Integration of teaching and research: The active-learning and research-led approach in integrating multi-disciplinary concepts in operations management.

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ABSTRACT

In this research, the focus is on integrating teaching and research using the research-led approach where students learn about research findings through active participation in research activities and faculty research interests lead the curriculum content. Using the student active-learning as the center of an experiential activity, the paper presents the experience of enhancing student learning through a product redesign game to understand the interactions between cost goals and information timing. The continuous opportunity to use the game also provided data for further collaborative research that was published in a top-tier research journal. The win-win experience and the lessons learned are shared.

KEYWORDS: Integrating teaching and research, new product development, cost goals, experiential learning, information timing

INTRODUCTION

Recently a faculty-colleague of mine retired from our department after 35+ years of exemplary service. When he spoke during his retirement party he nostalgically recalled how during his initial years, University (business school) wanted him to only focus on teaching and conduct research and dissemination of research in his “personal time”. He lamented how times have changed today. This made me reflect on my own experience in linking teaching and research in a progressive manner and that is the focus of this paper. I am not going to discuss about whether we should do it or what are the pitfalls in doing the same. Rather, I will focus on the benefits using literature, and also modern strategies for successfully integrating the two iconic branches of pedagogy. Following this, I will be using a research that was conducted over a 5-year period involving several groups of students as part of an operations course and an accounting course, which provided opportunity for valid data collection using “experimental research” through “experiential learning,” and how the analysis of the data led to a collaborative research article published recently in a top-tier accounting journal (Gopalakrishnan, et. al., 2015)

LITERATURE REVIEW

The benefits of integration of teaching and research are non-trivial. First and foremost, it is known that increased knowledge through research certainly improves instructive
competence. Second, it is said that a teacher doing research is more likely to be intellectually alive that generally translates to involvement, and enthusiasm in the classroom. Third, research breeds good intellectual habits and the thorough organizational skills in research tend to influence structure and depth in preparing individual lectures or courses. Finally, students with research teachers have the opportunity to view great minds at work and by virtue of these examples better learn the habits of critical, reflective reason (Altbach and Lewis, 1995). So, if teaching were approached as a scholarly activity, looked at in terms beyond technique, and seen as a phenomenon worthy of study, reflection, and dialogue, then possibilities for integrating teaching and research would open onto new vistas (Weimer, 1997).

The NSF funded Center for the Integration of Research, Teaching, and Learning (CIRTL) formed as a collaborative effort between the University of Wisconsin–Madison, Michigan State University, and Pennsylvania State University, uses three conceptual “pillars” to guide CIRTL’s plans, programs, and activities in grooming future faculty who could integrate teaching and research. These include: Teaching-as-Research (TAR), Learning Communities (LC), and Learning through-Diversity (LTD). Specifically, TAR “involves the deliberate, systematic, and reflective use of research methods to develop and implement teaching practices that advance the learning experiences and outcomes of students and teachers.”

The framework developed by Griffiths (2004) classifies teaching as: (a) research-led: where students learn about research findings through active participation in research activities where the curriculum content is led by faculty research interests, and information transmission is the main teaching mode; (b) research-oriented: where students learn about research processes; or (c) research-based: where students learn as researchers, and the curriculum is largely designed around inquiry-based activities.

In this paper we focus on research-led paradigm to integrate teaching and research.

Furthermore, “active-learning” has been promoted as an excellent strategy for improving student cognition and retention. Active learning is generally defined as any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing (Prince, 2004). Introducing student activity into the traditional lecture, and promoting student engagement through collaborative learning are touted as the cornerstone of “active learning.” It is also shown that active learning improved learning outcomes relative to individual work across the board (Prince, 2004).

Lastly, the Stanford University center for teaching and learning provides the following four tips for instructors to bring the process as well as the products of research into the classroom (Teaching common, 2016).

(a) Use of current research perspectives, paradigms, and debates in the classroom to show that knowledge is contested and growing, rather than accepted fact.
(b) Inclusion of recent research results as part of curriculum content.
(c) Introduction of both generic and subject-specific research skills and scholarly activities into course assignments, including literature review, experiment design, peer
review, book review, conference paper presentation, and grant application.
(d) Providing opportunities to let students into your research community in small ways by requiring them to join scholarly email lists or discussion boards, use online conference proceedings as resources for class assignments, or attend departmental talks.

To summarize the literature, three issues relevant to this paper stand out as critical ones for attempting to integrate teaching and research.

(a) The focus of the effort described here is “research-led”, where a particular topic is used to provide an experiential-learning opportunity for the students that also serves to provide data/information from an experimental methodology used in answering research questions related to cost specificity and new product development (NPD) process.

(b) The concepts involving cost goals and information handling for NPD are taught using the “active-learning” approach, where students are totally involved in redesigning a product using “Lego” blocks and work in teams to enhance collaborative learning. Later the de-briefing of the game also provides an opportunity to enhance comprehension of the concepts covered as learning objectives for this topic.

(c) Lastly, the whole process follows the one of the tips provided by the teaching and learning center at Stanford University that encourages using the current research perspectives and paradigms to discuss the role of cost goals in NPD. The experiential-learning and the data (class results and its comparison to other data collected) helps shape the debate of conditions where cost goals are effective. Follow-up in executive MBA classes have led to anecdotal evidence that the learning from this course (and the particular topic) has influenced managerial thinking in dealing with cost targets.

Research perspectives

Many firms that compete based on the development of new and innovative products have begun to adopt concurrent new product development (NPD) processes in which product design phases occur in a non-linear and iterative manner. While concurrent NPD processes increase flexibility and reduce time-to-market as compared to traditional sequential processes, concurrency increases task uncertainty since the product design process begins before all important product features and specifications have been established. Such changes can result in costly redesign and rework. Prior research suggests target costing, where product design teams are assigned specific cost goals, is an effective method of controlling costs in sequential NPD. Even so, it unclear whether target costing will improve cost reduction performance when combined with a concurrent NPD process due to increased task uncertainty. We examine experimentally the ability of product design groups to achieve specific or general cost reduction goals under simulated sequential or concurrent NPD. We predict and find that the nature of the NPD process moderates the effect of specific cost reduction goals on actual cost reduction performance. While specific cost goals result in higher reductions in product
cost than general cost goals under a sequential NPD process, specific goals are no better than general goals in motivating design groups to reduce product cost under a concurrent NPD process; thus, we demonstrate boundary conditions on the usefulness of target costing as a cost control method (Gopalakrishnan et. al., 2015).

**Research-led Teaching:**
Both my co-researcher who teaches in the accounting department and me teaching in the supply chain management department collaborated on collecting data using the graduate level managerial accounting, and operations and supply chain management courses to utilize the research-led approach to teaching. We chose target costing as the appropriate teaching module in accounting and new product development as the module in the operations course. We also predominantly chose the classes at the evening MBA and executive MBA courses, since it provided us with students with reasonable amount of work-experience so that they would deal with cost targets in their line of work. Also, these classes were at least 3 hours long, which gave us the time to implement the experiential learning game and also conduct experiments using the game.

We were careful to avoid the students who overlapped both our courses to minimize duplicity of information. We also chose programs across the country and delivered these modules as guest lectures that gave us the opportunity to engage more students from diverse environments. Students coming to either of the classes were given standard reading material in target costing and the new product development phases (including relevant chapters from the prescribed books in managerial accounting and operations management). In addition, a research article that links the two through NPD metrics was also provided (e.g., Afonso et. al., 2008). Both the introduction of target costing and the NPD processes (sequential versus concurrent) were briefly touched upon from information-theoretic perspectives. For example, “target costing” was introduced as a pricing method used by firms for reducing the overall cost of a product over its entire life-cycle with the help of production, engineering, research and design. Without going over the mechanics at this juncture, students were told that market and other cost information leads to “cost targets.” The cost targets could be a fixed one versus a general one (do the best you can). Similarly, for NPD processes they were informed that the information timing differentiated the sequential versus concurrent processes. In the former, all information is generally available for a phase to start its part of the work, while in the latter a phase further down the NPD chain might start with incomplete information and update as new information comes in. Before the start of the experiential learning activity explained next, students do not generally have a well-formed idea of when cost goals would be effective. In other words the following hypothesis that was tested and results published in the research paper is not articulated to them, rather allowing them to uncover through the game and the follow-on discussions.

“The nature of the product design process will moderate the relation between cost goal specificity and cost reduction performance; groups assigned a specific cost goal will reduce product cost more than groups assigned a general cost goal under a sequential, but not a concurrent NPD process.” (Gopalakrishnan et al., 2015)
Experiential learning through the Lego game:

The game entails building and costing a truck using the Lego blocks. The finished product is provided in figure 1. Students are assigned to teams in a random fashion (team size was controlled at three). We were able to collect data from hundred plus teams.

![Figure 1 Finished Original Truck Design using Lego blocks](image)

Each team was provided with a packet containing the Lego pieces, instruction sheet on how to build the truck and a spreadsheet provided for calculating the cost of the final truck (see figure 2) with instructions on how to do the costing. Once the student-teams finish this activity (that allows them to see how many different parts are used and what is the scope for standardization to reduce cost and improve value), they are given extra Lego parts and an instruction sheet (sample provided as figure 3) to start the redesign activity. At this juncture half the teams are asked to depart to an adjoining room with the other half staying in the same room. The instruction sheets on redesign given to the teams either contain a cost target, such as redesign the truck so that you meet a cost target of “$X” or no cost target, such as redesign the truck so that you can bring down the cost “as much as you can.” Also, in the two rooms where student teams now are ready to start their redesign activity, we ensure equal number teams with cost target vs. no cost target. Figure 3 provides the sample instruction sheet with cost target and other quality and design requirements to be met for an accepted re-design. Extra spreadsheets as explained in figure 2 are provided for the teams to keep track of the costs as they redesign.

The two rooms simulate the sequential versus concurrent product development
environments. This is implemented as follows. In addition to the truck redesign requirements provided in figure 3, three additional needs from customers (end-customer and governmental regulation) affect the redesign (see figure 4). In the sequential room, all the information is provided in one shot at the beginning of the redesign activity. In the concurrent room these come in a staggered fashion with the student-teams stopped after every 15 minutes and the new requirement provided. A total of 60 minutes is provided to the teams in both the rooms to complete their redesign activity and calculate the cost of their final design.

### Costing Spreadsheet

<table>
<thead>
<tr>
<th>Plates (Thin)</th>
<th>Beg Inv</th>
<th>End Inv</th>
<th>Qty Used</th>
<th>Material and Labor</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2X2</td>
<td>2</td>
<td></td>
<td></td>
<td>$200</td>
<td></td>
</tr>
<tr>
<td>2X3</td>
<td></td>
<td></td>
<td></td>
<td>$200</td>
<td></td>
</tr>
<tr>
<td>2X4</td>
<td>2</td>
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<td></td>
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<tr>
<td>2X10</td>
<td>2</td>
<td></td>
<td></td>
<td>$700</td>
<td></td>
</tr>
<tr>
<td>4X4</td>
<td></td>
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<td>4X10</td>
<td>1</td>
<td></td>
<td></td>
<td>$1,100</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bricks (Thick)</th>
<th># of Unique Bricks</th>
<th>Subtotal</th>
</tr>
</thead>
<tbody>
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<td>1X2</td>
<td>13</td>
<td>$200</td>
</tr>
<tr>
<td>1X3</td>
<td>2</td>
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<td>1X4</td>
<td>2</td>
<td>$200</td>
</tr>
<tr>
<td>1X6</td>
<td>1</td>
<td>$400</td>
</tr>
<tr>
<td>1X8</td>
<td>2</td>
<td>$500</td>
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<tr>
<td>2X2</td>
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<td></td>
<td>$900</td>
</tr>
<tr>
<td>2X10</td>
<td></td>
<td>$1,100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Special Parts</th>
<th># of Unique Special Parts</th>
<th>Subtotal</th>
</tr>
</thead>
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<tr>
<td>Wheels</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Axles</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Grille</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Windshield</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Steering Wheel</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Roll Bar</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>$5,200</td>
</tr>
</tbody>
</table>

| Overhead Cost | Number of different parts used | $200     |

**TOTAL COST**
If you have any questions please raise your hand.

Your group’s **objective** is to redesign your truck and **achieve a cost target of $16,500**.

Your group must also satisfy the following design specifications and quality requirements:

**Design Specifications**
1. The redesigned truck must contain all of the special parts (4 wheels, 2 axles, a grill, windshield, steering wheel and roll bar).
2. The truck’s components must adhere to the following standards:
   - The truck’s cab must have a roof top.
   - A light and a roll bar are required and must be placed on top of the cab.
   - The dimensions of the space inside the cab must not change.
   - The dimensions of the area behind the driver (back of the cab) must not change.
   - Doors are required on both sides of the cab.
   - The dimensions of the engine must not change and it must remain in front of the cab.
   - The dimensions of the truck’s bed must not change (the inside of the bed must be 4 x 6 or 24 studs.)
   - For hauling cargo, the truck bed must have sides and a tailgate at their current height.
   - The undercarriage provides legroom for the driver and is required.
   - The distance between the two axles must not change.
   - The dimensions of the gas tank must not change.
   - The dimensions of the front bumper must not change.

**Quality Requirements**
1. The truck must maintain its integrity during a minor crash test (hitting a wall after traveling 18 inches at a 20% grade).
2. The truck must maintain its integrity while being lifted off the table two times, for five seconds each time.
   - For one lift, the facilitator will only hold on to the cab.
   - For the second lift, the facilitator will only hold on to the truck bed.

Figure 3: Information sheet for truck redesign
First Requirement:

The National Traffic Safety Agency has discovered that this truck becomes a fire hazard when it is hit from behind. Therefore, the gas tank that is located behind the rear axle must be moved.

Second Requirement:

A consumer focus group has found that this truck has insufficient legroom inside the cab. This problem can be corrected by extending the undercarriage to the front axle, thus providing more legroom. The focus group spoke to one driver who got so frustrated he tried to drive with his legs outside the cab.

Third Requirement:

Another consumer focus group recommends two additional changes for this truck. The first recommendation is to remove the indentation from inside the truck bed. Items being hauled in the truck were getting stuck in this sunken area. The second recommendation is to make the truck a four-wheel drive vehicle. This requirement can be met by extending the undercarriage to the rear axle.

Figure 4: Additional customer requirements for truck redesign.
De-briefing and learning

My colleague and I always try and get a graduate student to help us out in administering the game. We also have been present in each other’s class during the earlier implementation of the game to understand cross-disciplinary perspectives. Also, during travel (to other institutions) we had a grant that allowed us to travel and team-teach the class in other locations.

Once the game is done and the designs approved, the team bring back their final cost calculations back to the class. They are welcomed by a 2*2 matrix as illustrated in table 1 on the white board or on an overhead screen. The four cells in the matrix provide information on the average costs for the teams falling into that cell. For example, cell 1 is for the teams that were in the room with sequential (up-front) information and had a specific cost target. Similarly, cell 4 is for the teams in room 2 that simulated staggered (concurrent) information and general cost goals.

As a process of learning and discussion, the first is to find out for the teams in each of the rooms what their perception of highest cost-reduction cell. Table 1 tabulates this as an example for one class. As it is evidenced from this table, 60% of the teams that were in the room with sequential information and specific cost goals believed to have the highest cost-reduction, while only 50% of the teams in the room with concurrent information and specific cost goal believed that they had the highest cost reduction. This was due to the fact, that some of the teams could not meet the cost goals in the concurrent information room and they talked about the frustration of time-pressure and constant disruption as they were working on the redesign. Till this point of discussion the teams with general cost goals did not have an idea of the cost target given to the other teams. When the cost target was revealed, there is a sense of surprise and excitement for the teams that beat it in both rooms. However, when the actual cost data averages across the two rooms are revealed (table 2), the excitement turns into debate as to why the ones with lower cost reductions could not improve.

<table>
<thead>
<tr>
<th>Cost Goal Type</th>
<th>NPD Process</th>
<th>Specific</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Sequential</strong></td>
<td>1: 60%</td>
<td>2: 40%</td>
</tr>
<tr>
<td></td>
<td><strong>Concurrent</strong></td>
<td>3: 50%</td>
<td>4: 50%</td>
</tr>
</tbody>
</table>

Table 1: Class survey on which cell would get the maximum dollars of Cost Reduction by Condition (n = 12)

<table>
<thead>
<tr>
<th>Cost Goal Type</th>
<th>NPD Process</th>
<th>Specific</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Sequential</strong></td>
<td>1: $3786</td>
<td>2: $2819</td>
</tr>
<tr>
<td></td>
<td><strong>Concurrent</strong></td>
<td>3: $3507</td>
<td>4: $3737</td>
</tr>
</tbody>
</table>

Table 2: Actual Average Dollars of Cost Reduction by Condition (n = 12)
The debate follows the similar path of time pressure, task frustration with disruption (changes in customer requirements), and also the opportunity to use the last design before the change (in the concurrent room) as a benchmark to improve the next change. Hence, table 2 indicates, that if the information handling is sequential (information available upfront as in cases with minimum changes to the existing design—product upgrades) then cost specificity produces a lower cost design. On the other hand, concurrency introduces interesting challenges and opportunities that “do your best” might come out better for breakthrough products. This is clearly demonstrated as cell 1 dominates for sequential and cell 4 surprises for concurrent. At this juncture, the research hypothesis is displayed and the conclusions arrived. Following this depending on the course, either details of the mechanics of target costing or the NPD concurrent design process are discussed. The research paper by Afonso et al., (2008) is also brought up for discussion that ties the target costing approach as an overall framework in NPD to balance critical metrics such as time and cost.

Conclusion
Before the NPD game and subsequent analysis based pedagogy, the content was taught in the traditional way of introducing materials on target costing in managerial accounting and sequential versus concurrent NPD processes in the operations course in an independent manner using text-book based information and once in a while augmented by case studies (e.g., Walton, 1997). Both topics though well received, never created an excitement and did not come out in course evaluations. This integrated, multi-disciplinary effort, really created new enthusiasm for the topics as was evidenced by three critical feedback:

(a) Student comments generally praised the game and also performance in questions related to the topic was improved (case analysis, home work and quizzes).
(b) Increase in the number of working managers who met up with us after class or the course to discuss this specific topic (cost goals) in more detail and in some cases leading to auditing their processes (Gopalakrishnan, et. al., 2007)
(c) The game drew the attention of Boeing Co (Seattle, USA) that was using a different game to train its internal folks on target costing. They verified and validated the game for us, which through the class led to further data collection. This led to a collaborative research that answered the questions on the interactions between cost goals and NPD definitively (Gopalakrishnan, 2015).
(d) Moving forward, the research article becomes the starting point of read for the students. This approach now can be moved from a research-led to a research-based, where additional inquires can be made in a contextual manner differentiating the varying NPD environments (including service-based products). This in turn can lead to more research activities and the cycle continues.
References:


