Improving Operations Management Concept Recollection Via the Zarco Experiential Learning Activity

TONY POLITO
JOHN KROS
East Carolina University
Greenville, North Carolina

KEVIN WATSON
University of New Orleans
New Orleans, Louisiana

ABSTRACT. In this study, the authors investigated the effect of Zarco, an operations management "mock factory" experiential learning activity, on student recollection of operations management concepts. Using a number of single-factor and multiple-factor analyses of variance, the authors compared the recollection of students treated with the Zarco activity with that of controlled students. The results, based on 223 students at two universities, indicate that the Zarco experiential activity had a significant effect on student recollection, especially for those concepts most closely tied to the activity.

Many business schools require their students to complete an operations management (OM) survey course as part of their business core curriculum. The course introduces the students to techniques and concepts that are generally considered to improve the performance of production and service facilities. However, many students typically believe that the course's content, often discussed in the context of "the factory floor," will not be relevant to their intended careers as accountants, marketers, or financiers. Thus, introductory OM students unfortunately often are not as interested in OM course content as instructors would hope. Many instructors would conclude that this disinterest translates into a reduction of student performance. However, a known pedagogical tool called experiential learning—a process through which knowledge is created through the transformation of experience (Kolb, 1984)—can be used to increase student interest and improve course outcomes. An experiential OM "mock factory" learning activity, positioned at the beginning of the course, has the potential to engage the interest of students and thus improve their performance.

Business education literature supports the use of experiential learning toward improvement of course outcomes. For example, Babbar (1994) reported that his OM students perceived the use of an experiential activity that was assigned at the beginning of the semester to be relevant, valuable, and preferable to the traditional instructional mthod. Similar evidence of benefit from experiential learning activities frequently has been reported for other business disciplines as well. Hakeem (2001) found that using experiential learning in a business statistics class improved student examination and GPA performance. The majority of students participating in organizational theory experiential activities at a large Australian business school reported that they enjoyed that method of learning and believed that it supported their learning (Blunsdon, Reed, McNeil, & McEachern, 2003). When an active learning component was included in an introductory marketing course, students reported very high levels of satisfaction, value, and learning (Sautter, Pratt, & Shanahan, 2000). Replacing a macroeconomics lecture with an experiential learning treatment resulted in higher grades (Gremmen & Potters, 1997). Further, measurable learning gains resulted from the use of an experiential activity in an introductory negotiation course at Virginia Tech (Ball, 1999).

The hypothesis that use of a mock factory activity improves student outcomes is one that is also shared by OM instructors who routinely use them in their own classrooms. Bob Jacobs of Indiana University maintains a Web site devoted to the operations management experiential learning activities that he employs (Jacobs, 2003); Ron Wright and Salwa Ammar of Le Moyne College (Ammar, 2003) maintain similar sites. Recent publications document the use of mock OM factory activities that "produce" paper puppets (Heineke, 1997) and playing card suits (Gattiker, 2003) and that use LEGO® blocks as raw material (Satzler & Sheu, 2002). An economics professor at Weber State University uses a paper airplane factory experiential exercise to promote the learning of production costs and productivity (Grijalva, 2002). Many OM instructors have used "Styro," a video-

based mock factory activity originally produced in 1985 by John Deere employees and actively marketed by the American Production and Inventory Control Society (APICS, 2003) ever since it was distributed with a major OM textbook (Schonberger & Knod, 1991). Perhaps the best known cases of OM experiential activities are the red bead and funnel experiments developed by Dr. W. Edwards Deming (1986, 1994); the activities still are used routinely today. All these instructors clearly believe that their students will benefit from the direct observation of OM concepts that they otherwise would find highly abstract. The activity, they think, will support the students' subsequent recollection, reflection, and conceptualization and, in turn, their mastery. That premise—in combination with the positioning of the activity at the beginning of the course—is quite consistent with Kolb's Experiential Learning Cycle (Kolb, 1984).

In the belief that such activities do improve course outcomes, we created and first used the Zarco mock factory activity in 1994. Since then, it has been used at six institutions and continually improved. Although the notion of an OM mock factory did not originate with Zarco, we do believe it to be the most thoroughly developed, quantified, and student-centered activity of its type. This study formally tests for evidence that the Zarco activity improves student performance, specifically recollection of a number of common OM concepts.

Synopsis of the Zarco Mock Factory Activity

The Zarco activity begins with the instructor's assembly of a "ZargPak," a product built from rubber bands, staples, paper clips, and pieces of paper with colored shapes traced on them. Next, the instructor randomly selects four students to organize and operate a ZargPak factory with the aim of producing as many quality ZargPaks as possible within a 10-minute production period. The instructor then gives the four students a handout with assembly details as well as a cautionary note advising them to think carefully about how they will handle product design changes and customer returns. The four factory students are then excused from the room so they can go plan their approach.

Meanwhile, the instructor assigns responsibilities and gives instructional worksheets to the remainder of the students: the customers, who are to inspect the finished products and return defective units to the factory; a marketing manager, who is charged with initiating design changes; and timekeepers and shipping clerks, who will record the times and unit counts used to measure factory performance. The remaining students act as production accountants, who observe and note the quality of factory operation and also calculate a set of simplified quality, rework, scrap, and productivity performance measurements at the end of the production period.

Typically, the Zarco factory begins operations smoothly. However, after several minutes, performance problems—a bottleneck, idle labor, high reject rate, scrap resulting from the design change—usually will evolve and serve to capture the interest of the students. The role of the instructor during this time is to chide the workers humorously with management clichés relating to the problems; this approach is adapted directly from the posture taken by Deming in his facilitation of his red bead experiments. At the end of the production period, the instructor estimates the amount of scrap, rework, and work-in-process, and the production accountants calculate the performance outcomes.

Students usually are very engaged in the postproduction discussion, because they typically have strong opinions regarding what caused the factory problems and how the factory might be improved. The instructor can use the Zarco activity throughout the rest of the course to increase students' interest by informing them that they should be on the lookout for concepts that could be used to improve Zarco performance, because the activity will be repeated at the end of the course.

Method

The participants in this study were undergraduate students enrolled in an introductory operations management course instructed by three tenure-track OM faculty during spring 2003. The courses were taught at two different institutions. One institution is a large, regional Mid-Atlantic state university; the other is a smaller, private Northeastern university. Our study involved 223 students in eight course sections. Course section enrollments ranged from 23 through 42, reasonably equivalent enrollments for the purposes of our study.

Four of the eight course sections were treated with the Zarco mock factory experiential learning activity on the first day of the course. The other four course sections served as an untreated control group; in these sections, the first day was conducted in whatever manner the instructor deemed normal and typical. At the end of the course, students in both the controlled and treated sections completed a survey instrument that collected data regarding their recollection of six common OM concepts. In Table 1, we report the descriptive and exogenous data collected regarding major, gender, class standing, self-reported grade point average, and estimated final grade.

Given that we reasonably could expect effects resulting from other factors such as instructor, institution, and time of day, we designed the experiment to enhance their statistical differentiation. We implemented two treated sections and two untreated ones at each of the two institutions involved in the study. Course section start times progressed continuously through the day, from 8:00 a.m. through 6:30 p.m. Four sections started in the morning (before noon), and the other four sections started in the afternoon. Two morning sections and two afternoon sections were treated; the other four sections were untreated. One instructor implemented two treated sections and two untreated sections. A second instructor implemented two treated sections and one untreated section. The third instructor, who was conducting only one course section during the term, implemented one treatment. The only shortcoming that we noted in this design was that, because one of the institutions was represented by only one instructor, we were unable to distinguish error due to institutional effect through analysis of variance.

Analysis and Discussion

We tested the hypothesis that the Zarco activity increases student recollection of a common OM course by analyzing the survey instrument data provided by participants. The respondents used five-point Likert scales to report their degree of recollection for each of six common OM concepts. We compared a composite variable, created by summing the six responses, with the treatment. In Table 2, we display the results of the relevant single-factor ANOVA.

The p value of .0029 provided strong and significant evidence of increased recollection resulting from the Zarco activity. We also conducted a multiple-factor ANOVA to determine Zarco treatment significance when considering the other known variables. We report these results in Table 3. We found significant effects only for the instructor and estimated final grade factors. Although we found the Zarco treatment to be significant in the multifactor model, the resulting p value of .1895 still supports the argument for the Zarco effect when the value is compared with most of the other factors that generated p values quite near 1.00.

We found further strong evidence to support the recollection hypothesis when we re-analyzed the data, taking into account each concept's degree of experientiality. Three of the concepts—scrap, rework, and quality—were highly related to the experiential components of the Zarco activity; the participants directly observed the accumulation of scrap, rework, and quality materials and then computed the associated measures at the conclusion of the activity. The other three concepts—production planning, assembly lines, and effect of production changes—although observable in the Zarco activity, were less experiential in nature than the former three concepts. We created two composite variables, one for the "highly experiential" concepts and one for the "less experiential" concepts. We display the resulting multifactor ANOVA for the highly experiential concepts in Table 4.

The model, with an overall p value of < .0001, found strong significance for the Zarco treatment (p value of .0033), even with all the known factors considered. The only other factors of any significance were, again, instructor and estimated final grade. We performed a multifactor analysis (not presented in the tables) for the less experiential concepts; this analysis, with an overall p value of < .0001, found significance only for estimated final grade. These two analyses demonstrate that recollection of those concepts most closely tied to the Zarco experiential activity was significantly and positively influenced by the Zarco activity.

TABLE 1. Sample Descriptive Statistics

Factor	*N*	%	Minimum	Maximum	*M*
Self-reported GPA	223	—	2.75	4.00	3.15
Estimated final grade	223	—	1.00	4.00	2.99
Standing					
Freshman	8	3.6	—	—	—
Sophomore	37	16.6	—	—	—
Junior	127	57.9	—	—	—
Senior	51	22.9	—	—	—
Major					
Accounting	28	12.6	—	—	—
Decision sciences	18	8.1	—	—	—
Finance	58	26.0	—	—	—
Management	57	25.5	—	—	—
Marketing	62	27.8	—	—	—
Gender					
Male	129	57.8	—	—	—
Female	94	42.2	—	—	—

TABLE 2. Single-Factor ANOVA Model: Questions 1 Through 6

Source of variation	*SS*	*df*	*MS*	*F*	*p* value
Zarco treatment	131.51	1	131.51	9.10	0.0029
Error	3192.14	221	14.44		
Total	3323.65	222			

TABLE 3. Multifactor ANOVA Model: Questions 1 Through 6

Source of variation	*SS*	*df*	*MS*	*F*	*p* value
Zarco treatment	21.27	1	21.27	1.73	.1895
Instructor	81.96	1	81.96	6.68	.0105
University	—	1	—	—	—
Morning/afternoon	0.11	1	0.11	0.01	.9252
Self-reported GPA	28.89	7	4.13	0.34	.9366
Estimated final grade	362.64	3	120.88	9.85	.0001
Standing	21.28	3	7.09	0.58	.6300
Major	26.00	5	5.20	0.42	.8318
Gender	0.03	1	0.03	0.00	.9583
Error	2441.91	199	12.27		
Total	3323.65	222			

TABLE 4. Multifactor ANOVA Model: Highly Experiential Concepts

Source of variation	*SS*	*df*	*MS*	*F*	*p* value
Zarco treatment	41.59	1	41.59	8.85	.0033
Instructor	98.57	1	98.57	20.97	.0001
University	—	1	—	—	—
Morning/afternoon	1.00	1	1.00	0.21	.6448
Self-reported GPA	15.74	7	2.25	0.48	.8495
Estimated final grade	120.94	3	40.31	8.58	.0001
Standing	2.90	3	0.97	0.21	.8922
Major	6.51	5	1.30	0.28	.9253
Gender	0.00	1	0.00	0.00	.9886
Error	935.46	199	4.70		
Total	1722.22	222			

Conclusion

The results of our study support the hypothesis that the Zarco activity significantly affects OM concept recollection. In a more general sense, our study contributes to the body of knowledge that supports the use of experiential activities for improvement of student outcomes.

Our results also suggest areas for future research. This study could be repeated with a design that improves control of the instructor, institution, and estimated final grade factors for a more accurate gauge of the significance of the Zarco treatment. We encourage the use of the Zarco activity to further research and enhance instruction. At this writing, the student handouts and instructor lesson plan for the Zarco activity can be downloaded from http://www.tonypolito.com/zarco.doc.

REFERENCES

APICS. (2003). *APICS catalog directory, educational materials.* Retrieved July 1, 2003, from http://www.apics.org/scripts/bookstore/catalogfind.asp?id=593&title=true

Babbar, S. (1994). Molding students into better decisionmakers and managers: An experiential learning exercise. *Journal of Education for Business, 69*(3), 149–153.

Ball, S. (1999). Pareto optimality in negotiation: A classroom exercise for achieving active learning. *Journal of Education for Business, 74*(6), 341–346.

Blunsdon, B., Reed, K., McNeil, N., & McEachern, S. (2003). Experiential learning in social science theory: An investigation of the relationship between student enjoyment and learning. *Higher Education Research & Development, 22*(1), 43–56.

Deming, W. E. (1986). *Out of the crisis.* Cambridge, MA: Massachusetts Institute of Technology Center for Advanced Engineering Study.

Deming, W. E. (1994). *The new economics for industry, government, education* (2nd ed.). Cambridge, MA: Massachusetts Institute of Technology.

Gattiker, T. F. (2003). P-chart card game: The case of the new supplier. *Decision Sciences Journal of Innovative Education, 1*(2), 289–294.

Gremmen, H., & Potters, J. (1997). Assessing the efficacy of gaming in economic education. *Journal of Economic Education, 28*(4), 291–303.

Grijalva, T. C. (2002). *Paper airplane factory.* Retrieved July 1, 2003, from http://faculty.weber.edu/tgrijalva/econ4010%20fall%202002/handouts%20solutions%20and%20experments/paper%20airplane%20factory.pdf

Hakeem, S. A. (2001). Effect of experiential learning in business statistics. *Journal of Education for Business, 77*(7), 95–98.

Heineke, J. (1997). Enhancing learning using classroom games and exercises. *Quality Management Journal, 4*(4), 32–42.

Jacobs, R. (2003). *POM e-games.* Retrieved July 1, 2003, from http://www.pom.edu/e-games.htm

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice-Hall.

Satzler, L., & Sheu, C. (2002). Facilitating learning in large operations management classes using integrated LEGO projects. *Production & Inventory Management Journal, 43*(3/4), 72–77.

Sautter, E. T., Pratt, E. R., & Shanahan, K. J. (2000). The marketing Webquest: An Internet based experiential learning tool. *Marketing Education Review, 10*(1), 47–55.

Schonberger, R. J., & Knod, E. M. (1991). *Operations management: Improving customer service* (4th ed.). Homewood, IL: Irwin.

Wright, R. H., & Ammar, S. (2003). *Experiential learning activities for operations management.* Retrieved July 1, 2003, from http://web.lemoyne.edu/~wright/learn.htm