DOCUMENT RESUME

ED 406 189   SE 059 881

AUTHOR   Priebe, Roger
TITLE   The Effects of Cooperative Learning in a
                Second-Semester University Computer Science
                Course.
PUB DATE   21 Mar 97
NOTE   15p.; Paper presented at the Annual Meeting of the
                National Association for Research in Science Teaching
                (Chicago, IL, March 21, 1997).
PUB TYPE   Reports - Research/Technical (143) --
                Speeches/Conference Papers (150)

EDRS PRICE   MF01/PC01 Plus Postage.
DESCRIPTORS   *Academic Achievement; *Computer Science;
                *Cooperative Learning; Educational Strategies; Higher
                Education; Teaching Methods; *Thinking Skills

ABSTRACT
        This study compared the content comprehension and
logical reasoning ability in two groups of second-semester university
computer science students. The control group (n=25) received
instruction in a traditional lecture/discussion learning environment
three days a week for nine weeks. The treatment group (n=24) met in a
cooperative learning environment for the same number of hours as the
control group. Each group was given a pretest and posttest to measure
levels of content comprehension and logical reasoning ability. No
statistically significant differences were found with regard to
content comprehension or logical reasoning ability; however, the
experimental (cooperative) learning group did have a significantly
higher attendance rate. In addition, other qualitative differences
support many previous findings on cooperative learning environments.
Contains 21 references. (Author)

The Effects of Cooperative Learning in a Second-Semester University Computer Science Course

Roger Priebe

The University of Texas at Austin

priebe@cs.utexas.edu

Abstract

This study compared the content comprehension and logical reasoning ability in two groups of second-semester university computer science students. The control group (n=25) received instruction in a traditional lecture/discussion learning environment three days a week for nine weeks. The treatment group (n=24) met in a cooperative learning environment (as defined by Johnson and Johnson, 1994) for the same number of hours as the control group. Each group was given a pretest and posttest to measure levels of content comprehension and logical reasoning ability. No statistically significant differences were found with regard to content comprehension or logical reasoning ability. However, the experimental (cooperative) learning group did have a significantly higher attendance rate. In addition, other qualitative differences support many previous findings on cooperative learning environments.

Introduction

Life is a cooperative effort. Every day we all depend upon others for food,

companionship, and most of our basic needs. Even activities that seem to be competitive in nature

—such as games or sporting events— ultimately become a form of cooperation as we agree to

play by the same rules and maintain a common discourse. Gaining knowledge from our

surroundings is a never-ending process that contributes to who we are and how we contribute to

our society. Through this form of cooperation we define ourselves and are defined by others.

Although many of the world's activities are conducted cooperatively, the pedagogy used in

higher education is quite often competitive or individualistic (Johnson, Johnson, & Smith, 1991).

Teachers teach as they were taught (typically using a traditional lecture format), which makes

change in academia a slow process! Although still not the norm, strategies for cooperative

1

learning have been successfully used at the college level and are constantly challenging the current lecture-based learning paradigm (Purdom & Kromrey, 1995). This investigation examined how a cooperative learning environment affected students enrolled in a second-semester computer science class.

Statement of the Problem

Computer science is a highly complex and abstract subject matter. Many key concepts in computer science rely on students' formal reasoning skills. Toothacker (1983) found that only one-third of the entering university students were in Piaget's formal reasoning stage, another third could be classified as in the concrete operational stage, and a final third were in a transitional stage between the two.

Almstrum (1994) found that novice computer science students experienced more difficulty with concepts involving mathematical logic than more general computer science concepts. Kim (1995) concluded that propositional reasoning ability was related to course achievement in a logic class for computer science majors. Surprisingly, she also found that a logic course specifically designed to teach the logical concepts measured in the study did not improve the students' performance! One of her recommendations was to study new ways to teach introductory computer science courses, particularly the logic courses.

One interpretation Kim's (1995) findings is that the students who were her participants had not progressed far enough through Piaget's cognitive stages to understand the logic necessary for success in computer science. This theory is supported by the fact that students' skills in logic did not improve even though they were specifically being taught concepts in logic.

2

3

The attrition rates in the computer science major are quite high. Many students who struggle through the first few courses ultimately drop out of the major when the coursework becomes too complex. Much of this complexity is due to the increased amount of logic required for the courses. Could an attempt to create an atmosphere which fosters an improvement in logical reasoning skills improve the success rate for many computer science students?

Research Questions

What are the effects of cooperative learning on content comprehension, logical reasoning, and attendance in a second-semester computer science course? In particular:

- Will students in a cooperative learning environment comprehend computer science content better than students in a traditional lecture course?

- Will cooperative learning create an environment which helps students move through Piaget's cognitive stages and improve their logical thinking skills?

- Will a cooperative learning environment produce better attendance than a traditional lecture course?

Theoretical Foundations

Communication and Logic

Cooperative learning, by its very nature, causes an increased amount of communication. Most of this communication is verbal and the act of forming the words to explain a concept is very important. Vygotsky (1962) contends that the interrelationships between thought and language are a key to consciousness and therefore imperative to developmental changes. Instead of thought and language constituting two separate events, Vygotsky maintained the two are reciprocally implicated: the meaning in the thought is contained in the language and verbal

3

communication enhances the thought process. His model of how learning occurs hinges on the learner taking small steps forward while being "scaffolded" through a *zone of proximal development* (ZPD) by others. This scaffolding is typically accomplished through verbal or written communication (Vygotsky, 1978).

Although not in total agreement, Piaget and Vygotsky both viewed intellectual improvements as qualitative and not quantitative. Quality of thought and the ability to gain new knowledge is more important than sheer amount of knowledge. This quality is expressed in Piaget's stage transitions. Further, the phases in the abstract reasoning stage are defined primarily by logical reasoning (Brainerd, 1978). Ultimately, my research is based upon the theory that increased communication in the cooperative learning environment spurs a qualitative change in students' thinking skills and moves them slowly forward into a higher plane of logical ability. A cooperative learning environment should foster behaviors necessary to move students through cognitive stages and hence improve their logical thinking skills.

McKeachie (1988) concludes that three of the most important activities that can increase students' thinking skills are student discussion, explicit emphasis on problem solving using varied methods and examples, and verbalization of methods and strategies to encourage the development of metacognition. These activities are all central to a cooperative learning environment; studies have shown that cooperative learning promotes a greater use of higher-level reasoning strategies and critical thinking than competitive or individualistic learning (Gabbert, Johnson, & Johnson, 1986; Skon, Johnson, & Johnson, 1981; Slavin, 1985).

The majority of research in cooperative learning has been done at the elementary and secondary levels. Interestingly, cooperative learning has not been heavily researched at the college

level and particularly not in computer science (Johnson, et al., 1991). Mehta (1993) claims to have performed the first empirical investigation of cooperative learning in a college computer science course. Her findings were encouraging, finding a significant difference in test achievement between the control and experimental groups of students ($p \leq .01$). Other non-experimental research has been conducted in computer science using cooperative learning at the college level with generally positive results (Sabin & Sabin, 1994; Tenenberg, 1995; Yerion & Rinehart, 1995).

Experimental Design

The hypotheses in this investigation were tested by exposing the treatment group to a cooperative learning environment. The control group was given no treatment. This investigation is quasi-experimental (due to non-random sampling) and employs a pretest posttest control group design.

Population Sample

The population sample for the investigation consisted of the students enrolled in Computer Science 315 (CS 315) at a large southwestern research university during the summer term of 1996. CS 315 (the equivalent of CS2 at many universities) is a required course for computer science majors at this university. The course is typically taken as the second course in the computer science sequence. Students must have a grade of C or better in the prerequisite CS 304P (or equivalent) to enroll in CS 315.

The students in this sample all passed a first-semester course in computer science with Pascal programming (or an equivalent) and are considered representative of the population of second-semester computer science students at the university level. Several participants had previously taken CS 315 and not passed (or passed with a D, which is not sufficient for CS degree

5

credit). These students were not excluded from the study because a truly representative population would also have subjects of this type. Of the 67 students originally registered for the course, 49 completed every data-collecting instrument (25 in the morning section and 24 in the afternoon section). Therefore, the content comprehension and logical reasoning portions of the study were conducted with a final total of N=49.

Control Group

The control group consisted of the students in the morning section of the CS2 course, which met three days a week for 90 minutes of class each day and one day a week for a 90 minute discussion. The control group was conducted using the traditional lecture/discussion method. Students in the control group were responsible for doing all programming and other assignments by themselves in an individualistic mode. The control group was given six programming assignments, three quizzes, two midterm exams, and a final exam.

Treatment Group

The treatment group consisted of the students in the afternoon section of the CS2 course, which met three days a week for 90 minutes of class each day and one day a week for a 90 minute discussion. The treatment group used a cooperative learning environment for all class instruction based upon the principles of cooperative learning described in Johnson, Johnson, and Smith (1991). The treatment group's discussion section was organized in the same fashion as that of the control group. The treatment group was given similar programming assignments and the same quizzes and exams as the control group.

Students in the treatment section were assigned to two types of groups: Heterogenous *base groups* consisted of four or five students selected on the basis of demographic data collected

6

during the first class session. Base groups remained intact throughout the entire term, and were designed to provide academic and social support.

Most of the actual in-class coursework was completed in *working groups*, each of which consisted of three students. Working groups were formed prior to each of the term's three exams and dissolved after each exam. Each student was therefore assigned to a total of three working groups. To maximize the number of relationships formed, students were assigned to working groups heterogeneously with respect to base group membership and prior working group membership; no student was placed in a working group with another student from her or his base group or a previous working group. (An effort was also made to preserve heterogeneity with respect to demographic data.) Each working group completed one or two programming assignments and handed in one set of homework before each exam. All students in a given working group received identical grades on the programming assignments and homework; each student was individually responsible for his/her own test grade.

In a typical class for the experimental group, students began class by meeting in their base groups for five minutes to discuss any problems or other issues before them. Next, students broke into working groups to work on the problems covering material for the next exam. (Programming assignments were completed outside of class.) After about 20 minutes, the instructor gave a short (10-15 minute) lecture on a particularly important or difficult topic. After that, working groups reconvened and worked until the end of the class period.

Research Hypotheses

$H_0 1$: **There will be no difference between the cooperative learning and control groups in computer science concept comprehension.**

Comprehension was measured using the Burton Comprehension Instrument (BCI) (Burton, 1992). This instrument was specifically designed for measuring the comprehension of five critical topics in the CS2 course: complexity, stacks, queues, recursion, and sorting. The overall alpha reliability of the instrument is 0.76 (Burton, 1992). The BCI was administered by giving the pretest portion of the BCI during the first week of class and inserting the prescribed test items into the final exam for both groups.

$H_0$2: There will be no difference between the cooperative learning and control groups in the improvement of logical thinking skills.

The Propositional Logic Test (PLT) was used to measure the students' logical reasoning skills (Piburn, 1985). The PLT has shown reliability ranging from 0.82-0.94 on high school and college students (Enyeart, 1980; Piburn, 1989; Kim, 1995). The PLT was administered once during the first week of class and then an alternate version, the A-PLT (Kim, 1995), was given during the last week of class.

$H_0$3: There will be no difference between the treatment and control groups in attendance.

♦ A headcount was taken each day of class. Students were not graded on their attendance or participation.

Results

Content Comprehension

A test for difference on the BCI posttest between the two sections was conducted using an Analysis of Covariance (ANCOVA). Table 1 shows the raw score means on the BCI pretest and posttest. Table 2 presents the ANCOVA results using the BCI pretest as the only covariate.

8

9

Because the test for homogeneity of group regressions was not found to be significant (F=.000, p=.989) the analysis of covariance could be continued. There was no significant difference found between the lecture and cooperative learning group in the area of concept comprehension (F= 0.530, p=.471). Therefore the null hypothesis $H_0 1$ is not rejected.

Table 1: Means and Standard Deviations for the BCI Pretest and Posttest

Group	N	BCI Pretest Mean	BCI Pretest Standard Deviation	BCI Posttest Mean	BCI Posttest Standard Deviation
Lecture	25	7.44	3.54	18.36	3.49
Cooperative Learning	24	8.29	3.43	18.86	3.48

Table 2: ANCOVA Result Comparing the Cooperative Learning and Control Groups on the Burton Comprehension Instrument (BCI) (N=49)

Source of Variation	SS	df	MS	F	Significance of F (p)
Within Cells	478.83	46	10.41		
By Class	5.51	1	5.51	0.53	0.47

Logical Reasoning

A test for difference between the cooperative learning and control groups on the PLT was conducted using a Multivariate Analysis of Variance (MANOVA) for Repeated Measures. The repeated measures over time consisted of the pretest and posttest for the PLT. Table 3 shows the pretest and posttest means and standard deviations. Table 4 presents the summary results of the MANOVA. No significant difference was found between the lecture and cooperative learning groups on the improvement in logical reasoning as measured by the PLT (F=2.00, p=.164). Therefore, the null hypothesis $H_0 2$ is not rejected.

9

Table 3: Means and Standard Deviations for the PLT Pretest and Posttest

Group	N	PLT Pretest Mean	PLT Pretest Standard Deviation	PLT Posttest Mean	PLT Posttest Standard Deviation
Lecture	25	11.12	4.43	13.2	3.79
Cooperative Learning	24	13.17	3.75	14.17	2.68

Table 4: MANOVA for Repeated Measures Result Comparing the Cooperative Learning and Control Groups on the Propositional Logic Test (PLT) (N=49)

Source of Variation	SS	df	MS	F	Significance of F (p)
Residual	167.92	47	3.57		
Class by Time	7.14	1	7.14	2	0.16

Attendance

A test for difference in the attendance between the cooperative learning and control groups was conducted using an Analysis of Variance (ANOVA). Table 5 presents the summary results of the ANOVA. A significant difference was found at the alpha level of .05 between the two groups (F=5.054, p=.030). Therefore, the null hypothesis $H_0 3$ is accepted.

Table 5: ANOVA Results on the Attendance Between Classes (N=23 lectures)

Source of Variation	SS	df	MS	F	Significance of F (p)
Residual	0.37	44	0.01		
Between Classes	0.04	1	0.04	5.05	0.03

Discussion

This study compared the content comprehension and logical reasoning ability in two groups of second-semester university computer science students. The control group (n=25)

10

received instruction in a traditional lecture/discussion learning environment three days a week for nine weeks. The treatment group (n=24) met in a cooperative learning environment (as defined by Johnson and Johnson, 1994) for the same number of hours as the control group. Each group was given a pre- and posttest to measure the levels of content comprehension and logical reasoning ability.

Although no significant differences were found quantitatively, the character of the classes was certainly much different and qualitative differences were evident. The programming assignments and homework turned in by the cooperative groups was clearly neater and more complete than the individual assignments handed in by the control group. The researcher attributes these differences to an unwillingness to make everyone in the group look bad in the eyes of the instructor. In other words, *peer pressure*. This peer pressure may have also led to the significantly better attendance in the cooperative learning section of the course.

Another observed difference was the amount of after-class conversation. The students not only discussed the coursework, but engaged in a wide variety of school and personal conversation. The study of computer science at the university level is often a solitary pursuit. Students are often unprepared for the teamwork necessary in most working environments. This conversation was a very encouraging sign.

Very little direct instruction was performed in the cooperative learning group. Almost all of the course content for the exams and assignments was either peer-taught or self-taught. When given responsibility for their own learning, the students performed remarkably well. Quite often in larger universities, lower division and remedial courses are self-paced. The failure rates in these courses are typically quite high. Cooperative learning may work very well as a paradigm for such

11

courses. The extrinsic motivational factors that exist in a cooperative learning environment would very likely help many students stay on pace and complete these courses successfully.

As past research has shown, cooperative learning can be very effective. Although this research experiment is inconclusive, this investigator would strongly encourage more research in cooperative learning at the university levels.

References

Almstrum, V. L. (1994). Limitations in the understanding of mathematical logic by novice computer science students. Unpublished doctoral dissertation, The University of Texas at Austin.

Brainerd, C. (1978). Piaget's theory of intelligence. Englewood Cliffs, NJ: Prentice Hall.

Burton, D. (1992). The effect of closed laboratory activities on the comprehension of five concepts and the perception of effectiveness of the course in a second-semester computer science course. Unpublished doctoral dissertation, The University of Texas at Austin.

Enyeart, M. A. (1980). Relationships among propositional logic, analytical reasoning, and Piagetian level. Unpublished doctoral dissertation, Rutgers University.

Gabbert, B., Johnson, D. W., & Johnson, R. T. (1986). Cooperative learning, group-to-individual transfer, process gain, and the acquisition of cognitive reasoning strategies. Journal of Psychology, 120(3), 265-278.

Johnson, D. W., Johnson, R. T.,.& Smith, K. A. (1991). Active learning: Cooperation in the college classroom. Edina, MN: Interaction Book Company.

Johnson, D. W. & Johnson, R. T. (1994). Learning together and alone: Cooperative, competitive and individualistic learning. Fourth Edition. Edina, MN: Interaction Book Company.

Kim, Y. (1995). The reasoning ability and achievement of college level students enrolled in a logic class in computer science. Unpublished doctoral dissertation, The University of Texas at Austin.

McKeachie, W. (1988). Teaching thinking. Update, 2(1), 1.

Mehta, J. I. (1993). Cooperative learning in computer programming at the college level. Doctoral dissertation, The University of Illinois, Chicago.

Piburn, M. D. (1985). A test of propositional reasoning ability. In Educational Research: Then and Now. Hobart, Tasmania: Australian Association for Research in Education.

Piburn, M. D. (1989). Reliability and validity of the propositional logic test. Educational and Psychological Measurement, 49, 667-672.

Purdom, D. M. & Kromrey, J. D. (1995). Adapting cooperative learning strategies to fit college students. College Student Journal 29, March 1995.

Sabin, R. & Sabin, E. (1994). Collaborative learning in an introductory computer science course. The Papers of the 25th SIGCSE Technical Symposium on Computer Science Education, 304-308.

Skon, L., Johnson, D. W. & Johnson, R. (1981). Cooperative peer interaction versus individual competition and individualistic efforts: Effects on the acquisition of cognitive reasoning strategies. Journal of Educational Psychology, 73(1), 83-92.

13

Slavin, R. (1985). An introduction to cooperative learning research. In R. Slavin et al. (Eds.) Learning to cooperate, cooperating to learn. New York: Plenum Press.

Tenenberg, J. D. (1995). Using cooperative learning in the undergraduate computer science classroom. Journal of Computing in Small Colleges, 11(2), 38-49.

Toothacker, W. S. (1983). A critical look at introductory laboratory instruction. American Journal of Physics, 51, 516-520.

Vygotsky, L. S. (1962). Thought and language. Cambridge, MA: MIT Press.

Vygotsky, L. S. (1978). Mind in society. Cambridge, MA: Harvard University Press.

Yerion, K., & Rinehart, J. A. (1995). Guidelines for collaborative learning in computer science. ACM SIGCSE Bulletin , 27(4), 29-34.

14

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE
(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: The Effects of Cooperative Learning in a second-Semester University Computer Science Course

Author(s): Roger L. Priebe

Corporate Source:

Publication Date: 3/21/97

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following two options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all **Level 1** documents

```
PERMISSION TO REPRODUCE AND
DISSEMINATE THIS MATERIAL
HAS BEEN GRANTED BY

_____ Sample _____

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)
```

Level 1

☒ Check here
For Level 1 Release:
Permitting reproduction in microfiche (4" x 6" film) or other ERIC archival media (e.g., electronic or optical) *and* paper copy.

The sample sticker shown below will be affixed to all **Level 2** documents

```
PERMISSION TO REPRODUCE AND
DISSEMINATE THIS
MATERIAL IN OTHER THAN PAPER
COPY HAS BEEN GRANTED BY

_____ Sample _____

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)
```

Level 2

☐ Check here
For Level 2 Release:
Permitting reproduction in microfiche (4" x 6" film) or other ERIC archival media (e.g., electronic or optical), but *not* in paper copy.

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Sign here→ please

Signature:

Printed Name/Position/Title: Roger Priebe

Organization/Address: The University of Texas at Austin Science Education, SZB 340 Austin, TX 78712

Telephone: (512) 471-7354

FAX: (512) 471-8466

E-Mail Address: priebe@cs.utexas.edu

Date: 3/26/97

(over)

Share Your Ideas With Colleagues Around the World

Submit your conference papers or other documents to the world's largest education-related database, and let ERIC work for you.

The Educational Resources Information Center (ERIC) is an international resource funded by the U.S. Department of Education. The ERIC database contains over 850,000 records of conference papers, journal articles, books, reports, and non-print materials of interest to educators at all levels. Your manuscripts can be among those indexed and described in the database.

Why submit materials to ERIC?

- **Visibility.** Items included in the ERIC database are announced to educators around the world through over 2,000 organizations receiving the abstract journal, *Resources in Education (RIE)*; through access to ERIC on CD-ROM at most academic libraries and many local libraries; and through online searches of the database via the Internet or through commercial vendors.

- **Dissemination.** If a reproduction release is provided to the ERIC system, documents included in the database are reproduced on microfiche and distributed to over 900 information centers worldwide. This allows users to preview materials on microfiche readers before purchasing paper copies or originals.

- **Retrievability.** This is probably the most important service ERIC can provide to authors in education. The bibliographic descriptions developed by the ERIC system are retrievable by electronic searching of the database. Thousands of users worldwide regularly search the ERIC database to find materials specifically suitable to a particular research agenda, topic, grade level, curriculum, or educational setting. Users who find materials by searching the ERIC database have particular needs and will likely consider obtaining and using items described in the output obtained from a structured search of the database.

- **Always "In Print."** ERIC maintains a master microfiche from which copies can be made on an "on-demand" basis. This means that documents archived by the ERIC system are constantly available and never go "out of print." Persons requesting material from the original source can always be referred to ERIC, relieving the original producer of an ongoing distribution burden when the stocks of printed copies are exhausted.

So, how do I submit materials?

- Complete and submit the *Reproduction Release* form printed on the reverse side of this page. You have two options when completing this form: If you wish to allow ERIC to make microfiche and paper copies of print materials, check the box on the left side of the page and provide the signature and contact information requested. If you want ERIC to provide only microfiche or digitized copies of print materials, check the box on the right side of the page and provide the requested signature and contact information. If you are submitting non-print items or wish ERIC to only describe and announce your materials, without providing reproductions of any type, please contact ERIC/CSMEE as indicated below and request the complete reproduction release form.

- Submit the completed release form along with two copies of the conference paper or other document being submitted. There must be a separate release form for each item submitted. Mail all materials to the attention of Niqui Beckrum at the address indicated.

For further information, contact...

Niqui Beckrum
Database Coordinator
ERIC/CSMEE
1929 Kenny Road
Columbus, OH 43210-1080

1-800-276-0462
(614) 292-6717
(614) 292-0263 (Fax)
ericse@osu.edu (e-mail)