

# Experiential Learning Enters the Eighties, Volume 7, 1980

## THE RELATIONSHIP BETWEEN GROUP SIZE AND THE LEARNING CURVE EFFECT IN A GAMING ENVIRONMENT

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### ABSTRACT

Using a simulation game in an MBA Policy class, the time dimension of the decision-making process was compared between groups of one and three members. The smaller groups, or individuals, were found to be more efficient as measured by the learning curve developed from their time/decision during the game.

### INTRODUCTION

The use of computer simulation games in the Business Policy course is pervasive. However, the effects and effectiveness of games are still an empirical problem. Generally, the literature presents two kinds of results from the use of such games. First, there are results which confirm or deny the game as a method for improving learning in the policy course. Secondly, there are results which identify individual and group process variables associated with the use of the game.

The former results reflect a continuing controversy over the game's effect upon learning due to a lack of conclusive research. For instance, Raia [4] found that the game enhanced learning and heightened students interest in the policy course. Conversely, Rowland and Gardner [7] found no relationship between game performance and the final course grade. Finally, Wolfe [8] found that while neither the game nor the case method produced superior results alone, they did produce superior learning outcomes when combined.

The group process results indicate a growing use of games in a laboratory setting. Thus, Wolfe [9] reports that effective policy teams employed a flexible and wide range of responses to the problems presented. While content variables (rigorous analysis) were of minor importance to the successful firm, the decision making atmosphere was found to be the key. Lucas [3] reports that game players were unable to forecast the next play using subjective probability distributions. Finally, Remus [5] and later Remus and Jenner [6] report that while students put a lot of time and effort into the game, there was no significant correlation between self-reported time and effort and final rankings (in the game) -

It is significant that while each study contributed to either context or process knowledge of gaming, only Remus and Jenner addressed the time dimension of decision making. Furthermore, researchers have apparently assumed a group setting, i.e. intragroup interaction, enhanced the learning process in a gaming situation. The experiment reported here examined the group assumption in combination with the time dimension of the decision process in a gaming environment.

### USING LEARNING CURVE THEORY IN THE DECISION MAKING PROCESS

When a given task or decision making process is repeated a number of times, it usually takes less time to complete the task or to make the appropriate decision. Such behavior is called the learning curve effect. This concept has been

successfully applied to a number of industries and situations to more accurately predict the time that it will take to complete any given task and the total time that it will take to complete the entire task. Airline companies in particular have used the learning curve concept to more accurately predict the time and cost of producing a given number of airplanes.

The purpose of learning curve theory is to accurately predict the time it takes to complete any single task and the total time that it takes to complete all of the tasks or activities. The two fundamental properties of systems that display the learning curve effect are:

1. As the number of completed tasks increases, the time that it takes to complete a task decreases.
2. As the number of completed tasks increases, the time savings from one task to another decreases.

The above two properties imply that while there is a time savings for each additional task, the amount of the time savings decreases. Experience has shown that there is a point in time, when additional time savings in completing a task are not possible. This situation occurs when the individual performing the task has learned as much as he or she can.

When plotting the time it takes to complete a task versus the number of tasks completed, a nonlinear curve is normally observed. This curve decreases rapidly at first and then flattens out as the number of tasks increases. The mathematical equation that describes this relationship is given below (1). See Equation 1:

where

$$y_x = cx^n \quad (1)$$

X = the number of the task  
C = time required to complete the first task  
n =  $\log 1/\log 2$   
l = learning curve factor

When applied to decision making, X represents the decision number. X is equal to 1 for the first decision, it is equal to 2 for the second decision, it is equal to 3 for the third decision, and so on. C is the time that it takes to make the first decision, and l is the learning curve factor for decision making. The learning curve factor gives a general level of how fast an individual or a group is able to learn a given task. In this case, the task is making the same types of decisions. Multiplying l by the time it takes to make the first decision, C, gives the approximate time that it should take to make the second decision. For example, if the learning curve factor is .6, and it takes 100 minutes to make the first decision, it should take approximately 60 minutes to make the second decision. Thus, a lower learning curve factor means faster learning and less time to make the second and all subsequent decisions. While to the authors' knowledge there has been a lack of research into learning curve factors for decision making in a gaming environment, there have been other studies which have attempted to determine this factor for other situations. Some airplane manufacturers have used a learning curve factor of between

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.6 and .8 in estimating the time it takes to produce airplanes.

There are a number of approaches that can be used in solving for the learning curve factor. Special log paper can be used, learning curve tables can be used, or equation (1) can be manipulated into a linear equation and then regression can be used to determine the learning curve factor. The most accurate method is to manipulate Equation (1) into a linear equation and to use linear regression to determine the learning curve factor.

### THE GAMING ENVIRONMENT

Data were collected during an MBA Business Policy course utilizing the ENSIM\* (Environmental Simulation) game. ENSIM is a management simulation game with environmental constraints. The game was originally developed by Carl Gooding [2] of Clemson University and later modified by Dan Voich of Florida State University.

In brief, the company being managed is a two-product manufacturing firm for which a total of 27 decisions must be made each month, or run. Fundamental decisions (price, dealer's margin, marketing expenditures, R&D expenditures, production volume, and raw materials) must be completed for both products as well as financial decisions (bank loans, stock, bonds, notes, dividends, etc.) for the company as a whole. Productivity is also affected by expenditures on labor relations and management training and development as well as the real threat of being fired and/or shutdown for excessive air or water pollution.

Experience has suggested that in a graduate policy course three or four students appears to be the optimal group size for both effective and efficient behavior. To examine this belief, and because some students indicated a desire to 'go it alone,' two group sizes were established. First, three students preferring to play the game alone were identified and thus provided three groups of 1. The remaining 21 students then self-selected themselves into groups of "3." The resulting ten-firm industry consisted of 3 firms of 1 member each and 7 firms with 3 members each.

### THE STUDY

The overall purpose of the study was to investigate and test the following two propositions:

- Proposition 1: Both individual and group teams display the learning curve effect.
- Proposition 2: The learning for the group teams is greater than the learning for the individual teams.

Using the graphical procedures, this study investigated whether or not individual and group teams displayed the learning curve effect. This means that both individual and group teams would take less time for each subsequent decision, but the time savings would decrease as the number of decisions increased.

The second proposition was investigated using both graphical and linear regression procedures. Greater learning can be seen graphically by a steeper curve when the decision time is plotted against the decision number. This result can also be substantiated using linear regression. The learning curve factor will be less if greater learning is achieved.

### The Results

The two propositions can be investigated by analyzing the

graph of decision time versus the decision number (See Figure 1)

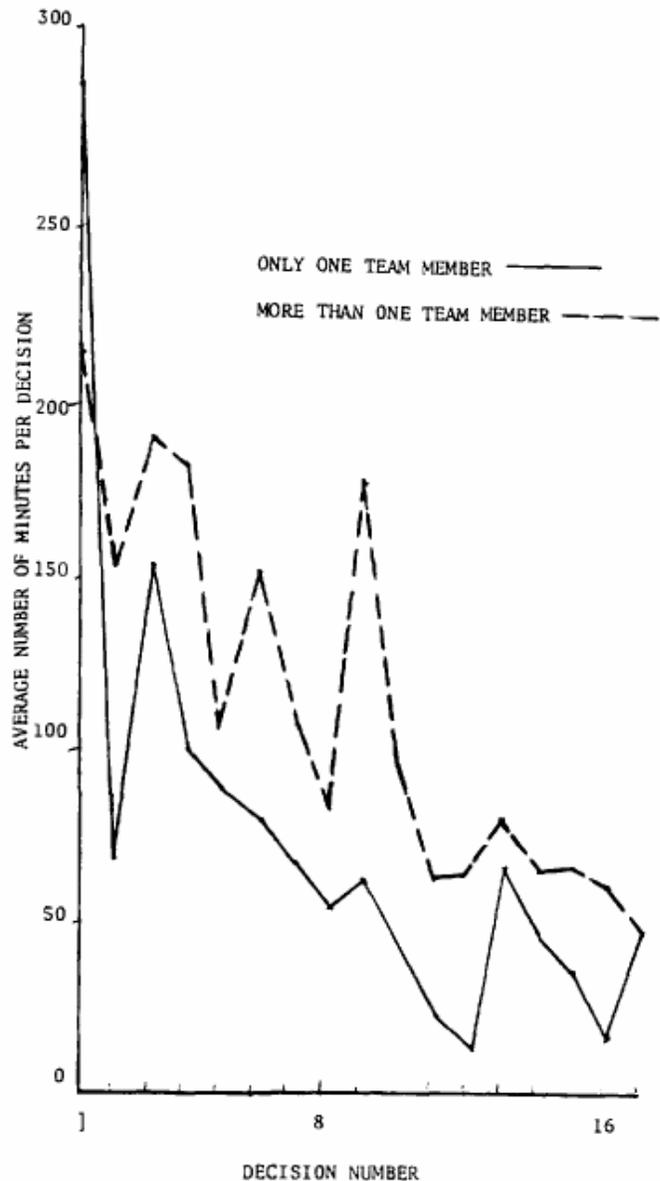


Figure 1; Comparative Group Decision Times

While there is some variability, it can be seen in Figure 1 that both the individuals and the groups playing the game displayed a learning curve effect. For both individuals and groups, the time it took to make subsequent decisions decreased at a decreasing rate. This result supports the first proposition. On the other hand, graphical analysis does not support the second proposition. Looking at the steepness of both curves, it is apparent that the individuals displayed greater and faster learning than the groups. This is also supported by the fact that the average of the individual decision times displayed both the highest decision time of about 290 minutes in decision 1 and the lowest decision time of about 15 minutes in decision 12.

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In addition to graphical analysis, this study performed linear regression on Equation (1) after manipulating it into a linear form with regards to the learning curve factor, 1. The learning curve factor for the groups was .743, and the learning curve factor for the individuals was .609. These values are consistent with the graphical analysis, and they appear to be consistent with the learning curve factor for other situations.

### Implications for Future Research

While both individual and group teams displayed the learning curve effect, both teams had a substantial amount of variability in decision times over the game. Both individual and group teams had saw-tooth shaped curves of decision time versus decision number. With the dynamic nature of the game, this variability is to be expected. For any given decision, the variability for both groups was usually in the same direction. When the group teams required more time than expected for a decision, the individual teams also required more time than expected for the same decision. Because there were no external constraints placed on the game that could have caused this variation pattern, it might be possible that there are critical points during a game requiring more time by all players than expected. This interesting result justifies further investigation.

The overall purpose of this study was to investigate the learning curve effect in a gaining environment and to test two specific propositions. This study has also raised additional questions for future study and research. Why did the individual teams learn faster than the group teams? Is there an explanation for the variation in the decision times? Why is the variation in the same direction for both groups for a given decision? How is the time for any decision allocated to various areas, such as marketing, production, finance, labor, etc.? Does the allocation of time to various areas during the decision making process impact on the total time it takes to make the decision and on the game outcome?

One of the most valuable resources for any manager is his or her time. Because of its dynamic nature, a gaming environment is an excellent research tool for investigating the learning curve effect and the effective use of time in general.

### REFERENCES

- [1] Chase and Aquilano, Production and Operations Management (Homewood~ Richard D. Irwin, Inc., 1973)
- [2] Gooding, C., Decision Making Under Environmental Constraints: A Management Simulation Game (unpublished Ph.D. dissertation, University of Georgia, 1976).
- [3] Lucas, H. C., "Performance In A Complex Management Game," Simulation and Games, Vol. 10, No. 1, 1979, pp. 61-74.
- [4] Raia, A. P., "A Study of the Educational Value of Management Games," Journal of Business, Vol. 39, No. 3, 1966, pp. 339-352.
- [5] Remus, W., "Who Likes Business Games?" Simulation and Games, Vol. 8, No. 4, 1977, pp. 469-480.
- [6] Remus, W. and S. Jenner, "Playing Business Games," Simulation and Games, Vol. 10, No. 1, 1979, pp. 75-86.

- [7] Rowland, K. and D. Gardner, "The Uses of Business Games in Education and Laboratory Research," Decision Sciences, Vol. 4, No. 2, 1973, pp. 268-283.
- [8] Wolfe, J., "The Effects and Effectiveness of Simulations in Business Policy Teaching Applications," Academy of Management Review, Vol. 1, No. 2, 1976, pp. 47-56.
- [9] Wolfe, J., "Effective Performance Behavior in a Simulated Policy and Decision-Making Environment," Management Science, Vol. 21, No. a, 1975, pp. 872-882.