STATEMENT

An Industrial Engineering Approach to Cost Containment of Pharmacy Education

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A 2-semester project explored employing teams of fourth-year industrial engineering students to optimize some of our academic management processes. Results included significant cost savings and increases in efficiency, effectiveness, and student and faculty satisfaction. While we did not adopt all of the students' recommendations, we did learn some important lessons. For example, an initial investment of time in developing a mutually clear understanding of the problems, constraints, and goals maximizes the value of industrial engineering analysis and recommendations. Overall, industrial engineering was a valuable tool for optimizing certain academic management processes.

Keywords: cost containment, efficiency, industrial engineer

INTRODUCTION

In 2014, President Obama proposed to hold higher education institutions accountable for cost, value, and quality by linking financial aid to performance.¹ This directive came as a response to growing concerns about rising student debt,² decreased access to higher education for low-income and middle-income students, and a decrease in the number of US students receiving a college degree relative to those in other countries.³ Similar concerns have been raised about pharmacy education.⁴

The challenge of increasing quality while decreasing cost is not unique to education. A well-known maxim in the fields of design and project management is that there are tradeoffs between cost, quality, scope, and time.^{5,6} If we want to decrease costs of higher education, the savings may have to be found in decreased quality, time, or scope. Over the past few decades, new compliance and student services (eg, career development, counseling services, disability resources) have become required, which has added to the cost of education.⁷ In addition, some of the programs take longer to complete. Consider, for example, how the length of pharmacy programs has gone from 5 years, when a BS in pharmacy was the degree requirement, to 6 years for the doctor of pharmacy (PharmD), and for many schools today, 7 and 8 years when including the length of time for prepharmacy programs.

Professional school accreditation imposes additional constraints. Pharmacy school accreditation standards specify a minimum program length of 4 years and an educational scope that continues to expand. By recommending that schools target a student to faculty ratio of 10:1, the Accreditation Council for Pharmacy Education's (ACPE) "Guidance For Standards 2016"⁸ make it increasingly difficult to constrain the costs of our most expensive resources: faculty and staff members.

Despite these pressures, it is imperative that we steward our resources. According to Cain et al, in 2011, the average indebtedness for pharmacy students exceeded \$100 000 and was greater than the average first-year pharmacist salary.⁹ This increasing debt may force graduates to pursue career options less costly than pharmacy and with equal or better first-year salaries. Moreover, increases in tuition much beyond today's rate threaten to make pharmacy education increasingly prohibitive to many lower- and middle-income students.⁹

But, what if we could find ways to make pharmacy schools more efficient? More cost-effective teaching methodologies have been elusive, but there are labor-intensive administrative processes associated with pharmacy education that might benefit from process improvement. Happily, there is a profession whose expertise lies exactly in this area: industrial engineering (IE).

Industrial engineering is a branch of engineering the specialty of which is the optimization of complex processes or systems. It does this through the development, improvement, and implementation of integrated systems

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of people, knowledge, equipment, money, energy, and materials using the methods of engineering design and other sciences.¹⁰ Historically, the discipline found its origins in the Industrial Revolution. Frederick Taylor—well-known for his work in scientific management—is generally viewed as its founding father.¹¹ While the field's first efforts focused on industrial efficiency, industrial engineers work in many settings today, including supply chain management, ergonomics, project management, and health-system workflow design.

We encountered our first industrial engineer in the latter context: pharmacy colleagues in a local health system told us about the many improvements brought about by their IE team. At first we sought to employ an IE consultant, but the cost was prohibitive. However, the consultant directed us to the IE program at Iowa State University and, in particular, to its capstone design course, which synthesizes what students learn in the didactic curriculum. By tackling the problems of private and industry sponsors, students gain hands-on experience with projects that have real-world applications.¹²

The program is a boon to organizations with limited resources because they can capitalize on the competencies of 4 industrial engineering students (only months from graduation) and support and feedback of a faculty supervisor, at a reasonable expense (\$5000 per team). Moreover, the students are highly motivated to produce true value for their clients since their grade depends on the quality of their solution as well as whether the client implements their solutions.

IMPLEMENTATION OF THE IE PROJECT

The client begins the consultation process by proposing one or more projects to the IE course coordinator. If the project is of sufficient complexity and interest to one of the 4-person student teams, it is adopted, and the semester-long consultation begins.

At Drake, we employed 2 IE teams, one during the fall 2014 semester and the other during the spring 2015 semester to help us analyze and improve 4 systems: (1) the workflow of our Student Affairs Department; (2) the operations of our Experiential Education Department; (3) our administrative structure subsequent to the addition of a health sciences program; and preceding the addition of 2 other programs; and (4) the workflow of our teaching laboratories on pharmacy skills and health sciences.

In the first step of the IE process, the student team met with us to explore the state of the systems in question. This enabled them to collaboratively define problems, potential areas for improvement, goals, constraints, and assumptions. While each step of the IE process is important, this step is critical. It requires listening and advocacy

on the part of the IE and client to ensure that professional jargon, assumptions, and idiosyncratic organizational issues do not interfere with an understanding of the situation. In our context, the IE team had one primary client for each system they investigated.

The second step involved data collection. Industrial engineers use a broad range of approaches, but in our context they used client, student, faculty, and staff surveys to collect data and opinions, evaluated work processes through interviews, observations, and special efficiency techniques such as “red-tagging.”¹³ In addition, they documented the compensation, expertise, and job description of each worker, benchmarked peers, and tallied the cost of equipment and technologies in use.

Prior to the distribution of surveys to faculty members, a communication was sent explaining that we were employing IE teams to streamline our most labor-intensive processes. Information on the IE projects also was discussed during a regularly scheduled monthly college meeting, so that faculty and staff members were aware of the process and could have questions and concerns addressed. E-mails to students asking them to participate in this step explained that the purpose was to identify efficiencies that could improve services. This step also involved the IE team estimating costs of current processes, which included evaluating time spent on processes and the hourly salary rate of those involved in the process. Next, the data were explored using a variety of industrial engineering analytical methods and tools (See Appendix 1 for definitions).

The third step was a formal meeting during which the IE team met with us to ensure our understanding of the current state of the system in question, based on the team's analyses. After we validated their assessment, the IE team began the problem-solving process to design a better “future state.” This was undertaken scientifically, with the support of IE literature. Ultimately, the solution can involve process/workflow realignments, space redesign, adoption of, or changes in, technology, changed work distribution/responsibilities among staff and faculty members, and even changes in the product offered to clients (in our case, students, faculty members). This step included estimated savings based on costs identified in the second step plus any purchases of software or equipment in the future state, minus the estimation of time saved with the recommendation.

This is an important decision point. If the solution is cost-effective, it may be adopted. However, the process may reiterate several times before a solution is found. Moreover, the solution is only hypothetical—a data-driven and evidence-based guess. It may be that other issues are revealed once the solution is implemented.

OUTCOMES OF THE IE ASSESSMENT

Efficiency and cost containment are related, but not equivalent. A common saying among project managers is, “Given a project with three constraints, for example, fast, good, and cheap, you can only pick two. It is not possible to optimize all three concurrently.” The work of IE is limited by such accommodations, and they were apparent in our work. Most systems are far from optimal and can achieve considerable efficiencies that are also cost-effective, but trade-offs do exist.

Student Affairs

Our belief that inefficiencies existed within Student Affairs was confirmed by the IE team through a student satisfaction survey, a time study, and work sampling. Problems included: (1) an inordinate amount of time spent on e-mails, meetings, and face-to-face communication (significantly, the IE team estimated that answering student questions that they could answer themselves cost the college more than \$5K annually); (2) substantial time wasted and confusion resulting from distractions in the entry area (A desk close to the door cost the college more than \$20K annually in time wasted). Based on the time study conducted, it was found that the staff members in the welcome area were interrupted by visitors and passers-by an average 15.7 times per hour. The waiting area was outside the office, resulting in multiple trips back and forth for staff and students, leading to excessive wait times. The mail center for several campus offices was inside the entry, making it necessary for many people with no actual “business” in the office to enter.); (3) ineffective weekly newsletter with too much information that made it hard to find specific items and led to decreased usage and, not surprisingly, less knowledge of important information.

The IE team proposed 2 major changes: a redesigned front office entry and office area and a redesigned newsletter. The new office design placed the waiting area inside the door and added 2 more private offices. An iPad was put at the welcome desk and loaded with software that prospective and current students and other visitors could use to sign in (an each sign in generated an e-mail notification to the faculty or staff member). The mail center was moved outside the office area, which would decrease interruptions by the mail staff and office staff coming to pick up their mail. The IE team simplified the newsletter design and content, modifying the font and font color to improve readability and changed the mailing time to Monday evenings, when readership was expected to be highest.

Both recommendations for Student Affairs were accepted. The IE team estimated the renovation would cost approximately \$14K. In fact, with some of the additional

features we added (eg, carpeting throughout, windows in one of the offices), the renovation cost about \$35K. However, because the time-saving benefits of minimizing distractions and increasing efficiencies in the entry area was estimated at \$20K annually, the cost of the renovation would be paid off in less than 2 years. Moreover, the staff reported increased satisfaction with the new work environment.

Experiential Education

Managing the requirements of hundreds of practice sites and students, the Experiential Education office is a busy place. In our case, a shift in staffing left the office with fewer people than in the past. The assessment of the IE team—benchmarking of another experiential office, a student satisfaction survey, and work sampling—confirmed this impression and revealed some interesting findings. The work sampling study found that the office staff spent more than 24% of its time compiling and sending e-mails (eg, 5-10 e-mails per student are required to meet unique compliance requirements of various experiential sites), more than 17% of its time doing nonwork-related activities, often because of transitions from task to task, and 42% of its time doing job-specific activities. The benchmarked office used similar (and time-consuming) processes as our office, but we had a greater student-to-staff ratio (44:1 vs 33:1) and significantly more experiential sites (1200 vs 800). The necessity of some activities that added to workload (eg, reviewing the APPE schedule 3 times before releasing it to ensure curricular requirements and unique site and student needs are met; taking time to address student questions, the answers to which were available elsewhere on websites and in student manuals) was questioned by the IE team. However, the students were highly satisfied with their experience in the experiential office (91%), which was a source of pride and considered by the staff to be a significant payoff for their workload.

The IE team’s recommendations included: (1) using a workflow management process to transfer and monitor tasks of student workers; reducing workload by requiring more student responsibility (ie, referring students to sources such as a group site such as a Facebook page, the experiential policy manual, or student worker office hours to find answers to their questions; deducting points/grades or assigning less preferred experiences if students did not meet requirements); (2) creating a “home-grown” advanced pharmacy practice experience (APPE) scheduling system to manage the customization; and (3) decreasing the number of potential experiential sites and the customization offered to each student. The IE team estimated adoption of these changes could save up to \$50K per year.

The workflow management proposal was implemented to support more efficient student-worker task assignment and monitoring. The second recommendation to help students assume greater responsibility for finding information was implemented in that student workers promoted and held “office hours” to provide a forum for other students’ questions. As a new service, the initial uptake has been limited. Each pharmacy class already had a Facebook page (without faculty access), so the suggested system was in existence, but the ability to provide oversight to confirm accuracy was lacking.

Although the IE team suggested shifting greater responsibility to students for meeting site requirements, this was a delicate balance because of the potentially negative impact on experiential sites if requirements were not fulfilled. This had the potential to be costly to the college if relationships were damaged and sites are lost. In addition to the burden of fixing the resulting problems, these risks had the potential of outweighing benefits.

The last 2 recommendations were not accepted. When the IE student attempted to design a home-grown APPE scheduling system, its functionality was limited and could not include all requirements necessary for the APPE placement process. Decreasing the number of potential APPE sites definitely could save significant staff time in managing sites. However, the experiential staff believed this solution would decrease their ability to meet the individual needs of students. Because individualization is a core value of the office, this solution was also rejected.

The experience, however, provided valuable lessons in optimizing the value of this type of collaboration. First, all parties need to understand their roles in an IE project. Perhaps because they were educators, the experiential team approached the collaboration from an instructional rather than the client’s perspective. For example, when creating a “home-grown” system became of interest to one of the team members, the rest of the team supported its development, although, realistically, such a system would not be functional given the complexity of the experiential environment. Rather than redirecting the student to a more promising strategy (such as comparing existing vendors), the team allowed the student’s interest to drive the analysis that, in the end, and as expected, was not successful. Second, defining the assumptions of and desired outcomes from the analysis are important steps in the “state diagnosis.” For example, a better definition of the data to be collected from the work sampling studies would have been helpful. As expected, the analysis confirmed that a significant amount of time was spent on e-mail communication. However, without detailed understanding of the

purpose of the e-mails, no improvements in efficiency were possible. Likewise, ensuring that the IE team had a firm grasp of our quality criteria was critical, in hindsight. For example, decreasing the number of sites and the amount of customization offered to students was not acceptable, as these factors were considered integral to the “Drake experience.” Although increased services for students is a significant contributor to the cost of higher education,¹⁴ the student experience is our central value, and this includes customization and high levels of service. Finally, when selecting projects, some processes requiring a higher level of cognitive decision-making and customization that may be practicable for a full-time IE team may not be suitable as capstone projects.

Administrative Structure

Drake offers one health professional program (pharmacy), prepharmacy, and a 4-year, undergraduate health sciences (HS) program. When the HS program was initiated several years ago, it was incorporated into the existing administrative structure because its predecessor, a bachelor of science in pharmaceutical sciences, was administered in that manner. While this arrangement led to increased efficiencies, it yielded an outcome somewhat at odds with our valued focus on “student service,” as the satisfaction of the health science students was lower than that of the pharmacy students.

We feared that an impending implementation of 2 additional graduate programs (occupational therapy and athletic training) might exacerbate this problem. Furthermore, the ACPE Standards 2016 have an increased focus on interprofessional education (IPE), co-curriculum, administration of the Pharmacy Curriculum Outcomes Assessment – all of which will put additional strain on administrative structures.

This led us to consider the possibility that our administrative and committee structure could be better organized. As such, we proposed this as a potential area for the IE team’s work. While this was a situation unfamiliar to our IE students, it was within the scope of their profession, and they agreed to provide focused effort in this area.

The tools used in their analysis included a student satisfaction survey of health sciences student leaders and a faculty opinion survey. They also incorporated benchmarking with 2 approaches: interviews with the leaders of 3 schools who had previously taken on additional programs and online administrative structure analysis of 50 schools of pharmacy selected at random. The survey confirmed previous results regarding student satisfaction, and the benchmarking was used to propose a future state.

The benchmarking revealed that different institutions chose different administrative paths. All had their strengths and drawbacks, but in the end the IE team proposed the following administrative structure: (1) centralized administrative services including student affairs, experiential education management, and a “college” promotion and tenure committee (to serve as a second opinion to departmental committees); (2) decentralized programs for each of which directors would be accountable (including a director of preprofessional programs) and for which college committees would be formed (ie, curriculum, student affairs, admissions) to efficiently handle issues more common or unique to individual programs. One area not addressed in the solution was advising. However, the college intends to explore more robust advising models so that the needs of all students are better served.

The college is considering the adoption of the model described above. Moreover, one element—the hiring of a preprofessional director—already has been implemented. Whether or not this structure will meet the needs of all stakeholders remains to be seen. Regardless of the outcome, the benchmarking activity was valuable and provided information far beyond our initial concerns. We became aware of administrative possibilities we may not have ever considered without the IE team, and we predict this will be invaluable as we implement our strategy. Having the IE team do the benchmarking saved at least \$3000 in faculty and staff time alone. While our solution may not extend to all institutions, the process used to consider alternatives may be of interest to them.

Teaching Laboratories

Teaching laboratories have high educational value, but they are extremely costly in terms of faculty time and resources. We wanted to optimize some of the primary teaching laboratories offered in our college: the pharmacy skills laboratory in the professional program and 3 elective laboratories (medical physiology, human anatomy, and patient assessment) in the health sciences program. The laboratory courses suffered from widely distributed locations (eg, the skills laboratory is taught in 3 places) and inadequate storage (some locations have little or none). This led to significant time wasted in transport and coordination of spaces. We also were eager to find ways to free faculty members from many technical tasks that kept them from engaging in other activities such as scholarship.

With the addition of the new programs mentioned above, there was another concern regarding the health sciences laboratory: the added workload incurred as more

students enrolled. Thus, the goals of the IE team were to: determine how to supervise, maintain laboratory space, and teach laboratory sections; develop an inventory management system and determine optimal storage for laboratory equipment to reduce faculty time spent managing inventory by 50%; and create a strong argument for the appropriate division of labor among technical professional staff. The IE team used workflow observation, analysis of the job functions of faculty and staff members (including whether a particular function was being undertaken by an appropriately skilled and educated person), analysis of the inventory management system using “red-tagging,” and safety assessment.

The IE team presented us with multiple suggestions for improvement: (1) purchase enough supplies (eg, another teaching skeleton) so that transport time would not be required and issues such as locating missing items would be significantly reduced (this would require creating a storage space where none exists); (2) “kitting” the supplies, and using students or student workers to replenish the kits at a convenient time (this alternative also would include buying cabinets for additional storage—costs of both likely <\$1000); (3) disposing of unused inventory, which would increase space available for storage; (4) changing storage patterns to make best use of the space while ensuring optimal ergonomics; (5) identifying specific accountabilities for ordering/receiving supplies, building and maintaining a supply inventory, checking and calibrating laboratory instruments, and general laboratory set-up/tear-down (best, a technician); and (6) requiring students to print all materials required for laboratory activities (eg, the prescriptions and patient profile for patient counseling) by posting them ahead of time on the university’s web-based education management system.

The IE team estimated that implementing these suggestions would amount to an annual savings of >\$19K. Moreover, they developed a strong proposal to hire technical staff. As the new programs are implemented requiring additional hires—choosing one technician and a laboratory instructor in lieu of one additional faculty member—would save an additional \$17K per year in salary and would free faculty members for their academic endeavors.

We are implementing the inventory, storage, and kitting solutions. We also plan shift hiring according to their recommendations to save money, although we are concerned about retaining the savings in our college to support future initiatives. The only recommendation not accepted was requiring students to print laboratory materials. Faculty chose not to implement the changes in printing because items for laboratories were specific,

time-sensitive activities not appropriate for posting ahead of the sessions.

Limitations and Lessons

A potential limitation of employing student industrial engineers is that they have restricted time to interact with clients. The relatively few meetings available must be scheduled around their course schedules. Of course, this inconvenience is counterbalanced by the price—the services of working professionals are much more expensive.

Another limitation is the lack of understanding among the IE team, being of course from another discipline, of the processes and requirements inherent in a pharmacy educational program. While faculty and staff members were able to explain why processes exist and why some of the processes were similar to other educational programs, there were recommendations for experiential education and laboratory processes that were not able to be implemented.

In reflection, we suspect that the expertise of industrial engineers could benefit other pharmacy programs, and we would encourage other schools to identify issues and seek IE student teams or professionals to assist with the identification of improved processes, particularly in light of the ACPE Standards 2016. Specifically, the implementation of outcomes-based interprofessional education and co-curriculum will be complex, requiring skillful management of logistics. Designing these programs according to the principles of industrial engineering would help ensure the best use of resources. In addition, we believe that improved efficiencies also could assist processes in the pharmacy profession. Industrial engineering could be invaluable in designing patient-centered community pharmacies and collaborative, interprofessional practices such as medical homes. Finally, IE could profitably be included in the design process when new programs and facilities are developed.

Conclusion

Using a team of industrial engineering students to improve our systems at Drake University gave rise to potential increases in efficiency, effectiveness, and student and faculty satisfaction. Moreover, although we did not adopt all their solutions, we still stand to save roughly \$60K per year. A full determination of actual savings would require a more detailed cost analysis of the day-to-day administrative process, as would be the case in many industrial settings where “running lean” could lead to significant increases in profit. However, although our savings are somewhat theoretical, the

subjective sense among our faculty and staff members is that they now have more time to devote to things that matter, including additional duties resulting from the addition of 2 programs at the college. That is already an incredible payback for our investment in the project, which included a one-time \$10K payment to the industrial engineering program (\$5K for each semester), faculty and staff time in meeting with the team 3 times for approximately 2 hours each time, and one half-day trip to the Iowa State campus to attend the final presentation of the team. Our successes have led other colleges and units at the university to seek the services of the IE students.

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REFERENCES

1. US Department of Education. College Rating and Paying for Performance. <http://www.ed.gov/college-affordability/college-ratings-and-paying-performance>, accessed April 15, 2015.
2. Foxx V. (R-NC), ICYMI. The Student Loan Debt Solution Is All About Jobs. <http://edworkforce.house.gov/news/documentsingle.aspx?DocumentID=392820>. Accessed January 26, 2015.
3. Office of the President of the United States. Higher Education. <http://www.whitehouse.gov/issues/education/higher-education>. Accessed on January 26, 2015.
4. Chase P. AACP Presidential Address. <http://www.aacp.org/news/media/Documents/PresidentChaseReleaseFINAL.pdf>. Accessed April 15, 2015.
5. Newell MW, Grashina MN. *The Project Management Question and Answer Book*. New York, NY: Amacom; 2003:8.
6. Shenhar AJ, Dvir D. *Reinventing Project Management: The Diamond Approach to Successful Growth & Innovation*. Boston, MA: Harvard Business School Publishing; 2007:276.
7. Cowan K. Higher Education's Higher Accountability. *The Presidency*. 2013:204. Accessed April 15, 2015.
8. Accreditation Council for Pharmacy Education. *Guidance for the Accreditation Standards and Key Elements for the Professional Program in Pharmacy Leading to the Doctor of Pharmacy Degree*. Chicago, IL: ACPE, 2015.
9. Cain J, Campbell T, Brennan Congdon H, et al. Pharmacy student debt and return on investment of a pharmacy education. *Am J Pharm Educ*. 2014;78(1):Article 5.
10. Salvendy G. *Handbook of Industrial Engineering*. 3rd Ed. Hoboken NJ: John Wiley & Sons, Inc.; 2007:5.
11. Taylor FW. *The Principles of Scientific Management*. New York, NY: Harper & Brothers; 1911.
12. College of Engineering Capstone Program. <http://www.engineering.iastate.edu/capstone/>accessed 4.15.15.

13. Alukal G, Manos A. *Lean Kaizen: A Simplified Approach to Process Improvements*, Milwaukee WI: ASQ Quality Press; 2006: 150.
14. David Educational Foundation. *An Inquiry into the Cost of Higher Education: Summary of Responses from Seventy College and*

University Presidents. Yarmouth, Maine: Davis Educational Foundation; 2012. <http://www.davisfoundations.org/site/documents/AnInquiryintotheRisingCostofHigherEducation.pdf>. Accessed June 1, 2015.

Appendix 1.

Industrial Engineering Tools and Definitions Used in this Study

Value Stream Map. A flowchart that uses symbols to depict and improve the flow of inventory and information. It is a fundamental “lean” tool that identifies waste, reduces process cycle times, and enables process improvement.

Pareto Chart. A chart that contains both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The left vertical axis can represent the frequency of occurrence, cost or another important unit of measure. The right vertical axis is the cumulative percentage of the measure. Its purpose is to highlight the most important among a large number of factors.

Time/Value Chart. A chart that illustrates the value added (or not) by each step of a process.

Relationship Matrix. A matrix that illustrates the relationships between people, tasks, and processes in a given system.

Red-Tagging. A visual management tool that is used to identify unnecessary items that need to be eliminated or relocated.

Kitting. A process in which individually separate but related items are grouped, packaged, and supplied together as one unit.