THE RELATIONSHIP BETWEEN STUDENTS' SUCCESS ON A SIMULATION EXERCISE AND THEIR PERCEPTION OF ITS EFFECTIVENESS AS A PBL PROBLEM

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ABSTRACT

This study explored the relationship between the students' success with a problem and their perception of its "goodness" as a PBL "problem" in a strategic planning course. This study found no significant relationship between financial performance on a simulation and student perceptions of its ability to achieve the benefits derived from a good PBL problem. Limitations and directions for future research are explored.

WHAT IS PROBLEM-BASED LEARNING?

Problem-Based Learning (PBL) is a pedagogical process that begins by presenting the learner with an engaging problem, question, or puzzle. Learners then discover course concepts for themselves as they explore the problem. PBL grew out of findings of the cognitive sciences regarding how we learn. It originated in medical education and has gone on to gain acceptance as an effective pedagogy in such diverse disciplines as physiology, food production, and geology (Allen and Duch, 1998; Bereiter and Scardamalia, 2000; Duch, Gron, and Allen, 2001; Lieux and Luoto, 2000; Mierson, 2001).

PBL is founded on the idea that problems should precede answers. It is designed to give students the opportunity to identify the ideas and skills they need to work through problems. This process helps students recognize their knowledge deficiencies about a discipline, motivates them to understand course concepts, and facilitates their application of those concepts to real problems (Miller, 2004; Brownwell and Jameson, 2004). Spence (2001) argues that PBL provides students with opportunities to examine and experiment with what they already know; to discover what they need to learn; to develop the people skills they need for improving their performance in a team setting; to improve their writing and speaking abilities (to state and defend their *own* ideas with sound arguments and evidence); and to become more flexible in their approach to problems. This pedagogical process, Spence contends, dramatically improves learning.

DEFINING PROBLEM-BASED LEARNING

Problem-Based Learning has been defined as "a method of instruction that uses problems as a context for students to acquire problem-solving skills and basic knowledge" (Banta, Black, and Kline, 2000, p1). It also has been described as a "range of educational approaches that give problems a central place in learning activity" (Bereiter and Scardamalia, 2000, p185).

Universal to all definitions of PBL is (a) the approach to learning utilized by the instructor and (b) the use of a problem as the central focus of attention in the course (Sherwood, 2004). We will discuss each of these elements in turn.

Locus of Learning

Barrows (1986) and Spence (2001) make a distinction between subject-based learning (i.e., traditional learning) and problem-based learning. Subject-based learning is teacher-centered; the teacher provides the subject (i.e., student) with the correct answer for various circumstances. The subjects are taught how to use this information as the teacher assigns problems applicable for these "answers". By contrast, problem-based learning is student-centered; the teacher expects the students to take responsibility for their own learning as they search for answers to the problem assigned.

Characteristics of a "Good Problem"

Duch, et al., (2001) argue the quality of the "problem" used in large part determines whether the implementation of the pedagogy is successful. They state that PBL problems need to meet two criteria to be effective for a PBL design. The problems should (1) engage student interest and (2) require the students to develop and implement the principal concepts of the course in order to successfully solve the

problem. They contend that establishing a good problem can require creativity because the material for good PBL problems is not found in traditional textbooks.

Lohman (2002) expands the elements of a good PBL problem, stating that it should have three "structural features". One, the exact nature of the problem should be unclear and the information needed to solve the problem should be incomplete. Two, there should be more than one way to solve the problem. And three, the problem should not have a single right answer.

Barrows (1986), Edens (2000), and Sherwood (2004) contend that the context of the problem must be considered in a PBL designed course, as it provides the circumstances that give meaning to the problem for the students. Sherwood (2004) notes the importance of both organizational and social context in the accomplishment of PBL objectives and offers vignettes, cases and simulations as examples of context problems for use in management education.

SIMULATIONS AS PBL PROBLEMS

Given their wide-spread use in business programs (Faria and Nulsen, 1996), simulation exercises could provide instructors with a familiar vehicle for introducing PBL into the business curricula to reap the pedagogy's benefits. However, before using a simulation exercise as the problem in a PBL designed course, it is useful to consider whether it meets the requirements of a good PBL problem. Our review of the literature found support that simulation exercises meet the three criteria needed to be a good PBL problem identified above. The simulation's ability to engage students' interest is supported in reviews of the literature by Wolfe (1985), and later by Washbush and Gosenpud (1991). Further, the linkage between a simulation exercise and the application of course concepts has been demonstrated in multiple studies (Anderson and Lawton, 1997, Green and Faria, 1995; Hemmasi and Graf, 1992, Miller, et al., 1998, Schellenberger, et al., 1989, Teach and Govahi, 1988, Wolfe, 1990). In addition, Anderson and Lawton (2004b) point out that simulations fit the three criteria outlined by Loman (2002) stated above. Finally, Anderson and Lawton (2004a) found support for students' perceptions of simulations as meeting the characteristics of good PBL problems.

PURPOSE OF THE STUDY

The question is not whether simulation exercises meet the criteria for serving as a good PBL problem, but whether student performance on the exercise is related to their perception of its usefulness for Problem Based Learning. Specifically, does financial success on a business simulation affect student perceptions of its effectiveness as a PBL problem?

Earlier research by Anderson and Lawton (2004a) found support for student perceptions of simulations as having the characteristics of good PBL problems. However

in later research, they found mixed support for its effectiveness throughout the duration of a course (Anderson and Lawton, 2005). While the students found the simulation to be engaging, enjoyable, and challenging, their enthusiasm for the exercise tended to diminish as the semester progressed. While the authors did not collect the data to test the hypothesis, they speculated that student performance on the simulation may have moderated their reaction to the game. It seemed plausible that for some students, an inability to achieve satisfactory results may have led to increased frustration and decreased enjoyment. This paper follows directly from that study.

Specifically, we set out to investigate four hypotheses:

H1: There will be a positive correlation between performance on the simulation and the students' attitudes toward the simulation experience.

H2: There will be a positive correlation between performance on the simulation and the students' perception of how much they learned from the simulation experience.

H3: There will be a positive correlation between performance on the simulation and the students' perception of how well the simulation reflects the discipline of management.

H4: There will be a positive correlation between performance on the simulation and the students' perception of how much they know about the discipline of management.

RESEARCH METHODOLOGY

The Subjects of the Study

Subjects for the study were seniors at a medium-sized, university located in the Midwest. All the students were traditional, college-aged students enrolled in a senior-level strategic management capstone course. The course is required of all business management majors. A total of 23 students participated in the study.

The Simulation

The simulation used was *Threshold Competitor* (Anderson, et al., 2003). *Threshold Competitor* is a moderately complex total enterprise simulation requiring students to make approximately 40 decisions involving elements of the marketing mix (e.g., price, quality, promotion), operations (e.g., hire and fire workers, order raw materials, set production levels), and finance (manage cash flow, borrow long-term funds) for each period of play. Each decision period represented three-months (i.e., one quarter).

Threshold Competitor has a Team version (in which student-managed companies compete against other student-managed companies) and a Solo version (in which one student-managed company competes against 15 computer-managed companies, not other student-managed companies). The Solo version allows students to process

their decisions and move to the next quarter of operation at their own pace, without need for instructor involvement. There are two versions of the Solo program; Solo Practice and Solo Exam. The Solo Practice version allows students to restart the simulation as often as they wish. That is, if students are not satisfied with their performance, they can quit that particular simulation run and initiate a new round of competition from the beginning (Quarter 1). This allows them to restart the simulation repeatedly until they achieve results with which they can live. The Solo Exam version is identical to the Solo Practice version with the exception that the students are allowed only one pass through the quarters. They cannot go back and reprocess new decisions for Quarter 1 once they have processed that quarter.

Research Design

In order to assess the relationship between the students' performance on the simulation and their evaluation of various aspects of the simulation, we collected data on three separate occasions: (1) after the students completed their individual Solo experience in Week 3 of the semester; (2) after the students completed their individual Solo experience in Week 13 of the semester; (3) at the end of the semester after the students completed their experience (in groups) with *Threshold Team*.

Assessment #1. The PBL pedagogical model calls for the early introduction of the problem students are to solve. To accomplish this, we introduced students to the simulation in the third class meeting of the course. The first

Table 1 Study Scales			
Scale Name	**Description of Items**	**Number of Items**	**Cronbach's alpha**
Performance	Three measures of performance on the simulation (all three of the following were standardized to make their magnitudes comparable): 1) Sales 2) Net income 3) "Points" awarded by the simulation to reflect the relative performance of each company	3	.907, .890, .990
Attitude	Six semantic differential scales. *The simulation was…* ▪ unpleasant 1 2 3 4 5 6 7 enjoyable ▪ frustrating 1 2 3 4 5 6 7 satisfying ▪ dreadful 1 2 3 4 5 6 7 engaging ▪ simplistic 1 2 3 4 5 6 7 challenging ▪ dull 1 2 3 4 5 6 7 stimulating ▪ overwhelming 1 2 3 4 5 6 7 manageable	6	.833, .841, .878
Perceived knowledge	▪ How knowledgeable do you feel you are about the discipline of management? (4 point scale from "Not at all knowledgeable" to "Very knowledgeable") ▪ How much do you feel you would have to learn about management before you would be able to perform competently in your first job in a management position? (Reverse scored 4 point scale from "Nothing" to "An extreme amount") ▪ How much do you feel you would have to learn about management before you would be able to perform competently as a manager? (Reverse scored 4 point scale from "Nothing" to "An extreme amount") ▪ If you landed a job as a mid-level manager of an area business, how capable would you be of handling the job? (4 point scale from "Not at all capable" to "Very capable").	4	.737, .639, .734
Reflected discipline	How well do you think *Threshold Competitor* reflects the discipline of management?	1	na
Learning	How much do you think you learned from participating in the *Threshold Competitor* simulation?	1	na
* Note: there are three values of Cronbach's alpha for each of the scales shown above, because the questionnaire was administered on three separate occasions.			

class meeting dealt only with class organizational issues (e.g., course requirements, testing, formation of student groups, etc.). The second class meeting was limited to a very general overview of course topics and concepts and a brief introduction to the simulation. At the next class, the students were given the assignment of using the Solo version of the simulation to run their company as an individual player for four decision rounds. This meant that the students operated their companies prior to a discussion of a framework for decision-making and prior to instruction on how course concepts applied to the simulation exercise. Following their completion of the Solo exercise, the students completed a questionnaire on their perception of the Solo exercise, providing feedback on the exercise's merits as a PBL problem.

Assessment #2. Over the next 10 weeks of the course, the students participated in the Team version of *Competitor*. This exercise consisted of 12 decision rounds. Following completion of this exercise, the students again were given a second assignment of using the Solo version to run their company as an individual player for eight decision rounds during a 3½ hour exam period. Following their completion of this Solo exercise, the students again completed a questionnaire on their perception of this Solo exercise.

Assessment #3. At the final class session the students completed the questionnaire with the instructions to respond based on their total experience with the simulation over the duration of the term. They were explicitly directed *not* to fill out the questionnaire based solely on their recently completed Solo Exam experience.

Assessment Measures

Five measures were used in this study. They were (1) performance on the simulation, (2) student attitudes toward the simulation, (3) students' perceived knowledge about the discipline of management, (4) students' perception of how well the simulation reflected the discipline of management, and (5) how much the students thought they learned from participating in the simulation exercise. The first three were scales consisting of multiple items; the last two were single items. Table 1 shows that for the multiple item scales; all three achieved acceptable levels of Cronbach's alpha indicating that the scales were internally consistent.

RESULTS

Table 2 shows the results of a test of the four hypotheses stated above. Each variable is labeled with a 1, 2, or 3 to reflect the time when the assessment was made.

Hypothesis 1. There was little support for the hypothesis that there is a positive correlation between performance on the simulation and students' attitudes toward the simulation. While all three correlation coefficients were positive, none was statistically significant.

Hypothesis 2. At best, there was weak support for the hypothesis positing a relationship between performance and the student's perception of how much he or she learned from the simulation. There was only marginal evidence of a relationship between performance and perceived learning when students played the simulation individually (i.e., Assessments 1 and 2). In both cases, the p-value was less than .10. There was no evidence of a relationship between the two variables when students assessed the total simulation experience (i.e., solo *and* team exercises).

Hypothesis 3. No support was found for a relationship between performance on the simulation and the respondents' perception of how well the simulation reflected the discipline. The p-values ranged from .141 to .986.

Hypothesis 4. Finally, support was found for an association between performance on the simulation and the students' perception of how much they know about the discipline of management. The correlation was not statistically significant for Assessment 1 (the period of play at the very start of the course), but evidence of a relationship was quite strong by the end of the course ($p < .01$ and $p < .05$).

Additional analyses were conducted in an effort to gain better insight into the assessments provided by the students. Analyses were run to examine whether there was consistency in the pattern of scores over time. Table 3 shows the results of this analysis. There is a separate analysis for each of the five assessments taken in the study.

In general, strong associations were found among the measures from one time period to the next. The sole exception to the relationship between the scores (on the same scale) from one time to the next occurred for the

Hypothesis Results Table 2						
Hypotheses		Performance1		Performance2		Performance3
H1	Attitude1	.218 .384	Attitude2	.345 .116	Attitude3	.145 .519
H2	Perception of learning1	.393 .087	Perception of learning2	.381 .080	Perception of learning3	.001 .996
H3	Reflected discipline1?	.341 .141	Reflected discipline2?	.060 .790	Reflected discipline3?	-.004 .986
H4	Perceived knowledge1	.323 .165	Perceived knowledge2	.575 .005	Perceived knowledge3	.506 .016
Cell contents: • Correlation coefficient • p-value						

Scale Relationships Over Time
Table 3

Performance Scale Relationships		
	Performance1	Performance2
Performance2	.161 .497	
Performance3	.198 .402	.515 .014

Attitude Scale Relationships		
	Attitude1	Attitude2
Attitude2	.544 .016	
Attitude3	.685 .001	.606 .003

Learning Scale Relationships		
	Perception of Learning1	Perception of Learning2
Perception of Learning2	.594 .007	
Perception of Learning3	.522 .022	.406 .061

Discipline Scale Relationships		
	Reflected Discipline1?	Reflected Discipline2?
Reflected Discipline2?	.647 .003	
Reflected Discipline3?	.476 .039	.810 < .001

Knowledge Scale Relationships		
	Perceived Knowledge1	Perceived Knowledge2
Perceived Knowledge2	.690 .001	
Perceived Knowledge3	.682 .001	.948 <.001

Cell contents: ⋅ Correlation coefficient
⋅ p-value

performance scale. There was not a statistically significant relationship between Performance for Assessment 1 versus Performance for Assessments 2 or 3. This lack of relationship is not particularly surprising, since at the time of Assessment 1, students were thrown into the simulation with virtually no preparation. There *was* a statistically significant correlation between Performance Assessment 2 and Performance Assessment 3. We were pleased to find a relationship between these two performance measures. Those students who learn to manage their companies effectively ought to be able to replicate their performance. It was reassuring to see that performance on the individual simulation occurring late in the semester was related to performance on the team simulation taking place over the course of the semester.

DISCUSSION

We were very surprised by the results of this study. Based on anecdotal evidence accumulated by the authors over many years, we believed that we would find a strong association between performance and student attitudes toward the simulation – those students who did well on the simulation would rate it more favorably, would have a greater belief that the simulation reflected the discipline, and would perceive that they learned more from participating in the exercise. We found only marginal support for one of these relationships. On the exercises involving individual play, there was weak support ($p = .087$ and $.080$) for a relationship between performance and the students' perception of how much they learned from participating in the simulation. However, we found virtually *no* support for a relationship between performance and either of the other two scales (attitudes toward the simulation and reflected the discipline). While all but one of the correlation coefficients was positive, the correlation coefficients for all other relationships were very small.

There was convincing evidence of an association between the students' perception of how much they knew about the practice of management and their performance on the simulation. Of course, we do not know how accurate the students' perception of their knowledge was and, in all likelihood, most of the students (being untested in the world of business) did not have a solid basis for evaluating their knowledge. Thus, this result is not particularly surprising. Some of the students are likely to have used their performance on the simulation as one of the cues in assessing their knowledge of management.

Perhaps the most intriguing finding was the high degree of consistency for the measures over time. In general, the attitudes and perceptions that the students held at the very beginning of the course tended to be strongly related to the attitudes and perceptions that they held at the very end of the course. Table 3 shows that, *relative to the other students*, a student's views of the simulation exercise changed little. That is, students who perceived the

simulation exercise more positively than their peers at the beginning (Assessment 1), tended to view it more positively than their peers at the end (Assessment 3). This is not to say that student perceptions did not change, just that when changes occurred they tended to occur in the same direction and to a similar degree. We would have expected that there would be more variation in the students' reactions to the simulation over time, leading to a changing of *relative* views of the exercise by the end of the term.

LIMITATIONS

There are two limitations of this study. One is the relatively small sample size. These findings are based on a sample of only 23 students. Clearly there is a need to replicate this study with a larger number of students.

A second limitation of the study is that it is based on a single instructor using a single simulation. It is conceivable that students would respond differently to other instructors or to other simulations. Again, this points up the need for replication of this study by other instructors using different simulations.

CONCLUSIONS

The implications of this study are not clear. As stated previously, these results are quite contradictory to our expectations. We anticipated a strong association between performance and attitudes toward the simulation. It seemed likely that the attitudes toward the simulation of students receiving positive reinforcement in the form of superior results would improve while those experiencing sub-par performance would deteriorate. We often have observed the excitement and elation of those performing well and the frustration and dejection of those performing poorly. The results of this study are inconsistent with our experience. One possible explanation for these findings is that this particular class of students was atypical. (As noted in the Limitations section, these results are based on a sample of only 23 students.) A second possible explanation is that individual students either are, or are not, attracted to the simulation – and that their affective reaction to the experience is largely independent of the results they achieve.

A clear need exists to replicate this study if we are to understand the results of this study. If there is something unique about this particular group of students, replication will demonstrate that these results are atypical. However, if these results hold across studies, it raises some interesting questions. What is it that causes students to be attracted to or repelled by simulations? Can we predict students' reactions to simulations? Are there certain personality characteristics that predispose students toward liking or disliking simulations?

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