools (Emmer and Gerwels 2002; Gillies and Ashman 1998; Dyson and Rubin 2003), secondary schools (Leonard and McElroy 2000), colleges and universities (Phipps et al. 2001), and the workplace (Vasquez et al. 1993). Within the academic environment, cooperative learning has been applied in a variety of disciplines including chemistry (Hagen 2000; Paulson 1999), biology (Lord 2001), physics (Paino 2001), management (Siciliano 2001), marketing (Hernandez 2002), and MIS (Ryan et al. 2000; Wehrs 2002).

Cooperative learning has been found to improve student performance (Hagen 2000; Paulson 1999), increase student motivation (Paino 2001), improve student social skills (Lord 2001) and increase student satisfaction (Lord 2001). Interestingly, MIS is an academic discipline in which the use of cooperative learning techniques has not achieved consistently positive outcomes. For example, Wehrs (2002) found that the use of cooperative learning techniques in the introductory MIS course did not improve student performance as measured by exams and group projects. Likewise, Ryan et al. (2000) found that students using cooperative learning in a database systems course did not produce better conceptual data models than students using techniques that emphasized individual learning.

In addition to the questionable results in MIS classes, concerns about the potential drawbacks of cooperative learning may inhibit adoption of the techniques. Potential drawbacks include the free rider problem, resistance to group-based grading by both instructors and students, and problems configuring teams. The free-rider problem exists when a student chooses to not work hard in a cooperative learning group (Joyce 1999). Students may engage in this behavior when they believe that they can earn a good grade in a class that uses cooperative learning techniques without working to their full potential. The issue of group grades is problematic from both the instructor and the student perspective (Phipps et al. 2001), and exacerbated by the free-rider problem. Finally, team configuration is the issue of assigning students to teams in such a way that the variability among the team members is maximized (Johnson et al. 1991). This can create a significant amount of work for an instructor and be met with resistance by the students who may have preferences regarding their team composition.

The mixed findings and potential drawbacks may lead MIS educators to avoid using cooperative learning techniques in their classes. We argue that positive results can be achieved in MIS, and that many of the drawbacks can be avoided. In the remainder of this paper, we discuss two specific cooperative learning strategies designed to achieve positive learning outcomes while avoiding the potential drawbacks. The first technique, paired thinking, is used to introduce material and to encourage students to begin the process of problem solving in the course. The second technique, the cooperative learning group, is used to encourage students to synthesize and apply course material. Evidence about the effectiveness of the two techniques is presented.

Methodology and Results

Two studies examining the effects of small-scale cooperative learning initiatives in the database management course were conducted. One study examines the use of paired thinking, and the other study examines the use of cooperative learning groups. In order to ensure that results are applicable to a wide variety of college and university settings, one study was conducted on a medium-sized, commuter campus, and the other study was conducted at a large, residential university. Undergraduate and graduate students were included in both studies.

Study 1. Paired Thinking

Procedure

Paired thinking is a cooperative learning technique in which student dyads work together to answer questions or solve problems. Dyads are instructed to approach problems using a three-step process: (1) each student solves the problem independently, (2) students exchange answers with each other, (3) each dyad formulates an answer to be reported to the class (Johnson et al. 1991). Paired thinking incorporates key characteristics of cooperative learning because students are asked to use the individual answers as the starting point in formulating the final solution for the dyad (i.e., positive interdependence), interact with a partner (i.e., face-to-face promotive interaction), are selected randomly to report the dyad's answer (i.e., individual accountability), and are taught to listen carefully without criticism during the second step of the process (i.e., social skills). Paired thinking does not typically require reflection on the performance of the dyad.

In this study, paired thinking was used extensively in both an undergraduate and a graduate course to teach fundamental concepts of database design, implementation, and use, including conceptual data modeling, logical design, physical design, database implementation using SQL and information retrieval using SQL. A typical class session consisted of a series of short lecture segments interspersed with frequent paired thinking exercises. Typical problems solved by the dyads asked students to draw a conceptual data model or to formulate an SQL query.

At the end of the semester, students completed a survey about the use of the paired thinking technique. Students responded to four survey items regarding their satisfaction with the technique and four open-ended questions. The survey items are contained in Appendix A.

The survey was administered to 18 graduate students and 61 undergraduate students. Three of the undergraduate surveys were excluded from the analysis because of apparent problems with comprehension of the survey items (e.g., a respondent indicates that Paired Thinking was both "Extremely Positive" and "Extremely Bad").

Results

Responses to the satisfaction items indicate that students hold moderately favorable perceptions of the paired thinking exercises. The overall mean across subjects was 5.7 with a standard deviation of .89. No differences were found with respect to gender, however the graduate students are significantly more satisfied than the undergraduate students as shown in Table 1.

Table 1. Graduate versus Undergraduate Perceptions

	Graduates	**Undergraduates**	**Significant?**
Satisfaction	6.1	5.6	Yes*
* $p \leq .05$			

Responses to the open-ended items were analyzed to help explain these differences. One key theme emerged from the analysis. Undergraduate and graduate students differ significantly in their views of their partner. Undergraduate student responses were critical of their partners. Graduate student responses, on the other hand, tended to reflect positive views of their partners noting, for example, that it is sometimes easier to ask a partner to explain a difficult concept than to ask the instructor, that partners are able to explain difficult concepts, and that the partners are able to help when a student is stuck working on a problem. While many undergraduate students articulated benefits of working with a partner, compared to the graduate students, undergraduates were more likely to complain about problems with their partners. Some undergraduate students indicated that their partners came to class unprepared, were not knowledgeable enough to contribute to the partnership, were not motivated to try hard during the paired thinking exercises, and exposed them to "stupid answers." One student noted that if the partner is not adequately prepared for class the activity becomes "one way of thinking instead of paired thinking."

In addition to the analysis discussed above, an analysis of the responses to the open-ended questions was conducted to gain insight into the general strengths and weaknesses of paired thinking from the students' perspectives. Strengths of the technique noted by the students include encouragement of diverse ways of thinking about problems, respect for different perspectives, improved understanding of the material stemming from explaining concepts to the partner, deeper understanding of the material, better retention of knowledge, increased motivation to learn, and enjoyable and interesting class sessions. In addition to the problems with partners noted by the undergraduate students, a few students noted that paired thinking tends to slow the pace of a class. Because time is devoted to working problems during class sessions, less material can be covered through lecture. This is, however, a common criticism of the use of active learning exercises (Davis 1993, p. 154).

Study 2. Cooperative Learning Groups

Procedure

A cooperative learning exercise was designed to reinforce the concepts of normalization. In this exercise, the students are asked to meet in their project groups, consisting of four or five people, to solve three problems related to normalization. As student teams complete the problems, the instructor asks a (random) member of the group to provide the answer and to explain it. Typically, the instructor will simply ask, “Why is that the answer?” or “Why is this not the answer?” to assess the students’ understanding of the concepts. If the selected student can answer the instructor’s questions, the group receives a point. Groups that collect all 3 points are rewarded with bonus points that can be used on homework.

The design of these groups is consistent, in part, with Johnson et al.’s definition of cooperative groups. The students believe that they need each other in order to earn full credit (i.e., positive interdependence), they discuss the problems in their groups (i.e., face-to-face promotive interaction), and the performance of each individual impacts the group’s performance (i.e., individual accountability). There is, however, no teaching of social skills or required reflection on the group’s performance in this activity. In addition, this exercise design overcomes the drawbacks of cooperative groups by using already established (student-formed) groups (i.e., configuring teams), holding all students responsible for points (i.e., eliminating free-riders), and only allocating a small percentage of the overall course grade to the exercise (i.e., group grading).

To evaluate this exercise, two different assessments were used. In the first class, a graduate-level course in data management, students were asked to self-assess their knowledge of certain key constructs prior to participation in the exercise. Upon completion of the exercise, students were asked to again self-assess their knowledge of the various constructs.

The second round of data collection was conducted in an undergraduate database course. Two sections taught by the same instructor were used for this assessment. In the first section, the cooperative learning technique was used. In the second section, the same exercise was performed, however, students completed it individually, and the class discussed the answers as a large group. Both classes were given a quiz at the completion of the exercise.

Results

In the first round of data collection, 15 graduate students reported on perceived learning. Overall, students believed that the cooperative learning exercise increased their understanding of normalization concepts, as indicated by a score of 6.33 on a 7-point scale. Table 2 reports the results of analysis of variance on perceived learning. The understanding of most concepts increased significantly with the exercise.

Table 2. Analysis of Survey Results for Cooperative Learning Exercise

		Pre-exercise Mean	Post-exercise Mean
1.	Modification anomaly	5.1364	6.1111*
2.	Insertion anomaly	5.0455	6.1111**
3.	Deletion anomaly	5.1364	6.1111**
4.	Partial functional dependency	5.5000	6.6667***
5.	Transitive dependency	5.5000	6.6667***
6.	First normal form	5.5000	6.3333*
7.	Second normal form	5.3182	6.3333*
8.	Third normal form	5.1364	6.2222*
9.	BCNF	4.5000	5.6667*
10.	Foreign key constraint	5.3636	5.8889
11.	Translation rules	4.5455	5.6667**
12.	Referential integrity	4.1818	5.1111*
13.	Entity integrity	4.3636	5.3333*
14.	The null option	5.2727	6.0000
15.	On delete options	5.0000	6.0000*

Notes: $^{*}p \le .05$, $^{**}p \le .01$, $^{***}p \le .001$

In the second round of data collection, students took a quiz to assess learning. Thirty-five undergraduate students took part in this phase of the study; 15 in the cooperative learning group experience and 20 in the individual experience. The quiz included a total of 18 points. The quiz grades ranged from 10 to 18, with an overall standard deviation of 2.04. The cooperative learning group participants scored significantly higher on the quiz than did the students who performed the exercise individually, as demonstrated with $F_{(33,1)} = 4.209$, significant at the $p<.05$ level.

Discussion

Results of the studies show positive student attitudes with paired thinking and an improvement in student perceptions of learning and improvements in actual performance with the cooperative learning groups. Further, these benefits were achieved while minimizing the drawbacks typically associated with cooperative techniques. Specifically, the impact of free-riders was minimized by employing the techniques judiciously in each class. As a result, issues associated with assigning group grades were practically non-existent. Finally, no special actions were taken in the formation of groups; in fact, in study two, all groups are student-created. Thus, the drawbacks associated with grading and additional overhead need not be impediments to using cooperative techniques.

We are left with an interesting question: Why is it that prior research using cooperative learning techniques in a database course showed no benefit while this study did? Study 2 employed cooperative learning groups similarly to those in Ryan et al. (2001). We posit that the primary difference has to do with the type of knowledge that was being conveyed and/or reinforced. In the study by Ryan et al., the focus of the cooperative activity was on data modeling. Data modeling is a fairly abstract technique, employing very few rules, and open to some interpretation. Our study, on the other hand, examined normalization, a process for which a set of rules exists, and there is very little opportunity for interpretation. It is possible that the rules provided a mechanism for group members to articulate their knowledge. The explanations were then based in the rules and could be reinforced more successfully as the students put the rules in their own words. It is quite likely that students can explain why they perform certain steps in normalization, while they may have difficulty explaining their actions in data modeling. Clearly, additional research is needed to tease out the appropriate fit between pedagogical techniques and the concepts that are being taught.

Alternative explanations for the discrepancy between the findings of this study and the findings of Ryan et al. may also include differences in student characteristics, student expectations, and course content. Future research will examine these possibilities.

A limitation of the first study discussed in this paper is that no comparison is made with a control group that did not use paired thinking. Future research will compare the group that used paired thinking with a group that does not use paired thinking.

Conclusion and Implications

We have demonstrated, through the use of two techniques and four different student samples, the efficacy of using cooperative learning techniques in a database management course. Further, these studies demonstrate that an all-out full-scale implementation of cooperative learning is not necessary for students to achieve learning benefits. We encourage other instructors to adopt as much or as little of these techniques as they feel comfortable in order to enhance learning in the MIS classroom.

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Appendix A. Items for Study 1

All things considered, my participation in the paired thinking exercises was…

1.	Extremely Negative	Negative	Mildly Negative	Neutral	Mildly Positive	Positive	Extremely Positive
2.	Extremely Good	Good	Mildly Good	Neutral	Mildly Bad	Bad	Extremely Bad
3.	Extremely Harmful	Harmful	Mildly Harmful	Neutral	Mildly Beneficial	Beneficial	Extremely Beneficial
4.	Extremely Pleasant	Pleasant	Mildly Pleasant	Neutral	Mildly Unpleasant	Unpleasant	Extremely Unpleasant
5.	In what ways has our use of Paired Thinking been beneficial to you in learning the course material?						
6.	In what ways has our use of Paired Thinking hindered you in learning the course material?						
7.	In what ways has our use of Paired Thinking affected your satisfaction with this course?						
8.	What general comments or suggestions can you offer about our use of Paired Thinking?						

Appendix B. Items for Study 2

All items were evaluated on a 7-point scale, in which 1= strongly disagree and 7 = strongly agree.

I believe I could identify and fix:

1. Modification anomaly
2. Insertion anomaly
3. Deletion anomaly
4. Partial functional dependency
5. Transitive dependency

I can determine if a relation is in

6. First normal form
7. Second normal form
8. Third normal form
9. BCNF

I feel comfortable applying

10. Foreign key constraint
11. Translation rules

I would have no trouble explaining

12. Referential integrity
13. Entity integrity
14. The null option
15. On delete options

16. Overall, the cooperative learning exercise has increased my understanding of normalization concepts.