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# RESEARCH ON PREDICTING PERFORMANCE IN THE SIMULATION

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## ABSTRACT

This paper reviews research on the degree to which simulation performance is predicted by academic ability, academic major, personality, motivation, team cohesion and organizational formality. It suggests that performance varies with combinations of independent variables and that the relationship between some independent variables and performance is conditional.

## INTRODUCTION

The purpose of this paper is to review the literature regarding the prediction of performance in the simulation. It emerges from the 1986 ABSEL research symposium 1561 and seeks to be both part of and a basis for a coordinated effort among researchers interested in the prediction of business simulation performance. It presumes that a number of factors affect simulation performance and that at least to some extent, different factors affect performance to different degrees in different situations. For example, academic background may affect performance substantially when the game is played by individuals but less so when the game is played in teams. It should be noted that performance in this paper is defined in terms of results from the simulation itself, such as return on equity, net income and/or sales. This paper does not report studies whose outcomes are indirect outcomes of simulation play, such as learning or course grades. It should also be noted that this paper deals predominately with general integrative business simulations such as the Tempomatic or the Executive game. Very few articles using non business or specific function simulations are included for this review

The remainder of this paper will be divided into three sections. In the first, a review of the literature organized around predictors will be presented. The focus will be on six general variables that emerge as predictors from the literature, namely academic ability, personality, interests and background, motivation, cohesion, and organizational formality. These variables are not in control of the researcher. Such variables that are under researcher control, such as information provided to players, team size and reward system, will not be covered in this review. In the second section hypothesis will be offered as to how combinations of variables predict performance and how and why the relationship of some variables to performance is conditional. The final section will discuss research methodology. Both of the last two sections will contain suggestions for future research.

## A REVIEW OF LITERATURE OF FACTORS LIKELY TO AFFECT SIMULATION PERFORMANCE

### Academic Ability

Since the computerized game is an academic exercise usually occurring in academic environments, it would be expected that performance in it would be affected by academic ability. Academic ability is usually measured by previous grade point average (CPA) and has been hypothesized to predict all kinds of performance in both educational and work settings [1; 8; 27; 39]. College CPA has been found to predict success in graduate school [ 52] on a land survey project [48] in overall careers [25].

In the simulation, Cray [18] and Vance and Cray [50] found significant correlations between Business school CPA and game performance but Vance and Cray [50] failed to find significant correlations between performance on one hand and SAT scores and university CPA on the other. Gosenpud and Miessing [15] found a significant correlation between university CPA and simulation performance and Wolfe [55] found that eight academic variables correlated positively and significantly with performance, including university, business college, quantitative and academic major CPAs and English, mathematics, social sciences and comprehensive ACT scores. McKenney and Dill [33] also found a positive relationship between academic ability and performance. For these researchers, academic ability was obtained by combining university CPA, first year graduate school grades and an up to date test score (the ATCSB) into above-average, average, and below average scores. McKenney and Dill [33] found that above-average teams made the highest profits and the below average teams made the lowest, but their results were not statistically significant.

On the other hand, many studies show no relationship between academic ability and game performance. Norris and Niehbor [39], Gosenpud, Milton, and Larson [17] and Hornaday and Wheatley [20] all performed studies in which game performance measures were correlated with previous university CPAs of each player, and in each study the correlations were not significantly different from zero. Wolfe and Box [56] found no relationship between the average CPAs of simulation teams and their resulting performance, and in a study involving a non business game and seventh graders, Seginer [44] found no relationship between two indices of previous academic ability (arithmetic and language scores) and game performance.

### Personality

Since unique individuals with diverse personality traits play the simulation with diverse results, it is possible that variances in specified personality traits are associated with variances in performance. In other words, it is possible that some kinds of people do better in the simulation than others.

The personality trait most often hypothesized to affect performance has been self-esteem. Bandura [2] and Shaw, Edson and Bell [45] hypothesize a strong relationship between esteem and performance in general, and Vance and Cray [50] and Gosenpud and Miessing [15] have hypothesized that confidence would affect performance in the business simulation. Esteem has been found to affect performance for high school students [45], for college students in the laboratory [29] and for employees in the workplace [24; 47].

Only three studies have explored the relationship between esteem as an independent variable and performance in simulation situations. Gosenpud and Miessing [15] found no relationship between a self report index of confidence and performance in a business simulation and Seginer [44] found that esteem did not help explain game ability in a non business game. On the other hand,

Vance and Cray [50] found a positive correlation between a measure of self assurance and game performance for both students and businessmen.

Hornaday and Wheatley [20] studied the impact of another personality trait-that of marginality-in performance. Marginality was defined as the orientation of an individual towards reference groups. Marginal individuals bridge gaps and mediate groups whereas non marginal individuals identify with one group and defend it against others. The authors classified individuals as marginal, indeterminant and non marginal and found for two person teams, that groups with at least one marginal individual out performed teams with at least one non marginal individual.

Interests and Background

Many authors including Child [10] and Williams [53] contend that performance in a given endeavor varies with a person's pertinent interests and experiences, that in a given task people with appropriate interests will out perform those without such interests. Fisher [12] and Berdie [4] have undertaken studies supporting this contention in the classroom and Child [10] has done the same in the workplace. In addition, University of Illinois data [49] comparing salary levels five years after graduation across majors also supports the contention that students with some backgrounds and interests perform better than others.

Applied to the simulation, this contention suggests hypotheses about the impact of a student's academic major. More specifically, since the simulation entails an understanding and manipulation of financial statements and equations, it can be hypothesized that those with financial or quantitive backgrounds will out perform those without them. The evidence from the simulation literature for this hypothesis is mixed. Hornaday and Wheatley [20] found that teams with at least one accounting major out performed teams without one. Gosenpud and Miessing [15] found that the accounting majors scored significantly higher in the simulation than management, marketing, and general business majors. Niehbor and Norris [38] found the quantitative majors out performed non quantitative majors. On the other hand, Wolfe [55J found that all academic majors fared equally in a simulation, Gosenpud, Milton and Larson [17] found no relationship between four indices of financial background and simulation performance, and Vance and Gray [50] found no relationship between previous performance in quantitative courses and simulation performance.

Motivation

Most would agree with the common sense notion that those who try harder do better [1; 8; 19; 42], and this effort performance hypothesis has been confirmed in industrial settings [23; 26; 30; 32].

For some reason, however, this effort performance relationship has not been studied extensively by simulation scholars. Vance and Gray [50] found significant positive correlations between simulation performance and initiative for both businessmen and students. Gosenpud and Miessing [15] found a correlation of .44 ($p<.001$) between desire to play the game and performance. Gosenpud, Milton and Larson [17] found positive significant relationships between end of game simulation performance and attendance at team meetings early in the game and expressed interest in playing the game a month before the game ended. On the other hand, Wolfe and Box [56] found a negative relationship between performance and effort as measured by reported amount of time worked on the game as a group.

Cohesiveness

Many authors have hypothesized a positive relationship between group cohesiveness and team performance in work settings including Cartwright [9], Gladstein [14], Bass [3], Seashore [43], and Pearce and David [41]. The relationship between performance and cohesion has also been studied extensively and there is evidence revealing positive relationships between cohesion and performance in the laboratory [14; 36] and in the workplace [3; 40].

Regarding research on the simulation, perhaps more studies have focused on the relationship of cohesion to performance than any other predictor variable. In studies where cohesion was defined by how groups were selected before the game began [11; 21; 39] no difference was found between the performance of cohesive and non cohesive groups. In studies where cohesion was defined in other terms, results are mixed. Norris and Niehbor [39] found a .52 correlation ($p<.05$) between performance and cohesion as measured by a version of a previously researched scale [43]. Gosenpud, Milton and Larson [17] found a correlation of .26 ($p<.05$) between performance and self reports of cohesion. Miessing and Preble [35] found that cohesion, as measured by likert scale, differentiated performance among six teams, and Miessing [34] found that among five teams the one with the highest ROI was the most cohesive as measured by student observers and the one with the lowest ROI was the least cohesive. Finally, Wolfe [54] found, using a critical incident technique, that successful simulation players were described as open and trusting of teammates and committed to the team's success. On the other hand Brand [6] and Gosenpud, Miessing and Milton [16] found no relationship between self report measures of cohesion and performance, and Wolfe and Box [56] found no relationship between simulation performance and cohesion as measured by the degree to which participants would reconstruct their group with its present personnel.

Formality

Most organizational theorists [7; 10; 13; 28; 57] hypothesize a contingent relationship between organizational formality and performance. A more formal structure is said to be more effective when the task or environment is simple or predictable and a less formalized structure is supposed to be more effective when the task or environment Is complex, unpredictable or uncertain. There is evidence to support this hypothesis [7; 10; 57] but there is also evidence to indicate that formality influences performance positively regardless of task conditions [36; 37].

The simulation evidence is relatively scanty. Wolfe [54] found that behavior facilitating formalization was associated with good performance. Gosenpud, Miessing and Milton [16] found a correlation $r = .25$ ($p<.001$) between a self report measure of formal planning and performance, and Miessing [34] found that among five teams the one with the highest ROI was the most organized, as measured by student observers, and the one with the lowest ROI was the least organized. On the other hand, Hutte [22] observed that among 12 teams there seemed to be an inverse relationship between performance and degree of centrality of decision making.

## MULTIPLE AND CONDITIONAL PREDICTION HYPOTHESES

The above review fails to yield consistant conclusions. The review concentrated on six predictors. None emerged as consistently predictive of performance, and none appear to be uniformly unrelated to performance. The reasons for the lack of consistency lie first in the

fact that few studies have been undertaken. It is impossible to legitimately draw conclusions when only five or six methodologically diverse studies have focused on the relationship between performance and a given predictor. Second, many of the above studies are also methodologically imperfect and these imperfections may obscure relationships among variables.

A third reason may lie in the fact that many of the above studies have explored the influence of one or a very few antecedent factors on performance when in reality the influences on performance are more complex. As Boswell has stated about the performance in the workplace in The Rise and Fall of Small Firms [10], vast number of influences on performance are at work. Some are quantifiable and some are not, some are external, some are managerial and subtly interwoven." In addition, performance is not simply an independent variable. "The performance levels achieved by an organization constitute a vital input to stimulate them to make adjustments in policies and modes of operations" (p. 209).

The notion that performance is influenced by a number of factors operating in combination is not new. Blum- berg and Pringle [5] and Locke, Fredrick, Lee and Bobko [29] and Seginer [44] propose that multiple factors operating jointly affect performance in organizations. Atkinson and Raynor [1] are among the organizational theorists who suggest that performance is caused by two major factors acting in combination --ability and effort, and Porter and Lawler [42], Green, Everet and Ebert [19], and Campbell and Prichard [8] believe that ability and effort in combination with one or a few other variables are major influences on performance.

Studies examining the impact of a number of variables on performance in business and educational organizations have been undertaken. Mahoney and Weitzel [31] used 24 items, including democratic supervision, planning, and staffing flexibility to attempt to predict performance in organizations, and Mott [36] researched the relationship between performance, the structure of the task and twenty independent variables including formal coordination, clarity of objectives and managerial awareness. Finally Latham and Steel [26] studied the combined effects of participative decision making and goal setting on performance in the laboratory. In educational organizations, Walberg and Weinstein [51] studied the effects of socio-economic status, home environment, time studying and T.V. viewing on high school achievement.

A few recent simulation studies have also attempted to study how multiple factors act jointly to influence hypothesize that the greater the group's cohesion, the greater the productivity of the group if group attitudes are supportive of the organization's goals. Conversely, productivity is lower if the group resists the organization's goals. Only one study has tested this hypothesis in a simulation. Wolfe and Box [561 hypothesized that high cohesion leads to high performance when moderated by heterogeneous skills and positive attitudes as exhibited by high academic achievement, but the hypothesis was not confirmed in their study.

A fourth reason why we have not yet found variables that consistently predict performance is that situational conditions may affect how given independent variables influence simulation performance. Niehbor and Norris [38] found that the favorableness of the game in terms of market potential and possible rates of return may be one such condition. They studied the influence of quantitative training of participants on game performance and found that it affected performance only under very favorable conditions but not under moderately favorable or unfavorable conditions. Another condition may be whether or not the game is played in teams. It is possible that GPA is more likely to be predictive of performance when simulation players play as individuals but less likely when the games are played in teams. It is possible that the condition of participating in teams could counteract the influence of individual academic ability. Still another confounding variable is the simulation played in a given study. Some simulations may be designed so that finance or accounting majors perform better, while others may have factors which help other majors perform better. Other potential confounding variables include team size, type of course, level of participant (undergraduate vs. graduate vs. executive) and how performance is measured. Further research reviews should attempt and research studies should be undertaken to verify the influence of some of the above variables.

## METHODOLOGICAL ISSUES

### Value of Performance

One issue that could be raised by a critic of simulation research is that the simulation is merely a game, that doing well is unimportant to participants and that predicting performance in it is therefore meaningless. The contention here is that the simulation has value to its participants partially because performance in it counts in a graded course and partially because most students simply value performing well in it. Almost invariably in the studies reviewed above, the game was played in its natural setting either as a real and ongoing part

Affective variables, such as cohesion or motivation can be affected by success as well as affect it [10; 46].

One solution to this problem is to measure the influencing variable well before performance is measured. This has been done by Gosenpud and Miessing and Milton [16], Gosenpud, Milton and Larson [17], and Miessing and Preble [35]. In these studies statistically significant relationships between cohesion and performance have not been found. However, if and when significant relationships between variables do appear and the influencing variable is measured well before performance, it will be clear that the statistic is measuring the influencing variable's impact on performance and not vice versa.

Measurement of Variables

The majority of studies discussed above have used one time, self report, attitudinal questionnaire items to measure such variables as motivation, cohesion and organization. Validity and reliability studies of these measures have not been undertaken, and without reliable valid measures of antecedent variables, the true nature of the relationships between performance and these antecedents will remain illusive. Researchers in this field must find improved ways to measure antecedent variables, and the literature contains some hints as to how to proceed. Miessing and Preble [351 and Norris and Niehbor [39] have used scales to measure cohesion instead of single or aggregates of items, and Norris and Niehbor [391 reported reliability scores. Meissing [341 had observers record cohesion and organization related behaviors of teams, and the behaviors reported were relatively concrete (e.g., ideas were shared and the leader served as a coordinator). However, the behaviors reported were unique to each group so groups were not easily comparable, and the methods used to observe these groups were not reported in the study. Gosenpud, Milton and Larson [171 and Wolfe and Box 56] used unobtrusive indices to measure motivation (attendance at simulation meetings for Gosenpud, et. al. and hours worked on the simulation for Wolfe and Box), but in both studies, instead of actually observing behaviors or asking participants to record their behavior at the time, students were simply asked questions about their behavior after the fact.

It is to our advantage to find economic observational techniques, unobtrusive measures or questionnaire scales which are reliable and valid. It is possible that the industrial literature contains such measures. If not, it is not beyond simulation researchers' ability to create them.

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