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THE EFFECTS OF DIFFERENT TEAM SIZES ON BUSINESS GAME PERFORMANCE

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ABSTRACT

The effects of four different team sizes in a complex business game were studied. Firm size was associated with non-linear performance results and different learning outcomes, learning sources, attrition rates and decision-making behaviors. 3-member firms obtained the highest learning levels while 2-member firms experienced marginal knowledge increases. Single- member firms experienced the most bankruptcies and drop-outs.

The impact of cumulative gaming research has provided the material for a contingency view of business game effectiveness. This view recognizes that a game's outcome effects are a function of a wide variety of factors including the classroom's atmosphere, procedural matters, the material being taught, student involvement, and the administrator's teaching skills and perceived demeanor. Research has been conducted on the game's complexity, instructor involvement, prior student associations, game pacing, learning objectives, and student preparation, aptitude and cognitive structure. Missing from this contingency array is empirical and controlled research on the effects of team size on game performance, playing behavior, and student learning. The firm's size should affect the number and nature of the learning cues available per member which in turn should influence the quality of the learning cycle's participative aspect. It is apparent, given other contingency factors, that an optimal team size might exist for maximum student learning and that different team sizes may produce unique learning environments and results.

PRIOR STUDIES

Both the direct and circumstantial evidence on the learning effects of different team sizes is sparse. Instructional psychology has been strangely quiet on the subject and only circumstantial evidence can be gleaned from the decision science literature. Size- related research includes the peculiarities of odd and even-numbered groups [2], optimal interacting group sizes [3][5][7], and the internal dynamics of increasing sizes [15]. Another decision theory literature subset involves situations where group decisions are superior to individually-derived ones [1][10][13], and the risky shift phenomenon which appears to accompany group decision-making efforts [14]. Summarizing this literature, an odd-numbered group of five participants seems to strike a balance for group creativity, decisiveness and accountability without a dysfunctional number of internal administrative problems. It appears that extreme sizes sacrifice certain qualities for others although the ideal size is still a function of the group's task and time constraints and the participants' individual abilities and motivations.

The business gaming field has only recently turned its attention to team size effects and those few reported studies are uncontrolled and attitudinal or anecdotal in nature. Although not a team size or a computer- based gaming study, Hoover and Whitehead [8] found that two classes, one with less than 15 students and the other with more than 20, experienced the same learning levels from a set of experiential exercises. Remus and Jenner [12] performed an attitudinal study on single-member versus three to five member firms. Although there were no between-group controls on game complexity, course credit, and course or class levels, their findings regarding personal accountability and responsibility diffusion are justifiable. Single- member firms felt the impact of the performance rankings more strongly than did the larger firms.

Another attitudinal and uncontrolled firm size study has been recently performed by Gentry [6] in a Business Logistics course using De Hayes and Suelflow's [4] LOGSIMX. It was concluded that no correlation existed between a team's size and its performance but that group dissension increased in larger firms.

One last business game study by Newgren, Stair and Kuehn [11] compared the self-reported decision-making times of one versus three-member MBA student teams. Using a learning curve analysis, single-member firms learned their tasks faster and made their decisions more quickly. No evidence was produced regarding decision quality or relative firm profits between the two formats employed.

HYPOTHESES

The circumstantial and uncontrolled nature of the literature just surveyed allows only the most tentative and conservative statements about the effect of team size on student learning. It appears that larger size lessens each person's ability to participate or react to the learning cues emitted by the game while simultaneously increasing the number of group-emitted learning cues. Larger size also increases the team's potential profits and brainpower until a point where coordinative and administrative problems begin to lessen the positive impact of additional decision makers. The simulation's complexity enters as a task factor as it dictates the extent that logical and meaningful divisions of labor can be made and integrative efforts are required. Accordingly, a nonlinear relationship, given game complexity, should exist between team size, participation, accountability and individual learning.

The study's hypotheses examined certain operational aspects of the experiential learning process. Behavior was measured as the number of decisions made each decision round and the amount of additional industrial information purchased by each company. Personal feedback entailed each firm's relative profitability while learning was measured through performance on a before! after business policy concepts examination. The specific hypotheses are as follows:

Firm behavior:

H_1: The number of decisions made each round are positively associated with *firm* size.

H_2: The purchase of industrial information is positively associated with firm size.

Firm feedback:

H_3: An S-curve characterizes the relationship between firm size and profits.

H_4: An Inverse relationship exists between firm size

Individual learning levels:

H_5: An S-curve characterizes the relationship between firm size and an individual's learning level.

H_6: A game as a knowledge source increases with firm size.

METHODOLOGY

Four separate senior-level sections of a Business Policy course played Jensen and Cherrington's [9] relatively complex business game for 55% of the course's credit. Each course section was successively comprised of one, two, three, or four-member firms and firm assignments were made by random draw.

The simulation allowed up to fifty-six explicit decisions per round with one being a decision to purchase additional industry-wide information. Total company earnings served as the performance measure while student knowledge levels were determined through the before/after use of the Business Policy Concepts examination used by Wolfe and Guth [16]. Five questions were added to the instrument to cover certain group process and structure concepts possibly realized through multi-member group play. The "before" test was given during the first week of classes and the "after" test was part of the course's final examination. The combined scores on both tests accounted for 10% of the course's final grade to encourage high performance and to discourage "faking low" on the pretest.

Spearman rank order correlation coefficients were calculated to determined grader reliability. Grading possessed high by-question reliability with r's ranging from .641 to .999 and an overall r' = .881. A split- half test also determined that grade assignments possessed no upward or downward drift.

Each question was scored for both conceptual and factual knowledge. Conceptual knowledge was judged by the ability to translate and extend each business policy statement's conceptual content; factual knowledge was demonstrated by the appropriate use of a course-derived example or illustration. The study controlled the instructor, class meeting tine, course, textbook, lecture notes, and case assignments and each section's demographics on age, sex, discipline majors, and grade-point averages were nonsignificantly different.

RESULTS

Firm behaviors

Table l's results demonstrate that the average number of per round decisions increased until firms possessed three members and then no difference occurred between three and four-member operations. The use of averages, however, masks the fact that different growth rates and patterns were associated with team size. Over the simulation's course one and two-member teams started from similar positions but two-member firms grew at a faster but less continuous rate and single-member firms continued their growth for a longer period. Three and four-member teams started from similar but superior positions and their ascensions were equal until the third decision round where four-member firms followed an erratic descending track and three-member firms continued a more erratic climb.

A test of each decision curve's shape was made by the orthogonal comparison method after accounting for correlated observations between decision periods. A quadratic equation best represented the one and two-member trend and a quartic was appropriate for three-member firms. A relatively small subject x trial sum of squares indicated that little variability in decision curve shape existed in these firm sizes. Four-member firms exhibited a cubic form although a relatively high sum of squares indicated the existence of a large degree of decision curve variability and experimental error.

Table I also demonstrates that three-member firms purchased the greatest amount of industrial information and one-member firms purchased the least; three and four-member operations purchased an equal and intermediate amount of information.

Based on these results, H1 and H are basically supported but the progressive effects of team size took on different nonlinear growth forms within the number of decisions made and the amount of industrial information processed.

TABLE 1
AVERAGE PLAYING BEHAVIORS[a]

Playing Behavior	Team Size			
	1	2	3	4
Number of Quarterly Decisions	24.9	30.0	33.9	34.2 n.s.
Number of Special Reports Purchased	.82	1.92	3.13 p<.05	1.43 p<.05 n.s.

[a]All mean differences significant pc .01 except where otherwise noted

Firm feedback

H3 was first tested by conducting a one-way ANOVA of ranked firm earnings. The Kruskal-Wallis test rejected the null hypothesis that firm performances came from the same population H = 34.89, 3 df, pc .001. Nonparametric tests were used in Table 2 as firm earnings were not normally distributed. The Mann-Whitney U-test found that one-member firms obtained the lowest earnings, three-member firms the highest, and two and four- member operations held a statistically intermediate position.

TABLE 2
MEDIAN FIRM EARNINGS[a]
(000)

Team Size			
1	2	3	4
$ 197.3	$ 249.7	$ 362.0 p<.001	$ 307.0
p<.0001			n.s.
p<.01			

[a]Mann-Whitney U-test; all differences significant p<.05 unless otherwise noted

The results for 114 are subject to interpretation. One and two-member teams experienced relatively high bankruptcy rates resulting from large negative earnings. Given firm survival, however, two-member firms had the greatest performance variability with three and four- member teams attaining an intermediate position. Performance ranges were the greatest for one-member companies where profits ran from $-158,831 to $ 391,463 plus five bankruptcies of greater losses.

Individual learning levels

A comparison of "before" knowledge scores between team sizes determined that they were statistically equal. Given this equality, Table 3 shows that all students increased their total knowledge scores with three and four-member teams increasing them the most, and two- member teams to only a marginal degree. A breakdown of the total knowledge score into its conceptual and factual components found that three-member firms increased their conceptual knowledge the most and one and four-member firms were tied for the next highest improvement degree. Three and four-member teams improved their factual scores the most with single-member companies next in improvement. A further analysis found that the superiority of the three-member format came from its high conceptual scores while four-member results came from superior factual scores.

TABLE 3
TOTAL KNOWLEDGE SCORES[a]

Firm Size	Score[b]	
	Before[c]	After
1	1.63	2.29 ⎤
		p<.002
2	1.70	2.03 ⎦ — p .01 —
3	1.70	2.74 ⎤ p <.005
4	1.74	2.59 ⎦

[a]Mean scores shown for presentational clarity

[b]Mann-Whitney U-test conducted for significant differences; all differences significant p<.0001 unless otherwise noted

[c]All between-group differences non-significant

Three factual knowledge sources were provided in the course-- the game, cases, and lectures. Table 4 shows that the game was used twice as often as a source of factual information on the business policy examination. A chi-square test, however, found that source usage differed between team size with two-member firms using the game the least and one-member firms using cases and lectures to an equally high degree. Three-member companies used the game the most often to an almost complete exclusion of the lectures as a factual knowledge source.

DISCUSSION AND SUMMARY

This study's results indicate that team size is an important factor in determining the impact and teaching

TABLE 4
SOURCES OF FACTUAL KNOWLEDGE

Firm	Proportions[a]			Citations
	Cases	Game	Lectures	
1	25.32%	46.84%	27.85%	2.63
2	18.75	40.63	40.63	1.23
3	19.05	71.43	9.52	3.65
4	26.09	60.87	13.04	4.11
Mean	22.30%	54.94%	22.76%	2.91

[a]Chi-square = 25.048, p<001, df=6

effectiveness of a business game experience. Accordingly, the decision unit's size should become an additional contingency factor along with game complexity and student scholastic aptitude, grade achievement, and cognitive structure. The differential quantitative and qualitative effects associated with team size also suggests a more selective use of the same game to accomplish a variety of teaching objectives. If an instructor wished to place an equal emphasis on all a course's knowledge sources a small team size should be used; if the desire was to teach the practical use of management information systems, students should be placed on three-member teams; and if the instructor wanted students to experience the euphoria that only high profits can induce, students should again be placed on three-member firms.

Given the richness of the simulation's basic complexity, a game will produce different results due to team size effects. The effects could be a source of the many conflicting findings regarding gaming effectiveness. Instructors should rigorously experiment with the games they are using to Insure that they are producing the results they truly desire.

In summary, three-member firms performed the best on the knowledge examination, obtained the highest earnings, and bought the most additional industrial information. One and two-member firms experienced a relatively higher number of bankruptcies while two-member firms increased their knowledge the least. All formats increased knowledge but to differing degrees and along different decision-behavior paths.

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