Cooperative Learning in Introductory Information Systems: Effectiveness and Efficiency at the Individual Level Preliminary Results

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Abstract

This paper presents the preliminary results from an experiment investigating the efficacy of cooperative learning on individual students in an introduction to information systems class. Statistical analysis of the experimental data indicates that cooperative learning did not have a positive effect on individual student learning or the efficiency with which an individual student learns. These results are in contrast to individual learning outcomes associated with cooperative techniques reported in the general literature on cooperative learning.

Introduction

Cooperative learning is becoming a popular instructional technique in higher education. There is great appeal to the concept that students can help each other learn. For a detailed introduction to the techniques of cooperative learning, see [2]. Furthermore, there is evidence that it is relatively effective in producing individual learning outcomes as compared to the broad alternatives.

> Between 1924 and 1997, over 168 studies were conducted comparing the relative efficacy of cooperative, competitive, and individualistic learning on the achievement of individuals 18 years or older. These studies indicate that cooperative learning promotes higher individual achievement than do competitive approaches ...or individualistic ones... [3, p.31]

This technique is also being applied in computer science and information systems classes. In those areas it is especially attractive since software development is frequently undertaken in a team context in business and industry. Cooperative projects are seen as significant in their own right in that the experience of developing a collective product serves to prepare the students for a role as a productive team member in their future professional career. The literature contains numerous narrative accounts of the implementation of the technique for classes focused on information technology projects. In general the entries in this literature are of two types. One group of studies are expositions of technique implementation based on the author's experience, see [1] and [5]. A second group focuses on refinements of the technique intended to produce more effective groups [4].

Acceptance of group experience as a dominant instructional objective contrasts sharply with the objective of cooperative learning espoused in the fundamental literature on this instructional technique.

> The purpose of cooperative learning is to make each member a stronger individual in his or her own right. Students learn together so that they can subsequently perform better as individuals. [3, p. 30]

Correspondingly, in view of the emphasis on group experience, the information technology literature related to cooperative learning is notably lacking in comparative studies focused on individual learning outcomes. While the general literature contains evidence of cooperative learning effectiveness at the individual level, is the technique sufficiently robust that it carries over to discipline areas involving information technology?

Another criterion to consider with respect to this technique is student time. Are there differences in the amount of time invested in the course by a student? If two instructional techniques are equally effective, but one requires less student time, that technique is said to be relatively efficient.

The Experiment

In order to generate data bearing on these issues, the author conducted an experiment involving three sections of an introductory information systems course. This course requires a project involving application software development in an interactive, end-user context. In one section, the students experienced a formal cooperative learning environment that extended to all components of the class. In a second section, the students experienced an environment in which a portion of the course, the project, was cooperative. In a third section, there was no formal cooperation. All three sections were administered the same tests.

The instructor formed the cooperative learning and project groups. There were two goals employed in forming the groups. Each group was heterogeneous in terms of student characteristics, especially grade point average, but homogeneous in terms of member schedules.

Each student subject to cooperative treatment received a document outlining learning group responsibilities and guidelines. An early responsibility for each group was to develop a group contract. The contract has two purposes. First, it defines agreed upon ground rules according to which the group would function. In this regard the contract also had to include a disciplinary process for group members who were not abiding by the rules. Second, it identifies the group role to be undertaken by each group member. These roles were meeting leader, meeting coordinator, learning facilitator, and account manager. In a cooperative environment, the role of the learning facilitator is especially important. If the group partitions learning tasks among the members, it is the responsibility of the learning facilitator to make sure that what was learned by one group member is communicated to the others.

In order to accentuate accountability within the group, each group member evaluated themselves and their fellow group members during the semester. These intragroup evaluations were incorporated into the class grading structure. To foster positive interdependence within the group, all members of a group were awarded test bonus points based on the test performance of

the group. These bonus points depended on the average of the two lowest group performers on each test. This provided the group a positive incentive to focus their help on those group members who needed it most.

Over the course of the semester, treatment group membership changed. Figure 1 illustrates this change over time in relation to the three tests that were administered. Section 5 of the course experienced a cooperative treatment over the entire semester. Section 7 had no formal cooperative aspects over the entire semester. Section 6 had no formal cooperative aspects prior to the administration of the second test. Following the second test, cooperative groups were formed in section 6 in order to undertake work on the project. Consequently, comparison of treatment versus non treatment individual test performance may be undertaken for (1) all tests as between sections 5 and 7, or (2) for tests 1 and 2 between section 5 and sections 6 plus 7, or (3) for test 3 between sections 5 plus 6 and section 7.

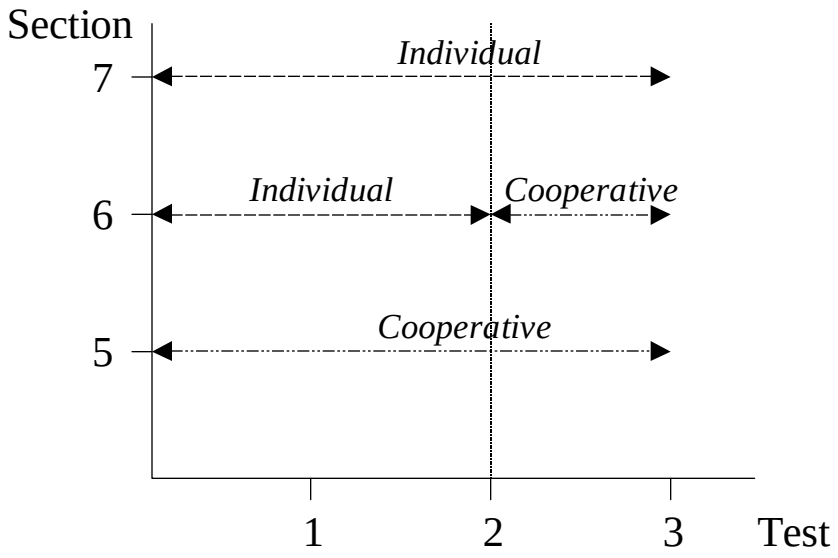

Figure 1: Section Treatment By Test Period

The Data Set

There were 69 students who completed the class and who had a complete data set. There were 23 of these students in each section. Between sections 5 and 6 there were 15 project groups. In section 7 there were an additional 24 projects completed by individual students. The tests were divided into two components. The first half of each test focused on IS (Information Systems) concepts. The last half focused on IS software. Attendance was recorded for each class session by student. Furthermore, each student logged his or her study time outside class and provided these data to the instructor on a weekly basis. Table 1 provides details on the characteristics of the resulting data set.

Category	*Variable*	*Description*
Learning Outputs	Project Score	100 points maximum
	Test Score	350 points maximum - 100 Test1, 100 Test2, 150 Test3
	IS Concepts	200 points maximum: Multiple choice on Information Systems Concepts - 50 Test1, 50 Test2, 100 Test3
	IS Software	150 points maximum: Written answer to software problems in a specific business context - 50 on each test
Demographic	GPA	Grade Point Average on a four point scale
	Age	In years
	Gender	Male or Female
	PEB	Preferred Ethnic Background: Categories - Asian, Black, Hispanic, White
Time Input	Attendance	Maximum 29 - Number of classes attended
	Study Time	Average weekly study time outside of class in hours

Table 1: Characteristics of the Data Set

The Statistical Model

$$
\begin{aligned}
TestScore = {} & \beta_0 \\
& + \beta_1 \mathrm{GPA} \\
& + \beta_2 Age \\
& + \beta_3 Attendance \\
& + \beta_4 StudyTime \\
& + \beta_5 Male \\
& + \beta_6 White \\
& + \beta_7 CooperativeTreatment \\
& + \varepsilon
\end{aligned}
$$

Male is a categorical (0-1) variable formed from gender. White is a categorical (0-1) variable formed from Preferred Ethnic Background. ε represents a random error term. The relevant test statistic is the estimate of β_7, the coefficient associated with cooperative treatment. This coefficient represents the mean difference in test scores between the treatment and non-treatment groups after allowing for the linear effect of the other covariates. A positive value indicates that mean test score of the treatment group exceeds that of the non-treatment group.

Results

Table 2 displays the results of the individual effectiveness statistical analysis. The individual effectiveness variable, Test Score, is made operational in three different forms corresponding to the three approaches to treatment group membership. Test Score is examined in total (Concepts & Software) and by test component; IS Concepts and IS Software.

	Sign of treatment coefficient	*t statistic significance level for treatment*	*Adjusted R^2: coefficient of determination*	*F statistic significance level for statistical model*
		Concepts & Software		
Tests 1 & 2	Negative	0.012	0.563	0.000
Test 3	Negative	0.239	0.543	0.000
All Tests Sections 5 & 7	Negative	0.020	0.688	0.000
		IS Concepts		
Tests 1 & 2	Negative	0.011	0.525	0.000
Test 3	Negative	0.116	0.291	0.000
All Tests Sections 5 & 7	Negative	0.001	0.603	0.000
		IS Software		
Tests 1 & 2	Negative	0.089	0.467	0.000
Test 3	Negative	0.846	0.534	0.000
All Tests Sections 5 & 7	Negative	0.413	0.683	0.000

Table 2: Individual Effectiveness by Test Component

Individuals subjet to cooperative treatment have lower test scores than individuals not subject to such treatment. Using a two-tailed significance level for the t statistic, the mean difference is statistically significant in some cases and not others. The most pronounced impact is on IS Concepts.

One issue often mentioned in conjunction with cooperative learning is student "hitchhiking" or "free ridership" [2]. This is a potential cause for the negative effectiveness results. Since a free rider may not have participated in vital learning experiences, test outcomes over that material would tend to be lower as compared to similar students undertaking course materials on an individual basis who are unable to ride free. On the assumption that academically less able students are more likely to attempt a free ride, a subset of the data may provide evidence of whether or not free ridership is a likely cause for these results. Table 3 displays the results of an effectiveness analysis comparable to Table 2, but restricted to only students whose Grade Point Average was in the lower 50 percentile of the sample.

	Sign of treatment coefficient	*t statistic significance level for treatment*	*Adjusted R^2: coefficient of determination*	*F statistic significance level for statistical model*
		Concepts & Software		
Tests 1 & 2	Negative	0.212	0.352	0.007
Test 3	Negative	0.213	0.261	0.029
		IS Concepts		
Tests 1 & 2	Negative	0.293	0.283	0.021
Test 3	Negative	0.166	0.043	0.328
		IS Software		
Tests 1 & 2	Negative	0.333	0.206	0.060
Test 3	Negative	0.551	0.277	0.023

Table 3: Individual Effectiveness - Lower 50% by GPA

These results do not support a differential effect based on treatment for less academically capable students. While the treatment effect is negative it is not as strong as in the entire sample. This may partly be due to a reduction in the number of degrees of freedom with the sample subset.

Thus far study time has been treated as a covariate in the statistical model. That is, it has been viewed as a determinant of effectiveness independent of cooperative treatment. However, differences in study time may be the result of cooperative treatment. Cooperative learning has the potential to reduce the time that a student must devote to learning a given body of material. One source for this potential has to do with how well the group manages the partitioning of instructional tasks. Especially in a project context, groups divide up the tasks they must accomplish between group members. This means that initially each group member spends less time doing the tasks in comparison with the time they would have to spend if each had to do all the tasks individually. However, in completing their particular tasks, individual group members learn about those tasks. In the second step, each group member must teach the others what they have learned. The learning must be communicated within the group. If this learning communication does not occur, the group members will spend less time learning but they will also learn less. A second source for potential time savings is peculiar to information technology. Learning how to use application software is often time consuming. Having a peer on hand to help one through those spots in the process when one cannot determine the source of a frustrating software problem may be very useful.

The data set allows an examination of the potential for enhanced efficiency due to cooperative treatment. A new dependent variable (Efficiency) was formed as the quotient of Test Score and Study Time. A revised statistical model employs Efficiency as the learning output measure and removes Study Time as a covariate.

$$\text{Efficiency} = \text{TestScore} / \text{StudyTime}$$

$$\begin{aligned} \textit{Efficiency} = {} & \beta_0 \\ & + \beta_1 \text{GPA} \\ & + \beta_2 \textit{Age} \\ & + \beta_3 \textit{Attendance} \\ & + \beta_4 \textit{Male} \\ & + \beta_5 \textit{White} \\ & + \beta_6 \textit{CooperativeTreatment} \\ & + \varepsilon \end{aligned}$$

In this revised model, the relevant test statistic is the estimate of β_6, the coefficient associated with cooperative treatment. Table 4 displays the results of the efficiency analysis by test component for sections 5 and 7.

	Sign of treatment coefficient	*t statistic significance level for treatment*	*Adjusted R^2: coefficient of determination*	*F statistic significance level for statistical model*
Concepts & Software	Negative	0.575	0.269	0.005
IS Concepts	Negative	0.113	0.131	0.072
IS Software	Negative	0.815	0.322	0.001

Table 4: Individual Efficiency - Sections 5 and 7 Only

In general the results do not support an efficiency advantage for the treatment group. The treatment effects are negative, but not significant at any reasonable level.

In view of the emphasis on group project work in information technology education, project outcomes are another learning output measure of interest. The data set for this study also allows a comparison of effectiveness for project outcomes between project groups and individuals. Table 5 presents the result of an analysis of mean difference between group and individual project scores.

	Mean Project Score	*Sample Size*
Groups	84.73	15
Individuals	79.83	24
Mean Difference	4.90	
	t = 1.009	
	Significance = 0.320	

Table 5: Group Versus Individual Project Scores

These results indicate that cooperative groups did have a higher mean project score than project outcomes for individuals. However, the mean difference is not significant at any reasonable level.

Conclusion

In summary, statistical analysis of the experiment data indicates that cooperative treatment:

- had a negative impact, in some cases significantly negative, with respect to individual student learning outcomes,
- was not efficient with respect to individual student learning outcomes in relation to student time input, and
- did not have a significant positive impact on project performance when compared with individual student project performance.

One explanation for these results is that the author's implementation of cooperative techniques was very poor. The details of that implementation are not the focus of this paper. The author has over twenty five years of teaching experience with student project groups and approximately eight years of experience integrating formal cooperative learning techniques into the introductory information systems course. This integration of formal techniques could no doubt be improved. However, at what point does the effectiveness payoff occur? Is cooperative learning a robust technique with respect to individual effectiveness, or is it fragile?

Assuming that cooperative techniques were appropriately implemented, the question that arises is why was the technique unsuccessful in terms of the criteria examined. These results contrast with the successful individual effectiveness outcomes reported in the general cooperative learning literature. A brief examination of free ridership by less capable students did not offer a promising explanation. This is an area requiring further research.

The relevance of the results may also be debatable. The results did indicate a positive impact for cooperative learning on collective project work, although it lacked significance. If group project experience is specified as a dominant instructional objective, should instructors be willing to accept some negative effects on individual learning as a trade-off? The answer to this question should depend on the curriculum level at which the technique is being applied. These results suggest that instructors should reconsider the implementation of cooperative techniques in lower-division information technology classes intended to promote core competencies. It might be best to foster the development of these core competencies on an individual basis. Once these core competencies are in place, learning group skills in a cooperative context in upper-division classes would take place on a firmer foundation.

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