Design and Effectiveness of a Self-Study Pedagogical approach to using a Simulation Game in the Classroom

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ABSTRACT

An innovative pedagogy is presented in which a simulation is designed and used as a self-study where students "learn by doing" on their own and at their own pace without direct instructor involvement. The learning effectiveness of the simulation self-study approach is tested in an economics course with respect to how it impacts student performance. It was found that the self-study, as a supplemental tool, had a significant and positive impact on student exams and the course grades.

INTRODUCTION

There has been an ongoing debate, since the early 1970s on the pedagogical effectiveness of simulations. A study by Gold (2015) presented a case arguing that the stream of research on the pedagogical effectiveness of simulations *should change focus*. The relevant question that needs to be addressed is not whether simulations are effective learning tools; enough studies have supported this hypothesis as evidenced by a comprehensive literature review on the subject by Wellington, Hutchinson, and Faria (2010). What we need to explore in further detail is the question: *What are the most effective ways to use or integrate a simulation in a classroom?* As highlighted by Goosen (2002), the degree of learning is highly dependent on the way in which a simulation is administered and integrated into the class by the instructor. Although research has been done on simulation pedagogy, advancements in computer technology with respect to accessibility, speed, and cost-reductions have opened up new possibilities for creative alternative teaching methods with respect to simulation use and, as a consequence, further inquiry in this area is warranted.

The primary purpose of this paper is to introduce an innovative "self-study" approach for integrating a simulation into a classroom that takes advantage of some of the latest technologies and then testing the learning effectiveness of this approach. The paper proceeds by: (a) explaining the design of the simulation self-study method used in this study; (b) testing the learning effectiveness of the simulation self-study; and (c) assessing the results of the tests.

DESIGN OF THE SIMULATION SELF STUDY

The basic idea of the simulation self-study is to allow students to play simulation games on their own with structured assignments that integrate exercises with the simulation that link to the theories being taught in the class. The students complete the games and exercises on their own and at their own pace, but subject to the time constraints established by the instructor. The number of assigned games and exercises would depend on the courses objectives established by the instructor.

The simulation self-study pedagogy explored in this paper is designed and developed for a course in economics at either the foundation or advanced (intermediate) levels using a web-based game called "Beat the Market Online: A Microeconomic Game" which may be accessed at http://www.goldsimulations.com. The major difference in the self-study between the two levels is the complexity of the simulation games used with respect to such factors as: the number of firm decisions, the number of firms competing in the marketplace, whether the economy is stable or changing, and if there are random events occurring.

Leaderboard

To motivate students to do well in the self-study simulation games and recognize their performance, there is an online leaderboard that broadcasts their accomplishments. Entry onto the **online *Leaderboard*** is reserved for the TOP 10% of all players, both nationally and internationally, not only in one course. The real-time leaderboard activity may be viewed by both players and non-players at http://www.goldsimulations.com/leaderboard. Players may elect to use anonymous or alias names.

Self Study Game Story and Learning Progression

Students begin their self-study journey by managing a **monopoly** firm with no direct rivals in a stable economy. The firm is producing a perishable product and is alerted to be careful not to overproduce. Students may repeat games until they succeed, and once they do the challenge increases! The monopoly market will change to an **oligopoly**, and the number of rival firms in the market will increase to 9. Although there are some rivals in this market, each firm will have a significant market share and the ability to differentiate their product and build brand loyalty. But players are warned not to drop their guard because their rivals are also large and powerful, and if aggressive can have a substantial impact on their sales, which was not the case in the monopoly market. After players have proven their ability to succeed in the oligopoly, the challenge (and fun) continues to increase! Now they have the *privilege* of showing their worth (economic skills) by managing a firm in a highly competitive market (called **Monopolistic Competition**) starting with 25 rival firms! And to further add to the challenge, new firms may also enter this market and compete. In this case, the players will need to figure out how to keep the customers they have or attract more customers when the numbers of rival firms increase. In this environment the players are cautioned that they will need to carefully determine the right price to succeed owing to the rising number of competitors. Once they have succeeded in this market the simulation is over; but students may elect to replay (*because learning is the key purpose*).

Learning Activities

Learning is further enhanced by uniquely combining *simulation games* with *topic-specific simulation exercises*. The topic-specific simulation exercises are very different than simulation games. In simulation games students manage a firm *applying economic concepts* to maximize profits whereas in the topic-specific simulation exercises they learn by observing what is happening in a set of pre-set example simulation games and then are asked a series of multiple choice questions or problems to test and reinforce their understanding of *specific topics* such as demand, equilibrium, price elasticity, production, costs and more. Both the simulation games and simulation exercises are *automatically graded and the solutions provided to the students.* To permit continued learning, exercises may be repeated, but the answers to the new exercises will be different because the parameter values used in the games will change (like price elasticities, average costs, and business cycles) with each new game. Repetition is considered to be important to help students learn from their mistakes.

I. Introductory Level Games and Exercises

A list of the recommended order for the students to complete the games and exercises in the self-study at the introductory level is given in Table I. Referring to Table I, we suggest (order 1) students first do an Introduction Exercise which requires viewing the "Guided Tour on How to Play the Game", and answering multi-choice questions about a pre-designed game. After this (order 2), students play Game 1 for practice, and then do two more exercises (order 3 and 4), including the short-run Monopoly and short-run Production Exercises. These exercises require students to play a game and answer multiple choice questions about the results in the game, focusing on the monopoly market and production relationships. Once students have done this, they are asked to repeat Game 1 (order 5) and see how much better they perform with their newly acquired knowledge. Games & Exercises may be repeated as many times as needed until students are satisfied with their understanding and performance. Remember that each new game repeated has different parameters (elasticity and productivity coefficients, etc.), so the results and answers to multiple choice questions would change, making repetition a valid learning experience. The self-study continues in a similar fashion by completing the remaining games and exercises in the order specified (6 to 17). The "leaderboard" mentioned previously is available for students to see how their performance ranks against other students.

TABLE 1
RECOMMENDED ORDER FOR COMPLETING GAMES AND EXERCISES AT INTRODUCTORY LEVEL

Order	*Simulation Games**	*Simulation Exercises*
1		Getting Started: Introduction
2	Game 1	
3		Short Run Monopoly
4		Short Run Production
5	Game 1 - Repeat	
6		Price Elasticity
7		Law of Demand
8	Game 2	
9		Market Equilibrium
10	Game 3	
11	Game 4	
12		Short Run Oligopoly
13	Game 5	
14	Game 6	
15		Short Run Monopolistic Competition
16	Game 7	
17	Game 8	LEADERBOARD**

* *Number of rival firms increase as you advance from games 1 to 8*
**Leaderboard results* for all game are posted on the Gold Simulations website.

II. Advanced Level Games and Exercises

The more advanced self-study procedure is shown in Table II and, similar to the introductory level (Table I) specifies the recommended order for completing games and exercises at this higher level. The differentiating feature at the higher level is the focus on the *long-run*, allowing firms to build capacity over time in the games and deal with changing economic conditions like business cycles.

Creating Personal Games to Directly Challenge Other Students

To add to the excitement of the self-study, students are given the option to set-up their own "*personal games*" and ask other students to compete against them. They may invite one or more (any number) of students to compete in a multi-player game environment where each student manages a firm in the same marketplace. These multi-player games are interactive and one student's decisions for their firm (like changing price) will impact the sales of other students. Students may set up as many of these personal games that they want and can even select the level of complexity of the game by controlling the number of firms in the market and even the number of decisions controlled by the firms.

ASSESSMENT OF LEARNING EFFECTIVENESS

To test the effectiveness of the self-study in terms of student learning, a *pilot* study of one graduate level foundation economics course was evaluated. Each student was required to complete all the advanced level II games with the accompanying exercises. These are single player games where each student competes against computer-managed firms. The students were given the assignment at the beginning of the semester and were required to complete it by the end of the semester. This gave them the opportunity to do the self-study at their own pace; but was given a recommended schedule of times to do the games and exercises during the course. The self-study games and exercises were worth 15% of the course grade. The student's performance on the self-study was then compared to their overall course grade which included all the other assignments and exams in the class that tested the knowledge of the textbook and lecture material. The results are shown in Table III, which lists each student's performance on the self-study ranked in order from the top rating to the bottom; along with the ranking of their exam grades and their overall course grades which included all assignments (except for the self-study). The exams tested theoretical material from the textbook, not the simulation. Referring to Table III, casual observation indicates that students ranked on top in the self-study rating also did well in the class ranking on exam and overall course performance (but a statistical test to assess this will follow). For example, Student "A" was ranked number 1 in the class in the self-study performance and number 2 in the exams and overall grade in the course. The worst performing student in the self-study (student T), ranked in last place (20^{th}) on this measure and in the overall course grade; but did better on the exams, placing 13^{th}.

To measure the statistical significance of the relationship between the ranking of the self-study performance and the student's overall course grade, a *Spearman Rank Order* correlation analysis was performed. The Spearman Rank Order correlation results are given in Table IV and show a statistically significant relationship between the performance ranking in the self-study and the exams, and also between the self-study and the overall course grade ranking. The magnitude of the Spearman rho correlations are between 0.47 and 0.58 with statistically significant confident levels exceeding 95% (P-values < 0.05).

The statistical significance in the Spearman rank order cor-

TABLE 2
RECOMMENDED ORDER FOR COMPLETING GAMES AND EXERCISES AT ADVANCED LEVEL

Order	*Simulation Games**	*Simulation Exercises*
1	Game 9	
2		Long Run Production
3		Long Run Cost
4		Long Run Monopoly
5	Game 9 Repeated	
6		Revenue Maximization
	Game 10	
7	Game 11	
8	Game 12	
9		Long Run Monopolistic Competition
10	Game 13	
11	**Game 14**	**LEADERBOARD****

* *Number of rival firms increase as you advance from games 9 to 14*
**Leaderboard results* for all games are posted on the Gold Simulations website

relation analysis is consistent with the hypothesis that the self-study assignment helps the student learn the course material and may be used as a predictor of a student's "overall" performance in the class. Yet, one may argue that the results show only correlation and not causation. Even if this is true, the results of the self-study has the additional benefit of being an early predictor of a student's performance in the class, and may be used by the instructors to flag students that may need additional help early in the semester.

As a further test of the impact of the self-study assignment, a linear regression was done to confirm the predictive ability of the student's performance in the self-study with the overall course grade (net of the self-study assignment). The results are shown in Table V.

The regression is statistically significant at the 1% level with an F-statistic of 9.58. The variation in the self-study grade explains 34.74% of the variation in the student's overall course grade. This is considered to be an important finding since the self-study is only 15% of the student's grade in the course. Also, the self-study rating coefficient of 0.669 is statistically significant at the 1% level based on a t-test statistic of 3.095. The estimated coefficient predicts that a 1% increase in the self-study performance rating will increase the students overall course grade (on assignments other than the self-study) by 0.67% which is a meaningful impact. This analysis also supports the hypothesis that a self-study methodology for integrating a simulation into the classroom has merit and appears to be an effective pedagogical approach. But this finding is based on limited data, in a pilot study in one course with only 20 students, and clearly further research on this methodology is needed.

SUMMARY AND CONCLUSIONS

This study resumes a stream of research examining the impact on student learning of using an educational simulation game in the classroom. The research question in this study is not whether learning occurs with a simulation, enough studies support this conclusion, but rather the pedagogical effectiveness of a specific approach. It has been argued that the way in which a simulation is used in the classroom is a significant determinant of its value to student learning.

An innovative methodology has been presented where a simulation is designed and used as a self-study in which students "learn by doing" on their own, at their own pace, without direct instructor involvement. The students are required to complete a set of pre-designed simulation games and exercises on their own; and there success is highlighted on a leaderboard to enhance motivation. Theoretically, this draws upon the most powerful aspects of experiential learning. This approach to using a simulation in the classroom also has the advantage of freeing up instructor time (since students work on the simulation activity on their own), which gives the instructor more time for supportive teaching activities.

As a pilot program, the self-study approach is tested in an

TABLE 3
COMPARISON OF STUDENT SELF-STUDY AND EXAMS:
RANKED BY SELF-STUDY PERFORMANCE

	Self-Study		Exams		Course*	
Student ID	Rating	Class Rank	Grade	Class Rank	Overall Grade	Class Rank
A	99.74%	1	93.00%	2	95.19%	2
B	99.05%	2	90.00%	4	93.33%	3
C	98.54%	3	86.00%	9	89.18%	9
D	98.49%	4	96.00%	1	96.13%	1
E	97.69%	5	90.00%	5	84.07%	14
F	97.68%	6	85.00%	11	90.69%	5
G	95.64%	7	80.00%	16	85.03%	13
H	95.32%	8	87.00%	8	90.14%	7
I	94.95%	9	91.00%	3	89.32%	8
J	94.82%	10	81.00%	15	87.25%	10
K	94.53%	11	74.00%	19	82.07%	17
L	94.18%	12	82.00%	14	87.07%	12
M	93.03%	13	84.00%	12	90.18%	6
N	92.68%	14	74.00%	20	80.81%	18
O	87.70%	15	77.00%	17	83.55%	15
P	87.04%	16	76.00%	18	83.08%	16
Q	86.37%	17	88.00%	7	78.02%	19
R	86.19%	18	85.00%	10	87.10%	11
S	85.09%	19	89.00%	6	91.76%	4
T	83.82%	20	83.00%	13	73.28%	20

economics course with respect to how it impacts student performance (grades) as a measure of learning effectiveness. The results support that: (a) there is a significant relationship between student performance on the simulation self-study and their grades on exams that cover the textbook material. This is consistent with the hypothesis that the simulation self-study is helping students grasp the content specific theories of the course; and (b) there is a significant relationship between student performance on the self-study and their "overall" grade in the class. This broader test of student performance further supports the contention that the self-study is helping achieve the overall learning objectives of the course that may go beyond the standard exams. The overall grade in this study included performance on other assignments, in addition to the exams, like reports and class presentations that require students to demonstrate their ability to create, process, and apply knowledge. This is somewhat different than the type of learning measured by the textbook-type exams which are more topic/content focused.

In closing, it is emphasized that this is a pilot study and the results need to be interpreted tentatively. It could be argued that the results only show correlation and not causation; yet the implications are worth considering in terms of how a simulation may be used as a learning tool. The fact that the self-study is correlated to a student's overall course grade may also serve the important function of being an early predictor of a student's future performance in the course and flag those students that need additional support. Further research is strongly encouraged, not only on the merits of a self-study approach to using a simulation, but on the broader issue of the pedagogical effectiveness of alternative, creative/innovative, approaches for using simulations in the classroom.

TABLE 4
SPEARMAN CORRELATION BETWEEN SELF-STUDY, EXAMS, AND COURSE GRADE

RANK ORDER CORRELATIONS	Self-Study and Exam Grades	Self-Study and Overall Course Grade
Spearman's rho	0.470*	0.577**
Significance (P-value)	0.037	0.008
Observations (N)	20	20

*Correlation is significant at the 0.05 level (2-tailed); ** significant at 0.01 level (2-tailed)

TABLE 5
LINEAR REGRESSION OF COURSE GRADE AS A FUNCTION OF SELF-STUDY PERFORMANCE RATING

Regression Statistics	
Adjusted R Square	0.34738
F-Statistic	9.58125
Significance: F-statistic	0.00624
Observations	20

Variables	*Coefficients*	*t Stat*	*P-value*
Intercept	0.242272	1.201845	0.244998
Self-Study Rating	0.669042	3.09536	0.006242

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