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The major hypotheses of this experiment were that students who play a computer game in teams of two or three will perform at least as well as those who play the game individually, and that teams of two or three students will be at least as successful in the game as individual students. Sixth graders of high academic ability were divided into four groups. Three of the groups played a computer game: one group played alone, one played in pairs, and one in threes. The fourth group did not play the game. All the subjects then took a test designed to measure learning from the game. No significant differences in learning were observed, but there was a statistically significant tendency for boys to play the game faster than girls. A difference in the machines used to play the game produces no consistent or significant effects. Appendices give some statements from the game and the test questions. (Author/JY)

THE JOHNS HOPKINS UNIVERSITY

REPORT NO. 51

GROUP VERSUS INDIVIDUAL PERFORMANCE AND LEARNING IN A COMPUTER GAME: AN EXPLORATORY STUDY

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SEPTEMBER 1969

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The Johns Hopkins University
Baltimore, Maryland

INTRODUCTION

Two of the most dramatic recent innovations in educational technology are computer-assisted instruction and simulation games. In CAI, the student learns by responding to stimuli presented under the control of the computer program in such a way that the student's response determines the next stimulus to be presented. In a simulation game, the student learns by adopting a role in a simulated environment and making decisions which, along with chance and the decisions of other players, determine the outcome of the game.

Computer games combine these essential characteristics of the two techniques. They differ from other simulation games largely in the complexities of the situations and the amount of arithmetic computations they permit. Like other forms of CAI and unlike most other games, they are often designed to be played by one student at a time. However, unlike the most common form of CAI - programmed instruction - the student's responses are not definitely right or wrong (although, in any game situation, some decisions may be clearly better than others).

Like other games, computer games offer the player a choice of strategies, and the best strategy is not obvious. This feature of computer games should (we reasoned) provide an advantage to the student who has the opportunity to discuss his responses with a teammate before typing them into the computer. Although the most enthusiastic supporters of CAI stress the advantages of one-to-one interaction between student and computer, we felt that in a computer game, interaction between students would prove more beneficial than one-to-one student-computer interaction. (There is, of course, an obvious economic advantage in having students play a computer game in groups, rather than individually, since the cost of computer time can be divided by the number of students using the machine at a time.)

Our hypotheses were explicitly stated as follows:

1. Students who play a computer game in teams of two or three will perform at least as well as those who play the game individually, on a test designed to measure learning from the game.

2. Teams of two or three students will be at least as successful in the game as individual students.

The reader will note that, in order for the results of the study to support both of these hypotheses, performance in the game will have to be positively correlated with performance on the test. Logically, one would expect students who learned most from the game to be able to use their knowledge to improve their performance in the game. However, two characteristics of educational games may counteract this effect. The first is that a player who employs risky strategies in a game, especially when playing it for the first time, is likely to fail spectacularly; yet, because of his more varied experiences, he is likely to learn more from the game than a player who uses more conservative strategies. The second is that players can learn to use strategies within the context of a game and still be unable to explain their strategies in words.[1] Thus, it would not be paradoxical for the results of the study to support only one of the hypotheses stated above.

Can learning activities designed for individual students working alone be made more effective by administering them to small groups? We found a number of studies which seemed relevant to this problem (although most of them came to our attention only after we had conducted our experiment). Dick (1963) and Sawaris (1966) found differences favoring group presentation; Klausmeier _et al_. (1963) and Noble (1967) found differences favoring individual presentation; and Hudgins (1960), Grubb (1964), King (1967), and Napier (1967) found no significant differences favoring either mode. The subjects for these studies ranged from fifth grade through college, and the learning tasks varied greatly in length, subject matter, and means of presentation. However, the results did not vary consistently with any of these factors.

METHODOLOGY

The subjects were 44 sixth-grade studdnts from a school in the Baltimore area. They were members of two special mathematics classes for high-ability students: a class of 22 boys and a class of 22 girls. The mean IQ (Kuhlmann-Anderson) for all 44 students was 132. (S.D. = 13.3) In addition to IQ scores, the students' scores on four measures of academic ability and achievement were obtained. All of the students were familiar with computer games, having played them at least twice before at the Center, but none had ever played this particular game.

The game used for this study was the Surfboard Game, developed by Jimmer M. Leonard, of BOCES (Board of Co-operative Educational Services, Yorktown Heights, New York). In this game, the player takes the role of the manager of a company which manufactures styrofoam surfboards. He is required to decide how many workers he will employ and how much he will charge for his product. If his accumulated profits increase to a certain level, he is also given the option of buying new machinery.[2] The routines in the game which provide for unplanned expenses occurring at random were removed for this study, since they would have introduced an uncontrolled variable. The criterion used to measure performance in the game was the average monthly increase (or decrease) in the player's net assets.

The test used to measure learning from the game consisted of three parts. The first part contained six multiple-choice items designed to measure the student's understanding of certain economic relationships which function in the game. These questions were phrased so as to require the students to make predictions similar to those that would be necessary for rational planning in the game. The second part consisted of three items designed to measure the student's grasp of certain accounting concepts which he should have used in making his decisions in the game. The third part was an open-ended question which asked the student to explain his strategy for setting prices in the game.[3]

The students were segregated by sex in their regular classes and were kept that way for the study. Within sex groups, they were assigned randomly to four treatment groups. The students in Group 3 played the game in teams of three, those in Group 2 played in teams of two and those in Group 1 played alone. All the students in these three groups took the test immediately after playing the game. The students in Group 0 did not play the game but took the test, with the open-ended question phrased as a hypothetical situation. Groups 1, 2 and 3 played the game and took the test at the Center; Group 0 took the test at school. The students were told not to discuss the game with other students, and we could find no evidence to indicate that they did discuss it.

Six students (all of the same sex) played the game at a time: one team of three, one team of two and one single student. The instructions for the game were printed and positioned at the computer terminals.[4] No additional instruction or help was given to the students. The students played the game for an hour and were allowed enough time to answer all the items on the test.

Of the three computer terminals available for this study, two were teletype machines connected to a time-sharing system and one was a console typewriter connected to the Center's IBM 1401. In order to avoid introducing a consistent bias into the study because of any difference in equipment, the machines were assigned as in Table 1.

RESULTS

Table 2 shows the mean scores, by sex and treatment group, for Parts I and II of the test. Two-way analysis of variance showed no significant main or interaction effects for sex or treatment group on either part of the test. Even the difference on Part I between Group 0 and 1 is not significant.[5]

Table 3 shows the mean scores, by sex and treatment group, for each of five antecedent measures. The verbal and quantitative scores from the Kuhlmann-Anderson Test have been converted from percentiles to T-scores to permit statistical manipulation. The achievement test scores for paragraph meaning and applied arithmetic are expressed as they were reported to us, in grade-level equivalents.

Table 4 shows the zero-order correlations, for all subjects taken together, between Parts I and II of the test and the five antecedent measures. On the basis of these correlations, we selected paragraph-meaning achievement and quantitative ability as control variables for an analysis of covariance, by treatment group, of the scores for Part I. The analysis of covariance did not yield a statistically significant treatment effect.[6]

A content analysis of the students' responses to the open-ended question (Item 10) produced the results shown in Table 5. There is no reason that a student could not have mentioned all three concepts; yet not one subject mentioned both seasonal demand and cost of production. Of course, it was possible to answer the question without mentioning any of the three concepts listed, and several subjects did so.

Table 6 contains a summary of the students' performance in the game itself, with each team (of 1, 2, or 3 students) counted as a single player. "Game score" is defined as the average monthly increase in the player's net assets. "Price range" and "employment range" are two independent measures of a player's willingness to experiment with extreme strategies. "Price range" is simply the difference between the highest and lowest prices charged by the player, and "employment range" is the difference between the highest and lowest numbers of machine operators he employed. "Rate of play" is counted in game months per hour of actual play.[7]

The results shown in Table 6 were tested for significance by means of a two-way analysis of variance for each of the four variables. Only two effects were significant. The tendency of boys to play the game faster than girls was significant at the .01 level ($F = 10.02$, df = 2 and 12). Also, the effect of interaction between sex and treatment group on "price range" was significant at the .05 level ($F = 5.40$, df = 2 and 12). However, this second result is difficult to interpret and may well not hold true for larger samples.

Intercorrelations were computed for the four game variables and Parts I and II of the test (using the mean score for each team for these last two variables). The results are shown in Table 7. The only correlation that approaches significance is that between "price range" and "employment range". A high positive correlation here could be expected, since each of these variables is an indication of the same general tendency on the part of the player.

Finally, a comparison of the students using the 1401 with those using the teletype is shown in Table 8. No significant difference between students using the different machines was found on either part of the test or on any of the four game variables.

DISCUSSION

The purpose of the study was to detect the educational advantages of group play (as contrasted with individual play) in a computer game. If these advantages exist, our study failed to find them.

There are two ways of measuring learning in a game situation. One is to observe the students' performance in the game; the other is to test them outside the game for the knowledge or skills they were to have acquired by playing the game. Our study showed no significant differences on either criterion between students who played in groups and those who played alone. What differences there were tended to favor the groups of three when game performance was the criterion and the individual players when test performance was the criterion. However, these differences were neither consistent nor statistically significant.

One result of this experiment may provide some insight into the kind of learning that takes place in a computer game. The differences in the scores for Part I of the test between Groups 1, 2, and 3, which played the game, and Group 0, which did not, are almost entirely accounted for by Item 2 of the test. This item requires the student to predict the effect on total raw material costs of a change in the number of production workers. The relationship is somewhat indirect; hiring more production workers enables a company to increase production, which requires more raw materials, which increases raw material costs. While the students who did not play the game had to try to "reason out" this relationship, those who played the game experienced it directly. The result was that none of the students who did not play the game answered this item correctly, while every student who played the game <u>alone</u> answered the item correctly. (Before conducting the experiment, we asked five or six adults to take the test. The only one who answered this item correctly was an experienced accountant.)

The boys in our sample played the game significantly faster than the girls. (The means were 17.83 game-months per hour for the boys and 14.25 for the girls.) However, we do not feel justified in generalizing this finding to other situations, since our subjects were all of high intelligence and all familiar with computer games (though not with this one). And of course, even among these same subjects the girls might have played faster than the boys if we had chosen a different computer game.

SUMMARY

Sixth-graders of high academic ability were divided into four groups. Three of the groups played a computer game: one group played alone, one played in pairs, and one in threes. The fourth group did not play the game. All the subjects then took a test designed to measure learning from the game. No significant differences in learning were observed, but there was a statistically significant tendency of boys to play the game faster than girls. A difference in machines used to play the game produced no consistent or significant effects.

TABLE 1

ASSIGNMENT OF SUBJECTS TO DIFFERENT MACHINES

	Day	Group 1	Group 2	Group 3
	1	1401	TTY	TTY
Boys	2	TTY	1401	TTY
	3	TTY	TTY	1401
	4	1401	TTY	TTY
Girls	5	TTY	1401	TTY
	6	TTY	TTY	1401

TABLE 2

TEST PERFORMANCE - MEANS

		n	Part I	Part II
Group 0	Male	4	3.25	4.22
	Female	4	3.25	4.67
Group 1	Male	3	4.17	4.33
	Female	3	4.33	4.00
Group 2	Male	6	3.67	4.50
	Female	6	3.00	2.50
Group 3	Male	9	3.89	6.25
	Female	9	3.44	3.50
Total Group 0		8	3.25	4.88
Total Group 1		6	4.50	4.17
Total Group 2		12	3.33	3.50
Total Group 3		18	3.67	4.44
All Male Subjects		22	3.77	4.68
All Female Subjects		22	3.45	3.77
Total All Subjects		44	3.61	4.23

TABLE 3

ANTECEDENT MEASURES - MEANS

		n	V	Q	IQ	PM	AA
Group 0	Male	4	60.3	61.0	137	11.6	11.9
	Female	4	54.6	55.5	129	10.1	9.8
Group 1	Male	3	50.7	60.2	132	11.4	11.3
	Female	3	61.6	52.4	130	9.9	8.8
Group 2	Male	6	55.8	57.4	134	10.6	11.4
	Female	6	56.9	54.1	130	10.6	9.8
Group 3	Male	9	52.4	59.6	131	11.2	11.0
	Female	9	58.4	54.0	131	11.0	9.6
Total Group 0		8	57.5	58.2	133	10.8	10.8
Total Group 1		6	56.1	56.3	131	10.6	10.1
Total Group 2		12	56.3	55.7	132	10.6	10.6
Total Group 3		18	55.4	56.8	131	11.1	10.3
All Male Subjects		22	54.5	59.3	133	11.1	11.3
All Female Subjects		22	57.8	54.1	130	10.6	9.6
Total All Subjects		44	56.2	56.7	132	10.9	10.4

V = Verbal Ability (Kuhlmann - Anderson Test)

Q = Quantitative Ability (Kuhlmann - Anderson Test)

IQ = IQ Score (Kuhlmann - Anderson Test)

PM = Paragraph Meaning

AA = Applied Arithmetic

TABLE 4

INTERCORRELATION OF TEST PORTIONS
AND ANTECEDENT VARIABLES (n = 44)

	I	II	V	Q	IQ	PM	AA
I	1.00	.34	.34	.27	.35	.42	.26
II		1.00	.36	.51	.51	.46	.40
V			1.00	.38	.78	.40	.35
Q				1.00	.82	.33	.63
IQ					1.00	.45	.59
PM						1.00	.46
AA							1.00

V = Verbal Ability (Kuhlmann - Anderson Test)

Q = Quantitative Ability (Kuhlmann - Anderson Test)

IQ = IQ Score (Kuhlmann - Anderson Test)

PM = Paragraph Meaning

AA = Applied Arithmetic

TABLE 5

STUDENTS' RESPONSES TO TEST ITEM 10

PROPORTION MENTIONING RELEVANT ECONOMIC CONCEPTS

	Group			
	0	1	2	3
Seasonal Demand	.000	.167	.417	.222
Cost of Production	.625	.000	.417	.278
Price - Quantity Relationship	.375	.500	.750	.389

Note: The concept of seasonal demand was not as relevant to the question answered by Group 0 as it was to the question answered by the groups that played the game.

TABLE 6

GAME PERFORMANCE - MEANS

		n	Game Score	Price Range	Employment Range	Rate of Play
Group 1	Male	3	2215	3.53	6.67	22.33
	Female	3	1581	2.17	9.00	13.67
Group 2	Male	3	1294	2.93	4.67	15.67
	Female	3	2351	1.20	2.33	13.67
Group 3	Male	3	4013	1.11	7.33	16.00
	Female	3	1214	6.25	16.33	11.33
Total Group 1		6	1898	2.85	7.83	18.00
Total Group 2		6	1822	2.05	3.50	14.67
Total Group 3		6	2613	3.68	11.83	13.67
All Male Subjects		9	2507	2.52	6.22	18.00
All Female Subjects		9	1715	3.21	9.22	12.89
Total All Subjects		18	2111	2.86	7.72	15.44

TABLE 7

INTERCORRELATIONS OF TEST PORTIONS
AND GAME VARIABLES (n = 18)

	I	II	GS	PR	ER	R/P
Test, Part I	1.00	.44	-.12	.03	-.18	.02
Test, Part II		1.00	.42	.29	.16	.20
Game Score			1.00	.16	.59	.26
Price Range				1.00	.67	.42
Employment Range					1.00	.15
Rate of Play						1.00

TABLE 8

COMPARISON OF STUDENTS USING DIFFERENT
MACHINES TO PLAY THE GAME

	IBM 1401		TELETYPE				
	Mean	S.D.	Mean	S.D.	t	df	p
Test, Part I	3.42	1.26	3.83	1.37	0.86	34	N.S.
Test, Part II*	4.08	3.28	4.08	2.45	0.00	34	N.S.
Game Score*	2668	1021	1833	2265	0.81	16	N.S.
Price Range	3.17	1.66	2.71	2.69	0.36	16	N.S.
Employment Range	11.67	3.28	5.50	2.02	1.87	16	N.S.
Rate of Play	17.83	5.93	14.25	2.83	1.63	16	N.S.

*Scores below zero are possible.

FOOTNOTES

1. For a more thorough explanation of these characteristics of games and of the ways in which games function as learning devices, see Coleman, 1967 and 1968, and McKenney and Dill, 1966.

2. Appendix A contains a sample printout for this game.

3. Appendix B contains a sample copy of this test, with the correct answers to items 1-9 indicated.

4. These instructions were as follows:

   HELLO:

   IN THE GAME YOU ARE ABOUT TO PLAY, YOU WILL ASSUME THE ROLE OF THE OWNER OF A FACTORY THAT MANUFACTURES STYROFOAM SURFBOARDS. YOU HAVE 30 WORKERS, 10 OF THEM ARE SHIPPERS, 10 OF THEM ARE PACKERS AND 10 OF THEM ARE OPERATORS.

   YOU HAVE 5 MACHINES PRODUCING SURFBOARDS, AND BY HIRING OR FIRING OPERATORS YOU CAN VARY PRODUCTION AND PRODUCTION COSTS. SINCE YOU HAD TO BORROW MONEY FROM THE BANK TO BUY THESE MACHINES, YOU HAVE TO PAY BACK THE BANK $10,000 EVERY DECEMBER.

   YOU CAN MAKE DECISIONS, SUCH AS WHETHER YOU WILL HIRE OR FIRE ANYONE, AND HOW MUCH YOU WILL CHARGE FOR THE SURF-BOARDS. WHEN THE COMPUTER WANTS YOU TO MAKE A DECISION, IT TYPES A ? LIKE THIS: ?

   THE SUMMER SEASON LASTS FROM MARCH THROUGH SEPTEMBER.

   NOW GO OUT AND MAKE A MILLION, AND GOOD LUCK.

5. By the use of Scheffe's method for <u>post hoc</u> comparisons, a difference of 1.89 would be required for significance at the .05 level.

   The internal consistency of Part I of the test, as measured by Kuder-Richardson Formula 20, is .276. This value translates by means of the Spearman-Brown Formula, into an estimated average item-intercorrelation of .057. Thus, these six items are almost unrelated.

6. F = 1.83; an F-ratio of 2.85 is required for significance at the .05 level. The adjusted means for Groups 0,1,2, and 3 were 3.23, 4.59, 3.45, and 3.57.

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APPENDIX A

Sample monthly report from the game

```
BEGINNING INVENTORY, ( 516 ) + MONTHS PRODUCTION ( 1650 ) =
 2166  SURBOARDS TO SELL THIS MONTH.

THIS MONTH'S SALES 2061 BOARDS AT $9.85  EACH
TOTAL RECEIPTS  $ 20300.9

INVENTORY REMAINING AT END OF MONTH = 105

     RAW MATERIALS    1650  BOARDS AT $4 EACH = $ 6600
     LABOR COSTS      33    WORKERS AT $200 EACH = $ 6600
     FIXED EXPENSES   $2275

     TOTAL MONTH'S EXPENSES $ 15475


PROFIT  (SALES - EXPENSES)
     LAST MONTH  :$ 5565
     THIS MONTH  :$ 4825.85

CHECKING ACCOUNT BALANCE :
     LAST MONTH  :$ 10565
     THIS MONTH  :$ 15390.8

LAST MONTH 10  OPERATORS WITH 5 MACHINES PRODUCED 1500 BOARDS
THIS MONTH 13  OPERATORS WITH 5 MACHINES PRODUCED 1650 BOARDS

DO YOU WISH TO HIRE OR FIRE ANY MACHINE OPERATORS?
TO HIRE, TYPE IN + AND THE NUMBER.
TO FIRE, TYPE IN - AND THE NUMBER.
TO LEAVE THE SAME, TYPE IN 0.
?0

LAST MONTH YOU SOLD 1984  BOARDS AT $ 10  EACH.
THIS MONTH YOU SOLD 2061  BOARDS AT $ 9.85 EACH.

HOW MUCH WILL YOU CHARGE FOR EACH SURFBOARD NEXT MONTH?
?10.25
```

APPENDIX B

Test used to measure learning from the game.

Answer all questions even if you are not sure of the answer.
Mark your answers directly on the question sheet.

1. If a bicycle manufacturing company hires more production workers, what will happen to its total labor cost?

   (✓) It will go up.
   ( ) It will go down.
   ( ) It will stay the same.
   ( ) You can't tell.

2. If the company hires more production workers, what will happen to its total raw material cost?

   (✓) It will go up.
   ( ) It will go down.
   ( ) It will stay the same.
   ( ) You can't tell.

3. If the company hires more production workers, what will happen to its fixed expenses (for example, rent, lighting, property taxes)?

   ( ) They will go up.
   ( ) They will go down.
   (✓) They will stay the same.
   ( ) You can't tell.

4. If the company raises the selling price of its bicycles, which of the following things is least likely to happen?

   (✓) The company will sell more bicycles.
   ( ) The company will sell fewer bicycles.
   ( ) The company will sell the same number of bicycles.

5. Suppose the company is selling all the bicycles it makes, and it hires more production workers. Which of the following things is least likely to happen?

   ( ) The company will sell more bicycles.
   (✓) The company will sell fewer bicycles.
   ( ) The company will sell the same number of bicycles.

6. Suppose the company is selling all the bicycles it makes. What will happen to its profits if it lowers the selling price of its bicycles.

   ( ) They will go up.
   (✓) They will go down.
   ( ) They will stay the same.
   ( ) You can't tell

7. On the following list, check only those things the company would need to know in order to find its total costs of production for one month.

( ) Number of bicycles produced during the month
( ) Number of bicycles sold during the month
( ) Selling price of each bicycle
( ) Inventory on hand at the beginning of the month
(✓) Total labor cost for the month
(✓) Total raw material cost for the month
(✓) Fixed expenses for the month

8. On the following list, check only those things the company would need to know in order to find the cost of producing each bicycle.

(✓) Number of bicycles produced during the month
( ) Number of bicycles sold during the month
( ) Selling price of each bicycle
( ) Inventory on hand at the beginning of the month
(✓) Total labor cost for the month
(✓) Total raw material cost for the month
(✓) Fixed expenses for the month

9. On the following list, check only those things the company would need to know in order to find the number of bicycles it had left at the end of the month.

(✓) Number of bicycles produced during the month
(✓) Number of bicycles sold during the month
( ) Selling price of each bicycle
(✓) Inventory on hand at the beginning of the month
( ) Total labor cost for the month
( ) Total raw material cost for the month
( ) Fixed expenses for the month

(Note: For items 7-9, the student received one point for each choice correctly checked, minus one point for each choice incorrectly checked.)

10. When you played the Surfboard Game, how did you decide how much to charge for your surfboards? How would you do it if you had another chance to play the game?

(Subjects who did not play the game answered the following alternate item.)

10. How do you think the bicycle manufacturing company ought to decide how much to charge for its bicycles?