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SIMULATION EXERCISES AND PROBLEM BASED LEARNING: IS THERE A FIT?

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ABSTRACT

Problem Based Learning (PBL) has become a recognized pedagogical aid for designing courses. Key to successful implementation of this pedagogy is the use of a "good problem". Factors that need to be considered when using a simulation exercise as a PBL problem are discussed. This study demonstrated that simulations can effectively serve as the "problem" in a PBL designed course. Limitations and directions for future research are explored.

INTRODUCTION

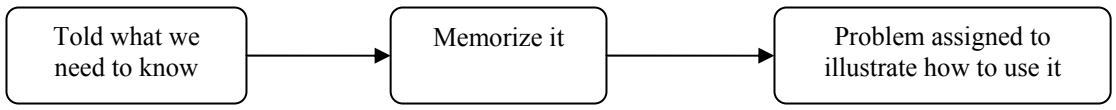
As instructors, we often assume that students recognize that they have much to learn about the discipline we are teaching them. In fact, in many cases, and especially for subjects like marketing and management, that belief is likely to be erroneous. Students have had lifelong experiences as consumers and, most likely, multiple exposures to managers. These experiences, combined with their perception of these disciplines as non-technical, often result in the belief that there is little new for them to learn about the subject. There is probably not a teacher of a basic management or marketing course who has not heard a student comment that "This stuff is just common sense. Why do I have to take this course?" Students who operate under the assumption that they already have an adequate grasp of the subject are unlikely to be productive learners. Those students who accept that they lack knowledge of the subject and see potential benefits from acquiring that knowledge are likely to be far more motivated and engaged in the learning process.

Proponents of Problem Based Learning (PBL) would argue that proper course design can address this dilemma. Their contention is that the PBL pedagogy prompts students to recognize their knowledge deficiencies and motivates them to learn about the discipline in question.

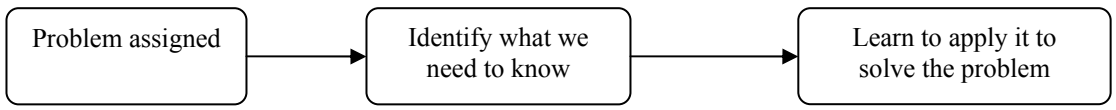
WHAT IS PROBLEM BASED LEARNING?

Problem Based Learning was derived from research in the cognitive sciences regarding how we learn. It is founded on the simple premise that answers flow from problems. In PBL, the learning process begins by presenting the learner with an engaging problem. As they explore the problem, students then discover for themselves how course concepts provide the means for resolving the problem. Spence (2001) argues that a PBL designed course 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 by learning to state and defend with sound arguments and evidence their *own* ideas; and to become more flexible in their approach to problems. The PBL pedagogy is designed to give students the opportunity to identify the ideas and skills they need to work through the problems they confront.

Subject Based Learning (SBL)



Problem Based Learning (PBL)



Spence (2001) makes a distinction between traditional learning, which he termed subject-based learning, and Problem Based Learning. The following diagrams highlight these two methods of learning.

According to Duch, et al., (2001), the success of Problem Based Learning depends upon the quality of the problem presented. To be effective for a PBL design, they argue that a PBL problem needs to meet two criteria. 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. Duch, et al., contend that developing a good problem is a challenging task because the substance for good PBL problems is not found in traditional textbooks.

The effectiveness of Problem Based Learning has been established in such diverse disciplines as physiology, food production, and geology (Allen and Duch, 1998, Duch, Gron, and Allen, 2001, Lieux and Luoto, 2000, Mierson, 2001). However, despite its use in a variety of fields, PBL has yet to gain much acceptance in business education (Banta, Black, and Kline, 2002, Stinson and Miller, 1996). This study sought to examine whether a simulation can act as the "problem" in a business course structured to implement the principles of Problem Based Learning. Given their wide use in business programs (Faria and Nulsen, 1996), simulations could provide instructors with a familiar vehicle for introducing PBL into the business curricula to partake of the pedagogy's benefits.

USING SIMULATIONS AS THE PROBLEM IN PROBLEM BASED LEARNING

Before using a simulation exercise as the problem in a PBL designed course, we first need to explore whether it meets the requirements of a good PBL problem. Our review of the literature found support that simulations meet the two 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). Conceptually then, it appears that simulation exercises have the potential to serve as a good problem for a course utilizing a PBL design.

CONSIDERATIONS IN USING A SIMULATION IN A PBL DESIGNED COURSE

While simulation exercises have the potential to serve as the problem for a PBL designed course, there are a number of factors an instructor should consider before implementing this approach. These include the scope of the simulation, the students' level of preparation as they begin the course, and the instructor's objective in using the simulation. We will discuss each of these factors in turn.

Scope of the Simulation

Some computer simulations are very limited in scope, dealing with only one facet of a discipline. These simulations are designed to introduce or reinforce some specific aspect of the course. For example, a simulation designed to demonstrate EOQ (Economic Order Quantity) is different in both scope and scale from an operations management simulation that models a production process that includes staffing and technology decisions. Other simulations, such as total enterprise simulations, are designed to cover a broad range of issues in a discipline.

Limited-scope simulations are unlikely to raise the concepts inherent in broader, more comprehensive, simulations. Most instructors will use a small-scale simulation when they cover the specific topic to which it is tied — and then the simulation will run for only a short time. Whether a simulation is effective as a PBL problem regardless of the scope of the simulation is untested. Does a small-scale simulation sufficiently engage students? Does a large-scale simulation overwhelm students and lead to their disengagement from the exercise? These questions have yet to be answered.

Student Level of Preparation

Some instructors use simulations in introductory courses (e.g., Principles of Marketing) while others employ them in upper-level courses (e.g., Marketing Management). The nature of the course will almost certainly be related closely to the knowledge base of the students enrolled in the course. For example, students entering an introductory marketing or entrepreneurship course are unlikely to be informed about the models and concepts of the discipline. On the other hand, most instructors of capstone courses for a discipline assume that students enter the course with an understanding of the basics of that discipline since they have already been exposed to basic concepts in prior coursework (Anderson and Lawton, 1997). But could this prior knowledge of certain concepts lessen the challenge presented by the simulation (i.e., the problem) and as a result lessen the students' engagement of the exercise? We could find no research addressing this question.

Objectives for Using a Simulation

Researchers have identified many possible objectives for using a simulation (Gentry, et al., 1979, Hemmasi, M. and L.A. Graf, 1992; Keys, B. and J. Wolfe, 1990; Miles, W.G., Jr., et al., 1986; Parasuraman, A., 1981). They include introducing new concepts, practicing the application of those concepts, and analyzing complex and competing information in a business context. Most instructors using simulation exercises attempt to simultaneously achieve multiple intellectual and behavioral objectives (Anderson and Lawton, 1997). That is, instructors are not seeking a simple application of the course concepts; they also want their students to see the relationship between the application of concepts, analysis, and performance (Burns, et al.,

1990). Instructors believe if this can be achieved, it will reinforce the students' efforts at analysis and application, and consequently provide them with the motivation to go beyond simple knowledge and comprehension of course materials. That is, once students see the relationship between the application of concepts and performance, they will embrace the value those concepts bring to a business activity. If a PBL design can facilitate students' recognition of this relationship, it can serve as a means for increasing a simulation's usefulness for accomplishing course objectives. But does it? Or does early introduction of a simulation as a PBL problem inhibit this recognition?

RESEARCH METHODOLOGY

While the discussion above argues for the suitability of a simulation exercise as a PBL problem, we could find only one prior study on this topic. Anderson and Lawton (2003) reported support for the use of a marketing simulation as the problem in a PBL designed 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 efficacy of simulations as a PBL problem. In order to address this issue, and to answer some of the questions we raised above, we conducted this study using two different simulations in two different courses. We describe each of these simulations below.

The Subjects of the Study

Subjects for the study were juniors and seniors at a medium-sized, university located in the Midwest. All the students were traditional, college-aged students enrolled in one of two courses, a junior-level principles of marketing course or a senior-level strategic management capstone course. The two courses are required of most business majors. Consequently, the students came from a variety of business disciplines. A total of 46 students participated in the study, 24 in the marketing course and 22 in the strategy course.

The Simulations

The simulations used were *Merlin* (Anderson, et al., 2004) and *Threshold Competitor* (Anderson, et al., 2003). *Merlin* is a moderately complex marketing simulation requiring students to make approximately 70 decisions involving elements of the marketing mix (e.g., price, quality, promotion) for each period of play. There are also decisions relating to the purchase of marketing research information and a small number (four) of production and financial decisions. Each decision represents a three-month (i.e., one quarter) period.

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. As with *Merlin*, each decision represents a three-month (i.e., one quarter) period.

Each of these simulations has a Team version (i.e., student-managed companies compete against other student-managed companies) and a Solo version (i.e., one student-managed company competing 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 repeatedly restart the simulation until they achieve results with which they can live. Data collected for this study was based on student experience after working with the Solo version, and before they used the Team version.

While both simulations are similar in complexity, one (Merlin) is discipline specific and was used in this study in the introductory marketing course. The other (Competitor) is a total enterprise simulation used for this study in the strategic management course. By using these two simulations in these two courses, we were able to test the suitability of simulations as a PBL problem across different simulations and different levels of student preparation.

Research Design

In order to implement the Problem Base Learning (PBL) pedagogical model in the two courses used in this study, we introduced each simulation to its respective students in the third class meeting for the course. For each 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 very general overviews of course topics and concepts and a brief introduction to the simulation. At the next class, the students were given the assignment to use the Solo version of the simulation to run their company for one year (four decision sets), and then submit their results. This meant that the students were presented with an assignment to operate their company prior to receiving a framework for decision-making or instruction on how course concepts applied to the simulation exercise. This early use of the simulation exercise met the criteria for its use as a PBL problem.

RESULTS

Table #1 shows the students' perception of the simulation exercise. For students who responded with a positive rating of 5, 6, or 7 on the seven-point scale, nearly two-thirds, or more, of the marketing students saw the Merlin simulation as challenging (85%), stimulating (71%), and engaging (64%). Reaction to the Competitor simulation was even stronger. All (100%) of the management students rated that simulation as challenging and nearly all saw it as stimulating (91%) and engaging (91%).

While 57% of the marketing students rated their simulation exercise as frustrating (a rating of 1, 2, or 3), only 29% thought it was overwhelming and 64% rated it as enjoyable. Similarly, 45% of the management students rated their simulation exercise as frustrating, but only 23% saw it as overwhelming and 82% thought is was enjoyable.

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

	1s	2s	3s	4s	5s	6s	7s	Ave.	Std D
Unpleasant – Enjoyable									
▪ Merlin (N=28)	3.6	0.0	7.1	25.0	46.4	7.1	10.7	4.75	1.27
▪ Competitor (N=22)	0.0	4.5	0.0	13.6	36.4	40.9	4.5	5.23	1.07
Frustrating – Satisfying									
▪ Merlin (N=28)	3.6	14.3	39.3	17.9	14.3	10.7	0.0	3.57	1.32
▪ Competitor (N=22)	0.0	13.3	31.8	9.1	36.4	9.1	0.0	3.95	1.29
Dreadful – Engaging									
▪ Merlin (N=28)	0.0	0.0	7.1	28.6	25.0	28.6	10.7	5.07	1.15
▪ Competitor (N=22)	0.0	0.0	4.5	4.5	27.3	36.4	27.3	5.77	1.07
Simplistic – Challenging									
▪ Merlin (N=28)	0.0	0.0	3.6	10.7	21.4	46.4	17.9	5.64	1.03
▪ Competitor (N=22)	0.0	0.0	0.0	0.0	18.2	45.4	36.4	6.18	0.73
Dull – Stimulating									
▪ Merlin (N=28)	0.0	0.0	3.6	25.0	39.3	25.0	7.1	5.07	0.98
▪ Competitor (N=22)	0.0	4.5	0.0	4.5	27.3	36.4	27.3	5.73	1.20
Overwhelming – Manageable									
▪ Merlin (N=28)	3.6	10.7	14.3	32.1	10.7	25.0	3.6	4.25	1.53
▪ Competitor (N=22)	4.5	4.5	13.6	27.3	22.7	18.2	9.1	4.50	1.54

Table #2 shows student perceptions of the discipline they would study that term and its relation to the simulation exercise. After exposure to the marketing simulation exercise, only 25% felt they were "quite" or "very" knowledgeable about marketing and nearly all of these students (96%) reported that they had "quite a bit" or "an extreme amount" to learn about the discipline. While over one-half (54%) of the students who played the management simulation reported they were "quite" knowledgeable about that discipline, a large majority (73%) still stated that they had "quite a bit" or "an extreme amount" to learn about managing before being able to perform competently as a manager.

Table #2
Student Perceptions of the Discipline and the Simulation

	Not at all		Somewhat		Quite a Bit		Very	
	#	%	#	%	#	%	#	%
How knowledgeable do you feel you are about the discipline of:								
• Marketing? (Merlin)	0	0.0	21	75.0	6	21.4	1	3.6
• Management? (Competitor)	1	4.5	9	40.9	12	54.5	0	0.0
How much do you feel you would have to learn about marketing/managing before you would be able to perform competently as a:								
• Marketing manager? (Merlin)	0	0.0	1	3.6	22	78.6	5	17.8
• Manager? (Competitor)	0	0.0	6	27.3	15	68.2	1	4.5
How well do you think the simulation reflects the discipline of								
• Marketing? (Merlin)	1	3.6	10	35.7	14	50.0	3	10.7
• Management? (Competitor)	0	0.0	2	9.1	12	54.5	8	36.4
How useful will this course be in helping to improve your performance in the:								
• Merlin simulation?	1	3.6	10	35.7	14	50.0	3	10.7
• Competitor simulation?	0	0.0	2	9.1	11	50.0	9	40.9

Table #2 also shows that the students perceived a relationship between the discipline and the simulation exercise. Nearly 61% of the marketing students felt that the marketing simulation accurately reflected the elements of that discipline. Sixty-one percent also reported that they believed the concepts to be taught in the marketing course would be helpful in improving their performance on the marketing simulation. The management students were nearly unanimous (91%) in their belief that their simulation reflected that discipline. Ninety-one percent also thought the management course would be useful in improving their performance on the simulation.

DISCUSSION

The Simulation as a PBL "Problem"

The results of this study provide support for the use of a business simulation exercise as the "problem" in a Problem Based Learning designed course. Student responses indicated that the PBL requirements of (a) an engaging problem and (b) the need to utilize course concepts for effective resolution of that problem exist for both simulations studied. Both the marketing simulation and the management simulation were perceived as challenging (85% and 100%, respectively), stimulating (71% and 91%, respectively) and engaging (64% and 91%, respectively). After their early exposure to the simulations, the students in both the marketing and management courses reported the need to learn more about the respective disciplines (96% and 73%, respectively). They also saw the course they would be taking as useful in improving their performance on the simulation exercise (61% and 91%, respectively).

Clearly, these results show that using these simulation exercises generated a student response consistent with the characteristics of a good PBL problem. The results also show that 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.

Student Level of Preparation

One of our questions was whether using a simulation as a PBL problem in an introductory course would work as well as it does when used in a capstone course. As we discussed earlier, one might reasonably expect that early introduction of a simulation would work well for students in a senior-level capstone course, where students have reasonably extensive knowledge of course concepts prior to entering the course. However, similar early exposure to a simulation might overwhelm students when they are novices to the discipline, as in an introductory course.

Results from this study show that there was a higher degree of frustration with the early exposure to the simulation for students in the introductory course than there was for students in the capstone course (57% vs. 45%, respectively). Perhaps related to this frustration, fewer of the introductory course students versus the capstone course students saw the exercise as enjoyable (64% and 82%, respectively), stimulating (71% and 91%, respectively) or engaging (64% and 91%, respectively). However, it should be noted that the majority of both groups rated the experience favorably on each of these measures. Further, there was little difference between the two groups on whether they perceived the exercise as "overwhelming", with only a minority of each group rating it as such (29% of the introductory course students and 23% of the capstone course students).

As might be expected, more students in the capstone course than students in the introductory course felt they were knowledgeable regarding the discipline to be studied (54% and 25%, respectively). However, the capstone course students were also more likely than introductory course students to see the course as helpful for improving their performance on the simulation exercise (91% and 61%, respectively). It would appear that the increased experience and knowledge base of the capstone course students relative to that of the introductory course students led them to recognize more easily what they don't know and to see how the course can help overcome those deficiencies.

Based on these results, a student's level of preparation is not seen as a limiting factor for using a simulation as a PBL problem. While the level of student preparation can affect their perception of a simulation's ability to meet the PBL requirement for engaging a student's interest, students in both the introductory and capstone courses found the simulation exercise as engaging and challenging, yet manageable. Both groups also believed that the course material would help them improve their simulation performance. In short, regardless of their level of preparation, students ascribed the simulation they worked with as having the characteristics of a good PBL problem.

CONCLUSIONS

We found strong support for use of the simulation as a problem in a PBL designed course. Students perceived the simulation exercise as stimulating and engaging. Following their experience with the Solo version of the simulation, students enrolled in both the introductory and capstone courses also believed the course would help them improve in their future simulation experience. With the Team version of the simulations representing a significant portion of future grades they would receive in the course, improved motivation for learning the concepts taught in the course appears highly probable. This finding held true for two different simulations (*Merlin* and *Competitor*), in two different disciplines (marketing and management), and with two different levels of student educational preparation.

We were pleased with student reaction to the exercises. A major concern was that students would be overwhelmed by the simulation and frustrated as they confronted a situation for which they were not prepared. This was less of a concern for the management simulation than the marketing simulation given the management students were seniors in a capstone course and consequentially should be more prepared for an early introduction to the exercise. As might be expected given their broader knowledge base, fewer of the capstone course students rated the simulation as frustrating than did the introductory course students. But, more importantly, only a minority of *either* group of students saw the simulation as overwhelming and most saw the simulation as challenging, stimulating, and even 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, both simulations were moderately complex. What is still untested are small-scale simulations (e.g., HR staffing) to see if they would work equally well as a PBL problem.

Further, both simulations had a "play-alone" (i.e., Solo) version that was used in this study. This allowed the students to restart the simulation exercise as often as they desired. Would students remain as engaged in the problem if they could not restart the simulation and had only one chance to succeed? Would early introduction of a simulation where students were "stuck" with their initial failures lead to greater frustration and, consequently, disengagement from the exercise? Further replications of this study that address these concerns are needed to understand the range of applicability of simulations as a tool for introducing a PBL designed pedagogy into a course.

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