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Vertical Integration: Results From a Cross-Course Student Collaboration

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The authors report the results of a cross-class project involving sophomore-level students in an Operations Analysis (OA) class with junior-level students in an Operations Management (OM) class. The students formed virtual teams and developed a simulation model of a call center. The OM students provided the management expertise, while the OA students provided the technical background. Our objective was to reinforce concepts from both courses while providing an opportunity to work in virtual teams. Results suggest great dissatisfaction with virtual teams. Many communication and technology challenges need to be overcome to make this approach a practical one.

Keywords: assessment, collaborative learning, student teams, virtual teams

In many business curricula, courses are intended to be taken in a sequence so that more advanced courses can build on the introductory courses. For example, students are typically required to take financial accounting before managerial accounting, and marketing principles before marketing tactics. However, it can be difficult to control when students take courses that are to be part of a sequence. All too often students do a knowledge dump of all the material they learned during a given term. Thus, it is a challenge to tie course material together in a meaningful and synergistic way.

Some pilot studies have tried what is called horizontal integration; that is, team teaching the content of a number of the functional areas. For example, at the featured institution, a two-semester, 18-credit class that included all of the advanced core business classes was offered. Other institutions have tried similar plans using cases or real-world problems to link two or more courses.

In the present article we report the results of a cross-class project involving sophomore-level students in an Operations Analysis (OA) class with junior-level students in an Operations Management (OM) class. The students formed virtual teams and completed a short case study involving an operations problem. To our knowledge, the idea of vertical integration, that is, linking a lower and upper division course, is new.

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LITERATURE REVIEW

Business leaders agree that the ability to work in teams is essential to the success of individuals and organizations. A great deal of research has been performed to study various aspects of student teams. Deeter-Schmelz, Kennedy, and Ramsey (2002) developed a model of team effectiveness and test it in the context of a marketing course. Many authors use specific classroom projects or activities to examine student team effectiveness in particular courses or disciplines such as marketing (Graham, Graham, & Whiting, 1997), management (Xu & Yang, 2010), information systems (Hasan & Ali, 2007), and operations management (Yazici, 2004), as well as in more general settings (Chapman, Meuter, Toy, & Wright, 2010; Sargent, Allen, Frahm, & Morris, 2009).

Cross-functional teams—those composed of members from several departments, disciplines, or classes—have also been the subject of previous studies. Crittenden and Wilson (2006) reported on the use of cross-functional teaching in marketing departments at colleges and universities. Many researchers have reported the results of specific projects including teams that integrate traditional business functions, such as marketing and operations (Darian & Coopersmith, 2001; Kruck & Teer, 2009); teams that cross disciplines, such as engineering and business (Grinols, 2008); and teams

that traverse international boundaries (Ross, Zufan, & Rosenbloom, 2008).

A final area of relevant research deals with virtual teams, where members generally do not work in the same place and thus often communicate electronically rather than face to face. Breaking down the traditional barriers of time, space, and organization affords much greater flexibility in forming teams, and the popularity of this practice has grown tremendously over the years as communication technology improves (Thilmany, 2008). Powell, Piccoli, and Ives (2004) discussed the evolution of virtual teams and presented an extensive review of related research. Although virtual teams have proven to be quite effective in many contexts, their very nature has a strong influence on what types of projects can be undertaken, the flow of work, and the organizational structure (Powell et al.; Townsend, DeMarie, & Hendrickson, 1998). From the classroom perspective, numerous case studies have reported how virtual teams are used in online classes (Williams, Duray, & Reddy, 2006) as well as in traditional, face-to-face classes (Barker & Stowers, 2009; Eveleth & Baker-Eveleth, 2003).

Although all of these works make important contributions to our understanding of teams, none address the particular situation of interest in this article: student teams that are virtual, cut across disciplines, and transcend class rank.

METHOD

All business students at the University of Massachusetts Lowell are required to take a two-course sequence in operations, one of the core business disciplines. The first course, Operations Analysis (OA), covers a range of quantitative decision-making tools such as linear programming and waiting line models, and it is typically taken in the sophomore year. The second course, Operations Management (OM), covers topics such as process design and capacity management, and it is typically taken in the junior year. More details about the courses are reported in Appendix A. Despite the obvious connections between the two courses, they often do not complement each other. OM teachers must often review techniques from the OA class, or even start over given the 3–12-month break between taking the two classes.

One of the simplest ways to connect the two courses is via a technique called *simulation*, which uses computer models to mimic real-life systems and processes. System variables and structure are defined, and the variables can then be changed to study different scenarios and make predictions about how the real system would behave. This technique can be used to model virtually any process and has been used in many fields. Thus, simulation is a good fit for pedagogical and practical reasons. After surveying available simulation software, we chose a package called SimQuick (Prentice-Hall, Englewood Cliffs, NJ) because it integrates with Microsoft Excel, is easy to use (Hill, 2002), and is much less expensive than other simulation packages (Swain, 2009).

Research has shown that students learn more, retain more, and enjoy the process more when they work in small groups (Davis, 2009). The goal of the exercise was for the OA students to get a sense of how the models can be used to solve larger scale problems and for the OM students to get an opportunity to mentor the OA students while solidifying their understanding of simulation. In addition to stretching the students' abilities, the case study also brought to light the connections between the two courses.

The exercise took place about nine weeks into the 14-week fall 2009 semester. The OA students had covered the basic concepts of simulation, solved some small problems in class, and completed a homework assignment requiring them to build and use simulations of simple waiting-line systems. The OM students had covered the basic concepts of process analysis and capacity management. Students from each class formed subgroups of 3–4 students, and these subgroups were then matched to form a cross-class group of 6–8 students.

The teams were assigned a case study, which involved analysis of a call center for a large company. Customers call a hotline for technical support issues related to computer software. If available, a representative answers the call right away; otherwise, the customer waits on hold for the next available representative. The purpose of the case study is to evaluate the effects of different operations-related variables (e.g., the number of technical support representatives) on the call center's performance. The exercise involved three parts: a) the OM students were required to analyze the process and to develop a flow diagram, b) the OA students took the flow diagram and developed a simulation model (similar to an example provided in the SimQuick manual), and c) the cross-class group worked together to analyze the call center and examine various scenarios using the simulation model. The joint group submitted a brief report summarizing their findings and recommendations. Interested readers may contact the authors for a copy of the assignment.

Team activities and communication were coordinated through Blackboard, the university's web-based learning management system. Students were asked to use either or both the chat and discussion forums available on the class website for all parts of the assignment. For example, even though the OM students could complete the first part of the assignment in a face-to-face setting, we felt that it was important to document the discussion and problem solving in a way that the OA students could access. Grades for the assignment were weighted heavily on the process and evidence of understanding (80%), rather than on the final outcomes (20%).

The idea of doing a cross-class assignment that combined lower and upper level students was new to not only the students, but also the instructors. Nevertheless, we had some

expectations about how the exercise would turn out, as summarized in the following propositions:

- *Proposition 1*: Students tend to forget specific course content after completing a class.
- *Proposition 2*: Working in cross-class, vertically-integrated teams would enhance learning outcomes.
- *Proposition 3*: Working in virtual teams would present communication and coordination challenges.

Note that all of the propositions apply to the learning process in general and thus are not unique to the subject matter covered. Next, we discuss the results of the exercise.

RESULTS AND DISCUSSION

Students were asked to fill out a simple questionnaire prior to the exercise and another one after the exercise. The questionnaires were submitted anonymously through Blackboard. Between five class sections, there were 73 OA students and 100 OM students, and over 80% of the students participated. Our surveys had four questions that required responses on a 5-point Likert-type scale ranging from 1 (*very comfortable*) to 5 (*very uncomfortable*), three questions that required a yes–no response, and several open-ended questions. All of the survey questions are listed in Appendix B. Students were asked to complete the postassignment survey within 48 hr of the final report submission. The sample sizes for both classes dropped off after the assignment (from 47 to 39 in OA and from 90 to 83 in OM), perhaps indicating a decrease in interest. We subsequently describe the before-and-after results for each main area covered in the questionnaire.

Exposure to Simulation Modeling

Students seemed quite familiar with simulation models before starting the exercise, with 87% of OA students and 95% of OM students indicating that they had discussed simulation in class before. In fact, the OA class had just covered the basic material on this topic, so we expected this response rate to be higher. Interestingly, the responses changed dramatically in the postassignment survey. The postassignment question was also phrased differently: Were you exposed to simulation modeling before this class? Only 64% of the OA students and 46% of the OM students responded "yes" to this question—a marked decrease. This result suggests that although the students were familiar with the term *simulation*, they also recognized that perhaps there were underlying concepts with which they were not familiar.

Group Work and Virtual Teams

Students in both classes had much less experience working in virtual teams, but the OM students had much greater exposure (23% for OA vs. 51% for OM). Very few students had worked on an assignment with another class (21% for OA vs. 13% for OM). This part of the exercise elicited very strong responses from the students in the open-ended response section of the survey. Some students thought that the exercise would be interesting. Many students, however, expressed concerns about coordinating activities with students from another class.

In the postassignment survey, both groups were decidedly unsatisfied with the cross-class group aspect of the exercise. Only 1% of OA and OM students thought that the groups were very successful, whereas a consistent 21% thought that the groups were very unsuccessful. On a more positive note, 44% of the OA students and 36% of the OM students thought the results were somewhat successful. These results indicate that from the students' perspective Proposition 2 is not supported. However, it is important to note that success and benefit are not synonymous here. That is, the students may have learned a great deal but still perceived that the exercise was unsuccessful, and vice versa.

As for the virtual team experience, overall less than one third of all students (31% of OA and 24% of OM) indicated a positive experience with the virtual teams. The open-ended responses for this topic indicated a high level of dissatisfaction with the virtual teams. Specifically, many students cited communication problems and suggested that the students from the other class had not done their fair share of the work. Part of the challenge, it seems, had to do with students not knowing their virtual teammates, and to some degree a bonding with the teammates in their own class. Students were allowed to form their own groups within their own classes, a further indication of a positive bond within the class that may not have been felt across classes. Thus, there is ample support for Proposition 3.

Waiting Line Models

Table 1 reports the full set of results for this question for pre- and postassignment surveys. In the preassignment survey, the OA students were much more comfortable than the OM students with respect to waiting line models (57% indicating either somewhat or high comfort levels from the OA students vs. 20% of the OM students). The higher comfort level for the OA students is probably due to the fact that they had recently covered waiting lines in class. This result also provides support for Proposition 1: students tend to forget course material.

It would be hoped that independent of the class, having done a hands-on exercise, all groups would feel more comfortable after as compared to before the exercise, and this was indeed the case for waiting line models. A total of 72% of OA students reported that they were very or somewhat comfortable, a substantial increase over the before survey. The very or somewhat comfortable response was 37% for the OM students—also a substantial increase. However, the

TABLE 1
Comfort Levels Before and After Class Exercise:
Waiting Line Models (% of Responses)

Response	OA before ($n = 47$)	OA after ($n = 39$)	OM before ($n = 90$)	OM after ($n = 83$)
Very comfortable	19	26	10	1
Somewhat comfortable	38	46	10	36
Somewhat uncomfortable	23	21	33	24
Very uncomfortable	2	0	8	0
Neither	17	1	39	33

neutral response changed very little for the OM students: 39% before and 33% after.

Building Simulation Models

We asked separate questions about building and using simulation models, because we feel that they require different sets of skills. Building a simulation model requires a detailed understanding of the process being modeled as well as the underlying sources of variability, but using the model does not require this depth of understanding. Table 2 reports the results for this item.

When asked about their confidence in building a simulation model, only 36% of OA students indicated either very or somewhat comfortable building a simulation model, whereas 53% of OM students indicated either very or somewhat comfortable. These results are more in line with expectations. The OA students had just finished the basics of simulation models at the time of the survey, whereas the OM students had been exposed to simulation in more depth, albeit months before. This result suggests that Proposition 1 may not be true for this particular subject. It is interesting to note that building the simulation model was the primary responsibility of the OA students in this exercise, and perhaps this influenced the responses.

In the postassignment survey, the comfort level with building simulation models increased dramatically for the OA students (jumping from 36% to 61% for very or somewhat comfortable) and decreased dramatically for the OM students (dropping from 53% to 40% for very or somewhat comfortable). The decrease for the OM students may indicate a level of frustration with the OA students who, according to their OM group members, did not construct the simulation model in a timely manner in many cases. It may also suggest that the OM students did not remember as much as they thought that they had prior to the assignment.

Using Simulation Models

Table 3 reports the results for this item for both pre- and postassignment surveys. In the preassignment survey, 57% of OA students indicated either very or somewhat comfortable using simulation models, whereas only 44% of OM students indicated either very or somewhat comfortable.

We expected that if there were any retention from OA to OM, then the OM students would have shown more comfort. Thus, there is some support for Proposition 1. This result may be partially driven by different interpretations of building versus using, and perhaps this needs further explanation in the future. A positive interpretation of these results is that an exercise such as this one potentially has value in reviewing and reinforcing the concepts from the OA course. A negative interpretation may be that insufficient time is being spent in the OA class teaching some key concepts and tools.

In the postassignment survey, the results for the using question mirror the response for the building question discussed previously. Specifically, the OA students' comfort level went up (rising from 57% to 66% for very or somewhat comfortable), whereas the OM students' comfort level went down (slipping from 44% to 34% for very or somewhat comfortable). This result indicates some support for Proposition 1. The OM students rated themselves as more comfortable with simulation before the exercise than after the exercise, suggesting that they did not retain some key concepts from the OA class. What is even more revealing, perhaps, is the shift from somewhat comfortable for the OA students. In the postexercise survey the very comfortable and somewhat uncomfortable responses increased, whereas the somewhat comfortable responses decreased. In other words, some OA students who were on the fence prior to the assignment clearly made up their minds one way or another.

TABLE 2
Comfort Levels Before and After Class Exercise:
Building a Simulation (% of Responses)

Response	OA before ($n = 47$)	OA after ($n = 39$)	OM before ($n = 90$)	OM after ($n = 83$)
Very comfortable	4	15	8	1
Somewhat comfortable	32	46	45	39
Somewhat uncomfortable	28	18	7	25
Very uncomfortable	4	1	9	2
Neither	32	15	31	30

TABLE 3
Comfort Levels Before and After Class Exercise:
Using a Simulation Model (% of Responses)

Response	OA before ($n = 47$)	OA after ($n = 39$)	OM before ($n = 90$)	OM after ($n = 83$)
Very comfortable	2	15	9	1
Somewhat comfortable	55	49	32	33
Somewhat uncomfortable	11	21	14	25
Very uncomfortable	0	0	8	1
Neither	32	15	28	28

CONCLUSIONS

In the present article we reported the results of a collaborative exercise involving virtual teams made up of students from a sophomore-level OA course and a junior-level OM course. Students gained value from this exercise, but in ways different than had been intended. Going into this project, we had three major expectations. First, we suspected that students tend to forget material between the OA and OM class. The results from out pre- and postassignment survey provide some support for this idea, although there was not a consistent pattern.

Second, because OA is a prerequisite to the OM course, we anticipated that learning outcomes would be enhanced by vertical integration. Our thought was that OM students would have an opportunity to review concepts from the OA class and would take a leadership role in the assignment. However, our surveys did not bear this out. In addition, there did not seem to be clear patterns with respect to the quality of the student deliverables—the OM part, the OA part, or the combined part. Rather, the differences seemed to be individual—students from either class who were motivated helped their classmates independent of which class they were in.

Third, we expected that working in virtual teams would be challenging. We found overwhelming evidence to support this idea, in terms of the numerical responses and open-ended responses in the survey. Both classes reported a high level of frustration with the other cross-class teammates. We expected the Blackboard discussion boards and chat rooms to help with this issue, but apparently more resources and/or training were needed.

This type of cross-class exercise was new to almost everyone. We suspect that if this kind of project were institutionalized (that is, all teachers of all sections using it) the success rate would be much higher. It would be interesting to repeat the exercise in a follow-up semester with the students who were involved in the OA class when they took OM, to see if they retained specific subject content or general lessons about working in virtual teams. Additionally, the time required by the instructors to manage the project is very large, but if proper rewards or benefits are foreseen, instructors would be encouraged to do so.

We found the cross-class exercise to be interesting and challenging in unexpected ways. The biggest obstacle by far was communication between classes. To address this issue we offer the following suggestions:

1. **Training.** Class time must be allocated to inform students about the functioning of virtual teams. Issues such as timely communication, the importance of a team leader, the importance of a group representative, and listening versus evaluative skills must be encouraged. In addition, a demonstration of the discussion boards and chat forums would be useful.
2. **Timing.** The participating classes should be offered at concurrent times or at least on the same days to facilitate one or more meetings between the two classes.
3. **Online assistance.** Instructors should both schedule chat hours during the exercise to allow for questions to be answered and to clarify expectations. It is hoped that doing this would help encourage students to make use of online resources.

Challenges also arose with respect to the structure and content of the assignment. The following recommendations address these issues:

1. **Background.** Students in both classes need sufficient time to master the foundation material before being asked to do the cross-class exercise. In our case, there was some evidence that the OA students did not have adequate confidence with simulation modeling. If possible, some portion of each class during the span of the exercise should be devoted to reviewing important concepts and linking it to the cross-class assignment.
2. **Grade weight.** Adequate grade value must be placed on the exercise to get the students' attention. The suggestion is to increase the value from 5% to 10% or even 15% of the course grade.

To really fully understand the value of a vertically integrated exercise, the pilot project would have to be expanded and more data would have to be collected. Ideally, we would compare learning outcomes with respect to waiting lines and simulation against a control group that did not participate in the exercise. Another issue to consider is the time between taking the OA class and the OM class for individual students. Finally, more details about team dynamics, such as the emergence of a team leader, would be of interest. We hope to pursue these extensions in future iterations of the exercise.

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APPENDIX A: Course Details

Operations Analysis (OA)

General description: Introduction to quantitative methods for analyzing business problems.
Semester: Fall 2009
Students enrolled: 73
Textbook used: *Quantitative Analysis for Management*, 10th ed., by Barry Render, Ralph Stair, and Michael Hanna (Pearson Prentice Hall, 2009).
Topics covered: Decision analysis, linear programming, integer programming, waiting lines, simulation, network models, and project management.

Operations Management (OM)

General description: Principles of production/operations management; nature and function of production systems.
Semester: Fall 2009
Students enrolled: 100
Textbook used: Selected chapters from *Operations Management: Processes and Supply Chains*, 9th ed., by Lee Krajewski, Larry Ritzman, and Manoj Malhotra (Pearson Prentice Hall, 2010).
Topics covered: Process analysis, quality management, capacity planning, inventory management, forecasting, and supply chain management.

APPENDIX B: Survey Questions

Preassignment Survey Questions

Which class are you in?

OA *OM*

Have you discussed simulation in class before?

Yes *No*

Do you like group exercises?

Yes very much *Yes but not very much* *Just a little* *No not at all*

Have you every done an exercise which included members of another class?

Yes *No*

Have you ever worked in virtual teams before?

Yes *No*

How comfortable are you with waiting line/queuing models?

Very comfortable (1) *Somewhat comfortable (2)*
Neither comfortable nor uncomfortable (3) *Somewhat uncomfortable (4)*
Very uncomfortable (5)

How comfortable do you feel with building a simulation model?

Very comfortable (1) *Somewhat comfortable (2)*
Neither comfortable noruncomfortable (3) *Somewhat uncomfortable (4)*
Very uncomfortable (5)

How comfortable do you feel with using a simulation model?

Very comfortable (1) *Somewhat comfortable (2)*
Neither comfortable nor uncomfortable (3) *Somewhat uncomfortable (4)*
Very uncomfortable (5)

Any general comments you have on being asked to perform a group task?

Postassignment Survey Questions

Which class are you in?

OA *OM*

Were you exposed to simulation modeling before this class?

Yes *No*

Do you like group exercises?

Yes very much *Yes but not very much* *Just a little* *No not at all*

How would you classify your experience of working with students from another class?

Very comfortable (1) *Somewhat comfortable (2)*
Neither comfortable nor uncomfortable (3) *Somewhat uncomfortable (4)*
Very uncomfortable (5)

Did you like working in a virtual team?

Yes *No*

How comfortable are you with waiting line/queuing models now, as compared to before the exercise?

Very comfortable (1) *Somewhat comfortable (2)*
Neither comfortable nor uncomfortable (3) *Somewhat uncomfortable (4)*
Very uncomfortable (5)

How comfortable do you feel with building a simulation model now, as compared to before the exercise?

Very comfortable (1) *Somewhat comfortable (2)*
Neither comfortable nor uncomfortable (3) *Somewhat uncomfortable (4)*
Very uncomfortable (5)

How comfortable do you feel with using a simulation model now, as compared to before the exercise?

Very comfortable (1) *Somewhat comfortable (2)*
Neither comfortable nor uncomfortable (3) *Somewhat uncomfortable (4)*
Very uncomfortable (5)

Any general comments you have on this exercise.