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THE EFFECTIVENESS OF A SIMULATION EXERCISE FOR INTEGRATING PROBLEM-BASED LEARNING IN MANAGEMENT EDUCATION

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ABSTRACT

Problem-Based Learning (PBL) has gained recognition as a valuable pedagogical approach. This study explored the effectiveness of using a simulation as the PBL "problem" in a strategic planning course. This study demonstrated that a management simulation can be an effective problem for integrating PBL over the duration of a course. Factors that need to be considered when using a simulation exercise as a PBL problem are discussed. Limitations and directions for future research are explored.

INTRODUCTION

Problem-Based Learning is founded on the simple premise that problems should precede answers. This stems from 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). In PBL, the learning process begins by presenting the learner with an engaging problem, question, or puzzle. Learners discover course concepts for themselves as they explore the problem.

Proponents of Problem-Based Learning (PBL) contend that this pedagogy 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 dramatically improves learning. He states that Problem-Based Learning 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. The PBL approach is designed to give students the opportunity to identify the ideas and skills they need to work through problems.

Based on its success in other disciplines, PBL would appear to offer benefits for business education. However, business instructors have been slow to introduce this pedagogy into their courses (Banta, Black, and Kline, 2002, Bigelow 2004). Bigelow (2004) states that of the 106 higher educational institutions reporting the use of PBL in 2001, only six business courses incorporated this pedagogy.

Instructors interested in introducing a PBL approach into their courses should recognize that the successful implementation of the pedagogy is highly dependent upon the quality of the "problem" used (Duch, et al., 2001). This study assessed the use of a management simulation exercise as the PBL "problem" over the duration of a strategic planning course designed around the Problem-Based Learning pedagogy. 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.

WHAT IS 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) assert that the success of Problem-Based Learning depends upon the quality of the questions presented. 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 because the material for good PBL problems is not found in traditional textbooks, establishing a good problem can require creativity and is a challenging endeavor in most disciplines.

Lohman (2002) expands the elements of a good PBL problem, stating that it should be an ill-structured problem with 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) and Edens (2000) 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) argues that the context of the problem "is a critical ingredient to successful learning with the problem-based approach." (p.538). He notes the importance of both organizational and social context in the accomplishment of PBL objectives. Sherwood offers vignettes, cases and simulations as examples of context problems for use in management education.

USING SIMULATIONS AS THE PROBLEM IN PROBLEM-BASED LEARNING

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.

Wolfe (1985), and later Washbush and Gosenpud (1991), summarized the lengthy body of literature that attests to the simulation's ability to engage students' interest. They reported an almost universal student preference for simulations over cases and lectures as a pedagogy for learning course concepts. There is also considerable research reporting the linkage between a simulation exercise and the application of course concepts (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). Using a simulation to present concepts and to provide students with a vehicle to experiment with the application of those concepts has been at the center of research on this pedagogy (Keys and Wolfe, 1990).

The dynamic nature and competitive context of business simulations fit the three criteria outlined by Loman. Anderson and Lawton (2004b) point out that students working with simulations are faced with an unclear problem (i.e., their competitors' plans for the next quarter) and incomplete information to solve the problem. And there are also many possible ways to solve the problem (e.g., multiple pricing options) and there is more than one correct answer to that problem (e.g., alternative price/quality positions to successfully compete).

The inherent design of business simulations involves modeling a business operating in a competitive environment. This places students into a context that requires the application of business concepts (Sherwood, 2004).

CONSIDERATIONS IN USING A SIMULATION IN A PBL DESIGNED COURSE

Conceptually, simulation exercises appear to hold considerable promise for a useful PBL problem in a business course. However, as noted by Anderson and Lawton (2004a), the term "simulation" spans a very wide range of applications and levels of sophistication. They identified the (1) scope of the simulation, (2) student level of preparation, and (3) simulation exercise objectives as factors to consider when applying PBL pedagogy in the design of a course.

According to Anderson and Lawton (2004a), simulation scope constitutes the breath of the domain the simulation is designed to cover. That is, does the simulation demonstrate (a) a specific concept or discipline (e.g., EOQ or Operations Management) or (b) an integrated set of discipline (e.g., a total enterprise simulation)? Student level of preparation involves the students' prior knowledge of the discipline modeled by the simulation prior to the course. Simulation exercise objectives refers to the desired outcomes the instructor hopes to achieve through the use of the exercise (e.g., introduction of a concept or development of analytical skills). Given the large number of possible combinations on these three dimensions, Anderson and Lawton (2004a) emphasize that instructors should give careful consideration to the choice of the simulation if they intend to use the game as the "problem" in a PBL designed course.

PURPOSE OF THE STUDY

While the discussion above argues for the suitability of a simulation exercise as the problem in a PBL oriented

course, there is little empirical support for its efficacy. Anderson and Lawton (2003) reported success in using a marketing simulation for introducing a PBL problem in a principles of marketing course. They noted, however, that their findings were limited to the parameters of their specific study and that further research was needed before generalizing their conclusions about the effectiveness of simulations as a PBL problem.

Anderson and Lawton (2004a) later reported the results of a study comparing student reaction to two different simulations in two different courses. The simulations used were for the marketing and management disciplines. The courses were a junior-level course and a senior-level course. Their study addressed questions relating to the simulations' scope and the students' level of preparation.

While Anderson and Lawton reported broad support in both courses for using simulations as a PBL "problem", student feedback was limited to perceptions of the exercise following a short exposure to a simulation at the beginning of the course. Their study did not report on whether the simulations were effective over the duration of the course. Since the PBL philosophy argues for incorporating the challenges of problem solving throughout a course, the question of as simulation's effectiveness as a PBL "problem" has not been not adequately investigated.

In order to address this issue, and to answer some of the questions raised above, the present study involved gathering feedback from students *prior* to their exposure to a solo version of the simulation, *after* exposure to the solo version of the simulation, and *after* their exposure to the *team version* of the simulation.

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 most business majors. Consequently, the students came from a variety of business disciplines. A total of 45 students from two sections of the same course taught by the same instructor 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. It also 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.

RESEARCH DESIGN

In order to assess the effectiveness of a simulation as a Problem-Base Learning (PBL) problem over the duration of a course, we collected data on student perceptions prior to and after working with the Solo version of *Competitor*, and then again after they used the Team version.

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 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. After this introduction, the students completed a questionnaire on their perceptions of the pending simulation exercise. At the next class, the students were given the assignment of using the Solo version of the simulation to run their company for one year (four decision sets), and then submitting their results. This meant that the students operated their companies prior to receiving 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 again provided feedback on their perception of the Solo exercise.

For the remainder of the course, the students participated in the Team version of *Competitor*. This exercise consisted of 8 decision rounds. Following completion of this exercise, the students again completed the questionnaire, providing feedback on the Team exercise. This final evaluation was done at the end of the term.

RESULTS

Table #1 shows the students' assessment of the simulation exercise before they undertook their Solo exercise, after completing the Solo exercise, and after completing the Team exercise. Before working with the simulation, the students anticipated that the simulation

assignment would be challenging, stimulating, and engaging (91%, 93%, and 86% respectively rated it at 5 or above on the seven-point scale). Eighty-four percent thought it would be enjoyable. On the other hand, 36% expected the simulation exercise to be frustrating (a rating of 1, 2, or 3) and 22% expected it to be overwhelming.

After completing the Solo exercise, the students' perception of the simulation improved. A slightly higher number saw the simulation assignment as challenging (93%), stimulating (93%), and engaging (98%). Ninety-one percent rated the simulation as enjoyable and the percentages for frustrating and overwhelming (a rating of 1, 2, or 3) decreased considerably (to 14% and 7%, respectively). These pre-post ratings for the Solo version of the simulation provide strong support that the simulation met the criteria of "engaging student interest" – one of the key characteristics of a good problem for a PBL-designed pedagogy.

The students continued to describe the simulation in terms consistent with the definition of a good PBL problem even after completing the Team exercise at the end of the course. Ninety-eight percent of the students saw the simulation assignment as challenging, 91% as stimulating, and 85% as engaging. Except for the rating for "challenging", these perceptions were about the same as the pre-Solo ratings. (When compared to the Post-Solo ratings, the degree of challenge is up a bit and the level of engagement is down somewhat.) It is interesting to note that there was an increase in the number of students rating the simulation exercise as frustrating (53%) and overwhelming (22%). While the student rating of the simulation as enjoyable remained high (69%), there was quite a decrease from the Post-Solo rating of 91%.

Figure #1 uses the averages for each measure reported in Table #1 to provide a graphical representation of the results. It shows that, with the exception for the "challenging" measure, the Post-Team ratings decreased from the Post-Solo ratings. Possible reasons for this will be addressed in the Discussion section.

Table #2 shows student perceptions of their preparation for the management discipline. We designed our course with a short, "throw-'em-into-the-deep-end" introduction to Solo. We did this with the expectation that the experience would provide motivation to learn the subject matter in the course. We anticipated that, without first providing a framework for approaching the simulation, the experience would be a bit daunting for the students and would provide them with compelling evidence that they had much to learn. The data indicate that this goal may not have been accomplished. Prior to working with the simulation exercise, 53% reported that they were "quite knowledgeable" or "very knowledgeable" about the discipline of management. After exposure to the Solo version of the simulation exercise, this number increased to 82%. The students were also asked about their self-perceived readiness to perform competently as a manager in a business. Prior to the exercise 78% of the students felt they had "quite a lot" or "an extreme amount" to learn. Exposure to the Solo version of the simulation reduced this number to 51%.

Figure #1

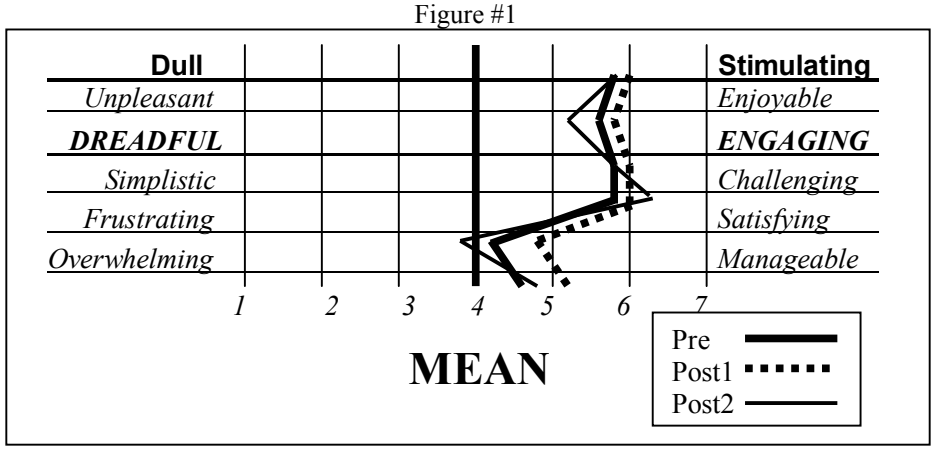

Table #1
Student Assessment of the Simulation Exercise
(Responses Expressed as Percents)

	1s	2s	3s	4s	5s	6s	7s	Ave.	Std D
Simplistic – Challenging									
▪ Pre-Solo	0.0	0.0	0.0	9.1	20.5	50.0	20.5	5.82	0.87
▪ Post-Solo	0.0	0.0	0.0	6.8	20.5	43.2	29.6	5.96	0.89
▪ Post-Team	0.0	0.0	2.2	0.0	13.3	33.3	51.1	6.31	0.87
Dull – Stimulating									
▪ Pre-Solo	2.2	0.0	0.0	4.4	22.2	48.9	22.2	5.80	1.08
▪ Post-Solo	0.0	0.0	0.0	6.8	18.2	38.6	36.4	6.05	0.91
▪ Post-Team	0.0	0.0	0.0	8.9	28.9	33.3	28.9	5.82	0.96
Dreadful – Engaging									
▪ Pre-Solo	0.0	0.0	2.7	11.4	20.5	36.4	29.6	5.80	1.07
▪ Post-Solo	0.0	0.0	0.0	2.3	22.7	34.1	40.9	6.14	0.85
▪ Post-Team	0.0	0.0	4.4	11.1	24.4	31.1	28.9	5.69	1.15
Unpleasant – Enjoyable									
▪ Pre-Solo	0.0	2.3	4.6	9.1	27.3	31.8	25.0	5.57	1.23
▪ Post-Solo	2.2	0.0	0.0	6.7	22.2	51.1	17.8	5.71	1.08
▪ Post-Team	2.2	2.2	6.7	20.0	17.8	26.7	24.4	5.27	1.50
Frustrating – Satisfying									
▪ Pre-Solo	4.4	6.7	24.4	17.8	26.7	17.8	2.2	.18	1.45
▪ Post-Solo	2.3	2.3	9.1	27.3	31.8	18.2	9.1	4.75	1.31
▪ Post-Team	6.7	20.0	26.7	11.1	15.6	6.7	13.3	3.82	1.83
Overwhelming – Manageable									
▪ Pre-Solo	2.2	2.2	15.6	20.0	37.8	17.8	4.4	4.60	1.27
▪ Post-Solo	0.0	2.3	4.6	18.2	34.1	36.4	4.6	5.11	1.06
▪ Post-Team	2.2	4.4	15.6	17.8	31.1	20.0	8.9	4.67	1.43

Table #2
Student Perceptions of their Preparation for the Management Discipline

	Not at all		Somewhat		Quite		Very	
	#	%	#	%	#	%	#	%
How knowledgeable do you feel you are about the management discipline?								
• Pre-Solo	0	0.0	21	46.7	20	44.4	4	8.9
• Post-Solo	0	0.0	8	17.8	35	77.8	2	4.4
• Post-Team	0	0.0	16	35.6	27	60.0	2	4.4
	Nothing		A little		Quite a lot		Extreme	
	#	%	#	%	#	%	#	%
HOW MUCH DO YOU FEEL YOU HAVE TO LEARN ABOUT MANAGING BEFORE YOU WOULD BE ABLE TO PERFORM COMPETENTLY IN YOUR FIRST JOB IN A BUSINESS POSITION?								
• Pre-Solo	1	2.2	28	62.2	15	33.3	1	2.2
• Post-Solo	1	2.2	31	68.9	11	24.4	2	4.4
• Post-Team	2	4.4	25	55.6	15	33.3	3	6.7
HOW MUCH DO YOU FEEL YOU HAVE TO LEARN ABOUT MANAGEMENT BEFORE YOU WOULD BE ABLE TO PERFORM COMPETENTLY AS A MANAGER IN A BUSINESS?								
• Pre-Solo	0	0.0	10	22.2	32	71.1	3	6.7
• Post-Solo	1	2.2	21	46.7	22	48.9	1	2.2
• Post-Team	0	0.0	16	35.6	25	55.6	4	8.9

Finally, the students were asked about how competently they would perform *in their first job* in a business position. Before exposure to the simulation exercise, 36% of the students felt they had "quite a lot" or "an extreme amount" to learn. Exposure to the Solo version of the simulation didn't change this perception very much (29%).

In summary, participating in the Solo version of the simulation early in the course apparently did not increase students' belief that they had something to learn about the discipline of management. Nor did it have much effect on their perception of their preparation for an *entry-level* position in business.

The final (post-Team) perceptions of the students were gathered at the end of the management course. It is interesting that nearly all of the ratings dropped from the post-Solo high points. The final rating for knowledge of the discipline dropped from 82% to 64% and their perception of their ability to perform competently as a manager fell (51% rated themselves as having "quite a lot" or an "extreme amount" to learn after playing Solo and this percentage increased to 75% in the post-Team assessment). Student ratings of their ability to perform competently in a first job in business showed little change, but, again, there was a slight decrease in perceived competence.

This decline in perceived preparation for management is an intriguing phenomenon. One might expect that, as the students moved through the course and the simulation, they would feel *more prepared*, not less. And, in fact, there is some improvement in the ratings when we compare those taken at the very beginning (pre-Solo) of the course to those taken at the end (post-Team). Nevertheless, the evidence shows a spike in the ratings following the brief exposure to the simulation and a decline from that peak.

Table #3 shows student perceptions of the relationship between the management discipline and the simulation exercise. The results show that the students believed the simulation accurately reflected the management discipline. This was true before they began the Solo version (91%) and after working with the Solo version (91%) and the Team version (84%) of the simulation.

Table #3 also shows the students' perception of the usefulness of the course for improving their performance on the simulation. Prior to exposure to the simulation exercise, 91% reported that they believed the concepts to be taught in the course would influence their performance on the simulation. Continued exposure to the course decreased this perception to 78% following the Solo version exercise and 60% after working with the Team version of the simulation. Needless to say, these results are disappointing.

Table #3
Student Perceptions of the Management Discipline and the Simulation

	Not at all		Somewhat		Quite a Bit		Very	
	#	%	#	%	#	%	#	%
How well do you think the simulation reflects the management discipline?								
• Pre-Solo	0	0.0	4	8.9	31	68.9	10	22.2
• Post-Solo	0	0.0	4	8.9	32	71.1	9	20.0
• Post-Team	0	0.0	7	15.6	25	55.6	13	28.9
How useful will this course be (was this course) in helping to improve your performance in the simulation?								
• Pre-Solo	0	0.0	4	8.9	26	57.8	15	33.3
• Post-Solo	0	0.0	10	22.2	30	66.7	5	11.1
• Post-Team	0	0.0	18	40.0	17	37.8	10	22.2

DISCUSSION

THE SIMULATION AS A PBL "PROBLEM" OVER THE DURATION OF THE COURSE

One of the questions we hoped to address in this study was whether using a simulation as a PBL problem would work well throughout the duration of the course. The results of this study provide support that the simulation met the PBL requirements of an engaging problem over the length of the term. The students consistently rated the simulation as challenging, stimulating, and engaging at all three assessment points – prior to the Solo exercise, after the Solo exercise and after the Team exercise.

There was less support, however, for using an early introduction of the simulation to convince students that they had a lot to learn about the discipline of management. The data show that this quick, early shot of the simulation actually served to strengthen the students' conviction that they were knowledgeable about management and prepared for a career in business. For example, their perception of their knowledge of the management discipline (rated as "Quite" to "Very" knowledgeable) increased from 53% to 82%.

The results also showed that the students' perception of the usefulness of the course for improving their performance on the simulation deteriorated over the duration of the course. When the students began working with the simulation, 91% believed the concepts taught in the course would be "Quite a bit" or "Very" helpful. This decreased to 78% after exposure to the Solo exercise and 60% after working with the Team exercise.

The results provide support that using the simulation exercise over the duration of the course generated a student response consistent with the characteristics of a good PBL problem. However, the results raised questions as to whether early use of the simulations helped students to recognize their deficiencies in the discipline and the potential for the course to improve their skills in that discipline.

SIMULATION DESIGN (SOLO VERSUS TEAM VERSIONS) CONSIDERATIONS

Earlier studies by Anderson and Lawton (2004b. 2004a, 2003) found support for using simulations as a PBL problem. However, their studies were limited to an investigation of using a solo version of a simulation introduced early in a course. This study added data collected on student perceptions based on a team version of the simulation that extended over the duration of a course. Although there was a small decline on a couple measures of student attitudes toward the simulation, this study demonstrates that the simulation holds up very well as a PBL problem over the entire length of the course (see Figure #1). Even after spending an entire term with the simulation, students still perceived it as stimulating and challenging. The rating for "engaging" dropped somewhat, but it dropped from 98% to a respectable 85%. Surprisingly, the percentage of students rating the simulation as frustrating and overwhelming showed a considerable increase from the post-Solo ratings. It might be anticipated that after a semester of experience with the simulation, they would find it less overwhelming.

There are a number of possible reasons to expect a decline from the Post-Solo to the Post-Team ratings. As the students become more familiar with the simulation and its characteristics, they might lose interest as the exercise becomes more predictable. However, since the students rated the team exercise as *more challenging*, more frustrating, and less enjoyable there is no evidence that the students became "bored" with the simulation as a problem to solve. These results lead us to the next possible explanation for the drop in ratings.

Another possible reason for the differences in the students' ratings of the solo versus team versions of the simulation is their greater ability to control their success with the solo version. The solo version affords the students the option of restarting the simulation as often as they would like if they are dissatisfied with their results (e.g., if they are unprofitable). While a restart takes them back to the very beginning (i.e., Quarter 1), it allows the students to shed a poor final result By contrast, the team version requires a continual march forward, regardless of the results. Students who do not see the same "payoff" for effort on the team version as they do on the Solo version could evaluate the exercise based on the results they achieve rather than what they are learning from the exercise.

CONCLUSIONS

We found support for use of the simulation as a PBL problem over the duration of a course. The simulation exercise served as a continuing "good" problem. Students perceived the simulation exercise as challenging, stimulating and engaging, not just when first exposed to the "problem", but at the completion of the course. These results are mitigated somewhat by the students' ratings of their knowledge of management and their preparation for being successful in business. The results of this study indicate the simulation exercise did little to change their perception that they had much to learn about management, both for the course and for their career. (Perhaps the students actually *did* enter the course already possessing the knowledge needed to be successful, but we have our doubts.)

As discussed above, the students' Post-Solo ratings were unexpected, especially when compared to the Pre-Solo and Post-Team ratings. The Post-Solo ratings reflect an increase in the students' perceptions of their knowledge of the management discipline and a perception that they have less to learn to be successful in the course or in business. Since the solo exercise took place at the beginning of the course, we had expected a decrease on these measures. We did expect an increase on the Post-Team rating at the end of the course, following course instruction. In fact, even though the students consistently rated the simulation as a good reflection of the management discipline, their perception of the value of the course for improving their performance on the simulation *decreased* over the duration of the course. It is not that the simulation did not have an impact on student perceptions. The results simply were unexpected given prior research. Whether this was due to a unique set of characteristics of this sample of students, the solo version's multiple restart option, or other unmeasured variables could not be determined. Given the contrast of this study's results with those of prior studies, continued exploration of the use of a simulation as a PBL problem is warranted.

Regardless of the mixed results of this study, we were pleased with student reaction to the exercises. We were concerned that early introduction of the simulation would overwhelm and frustrate the students. Given prior reported results, this was not a major concern, but still one that does not seem unreasonable. Fortunately, this problem did not arise. And even though some students reported an increase in frustration with the team exercise, nearly three-fourths still rated their simulation experience as enjoyable.

LIMITATIONS

As discussed above, there is a very wide range of simulations in terms of the scope of the concepts they attempt to address. For this study, the simulation was moderately complex. What remain untested are small-scale simulations (e.g., EOQ modeling). Would they work equally well as a PBL problem?

Further, as discussed above, the ability to restart the Solo version of the simulation may have influenced students' perceptions of the exercise. Research on the relationship between students' performance on the simulation and their perceptions of the simulation as a PBL problem is needed. Further replications of this study are needed to understand the impact of simulation design on its effectiveness for introducing a PBL designed pedagogy into a course.

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