Undergraduate Research in Healthcare Packaging

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Abstract: Christian Brothers University (CBU) is a primarily undergraduate institution with a focus on excellent teaching. Its engineering students usually obtain some undergraduate research experience through their senior design projects. However, many of these projects are routine design projects; thus, they do not contribute any new knowledge to the discipline. Unlike research institutions, it is not easy for a primarily teaching institution to develop undergraduate research that contributes new knowledge. Two factors have helped address this issue for CBU: the development of its undergraduate packaging program (including a certified packaging lab), and the establishment of a Healthcare Packaging Consortium. This paper discusses the needed infrastructure to make undergraduate research possible at primarily undergraduate teaching institutions, which includes meaningful projects, facilities, funding, and incentives for both faculty and students. It also illustrates the benefits students have received from these consortium projects.

Keywords: Healthcare packaging research, undergraduate research, research in primarily teaching institutions, industry-sponsored projects

Introduction

Christian Brothers University is a primarily undergraduate institution with four schools: the School of Arts, School of Business, School of Engineering, and School of Sciences. It was founded in 1871 as Christian Brothers College. The electrical engineering program began in 1933 and was followed by mechanical engineering, civil engineering, and chemical engineering programs. Currently, these four undergraduate engineering programs are accredited by ABET. Recently, engineering management has been added to the four traditional engineering disciplines, with two concentrations in information technology and packaging. The School of Engineering has also offered a Master's degree in engineering management for over 20 years.

It was natural for CBU to develop a packaging program due to its location in Memphis, which has long been recognized as a major distribution center. FedEx's world headquarters has attracted many companies to place their distribution centers in Memphis. Meanwhile, Memphis International Airport has helped the city redefine itself as America's premier aerotropolis. According to the Greater Memphis Chamber (www.memphischamber.com):

- Memphis is home to the busiest air cargo airport in North America since 1992.
- Memphis is on the path of I-40, the 3rd busiest trucking corridor in the U.S.
- Memphis has five Class I railroads passing through it: BNSF, CSX, Union Pacific, Norfolk Southern, and Canadian National.
- The Port of Memphis is the fourth largest inland port in the U.S.
- 10.2% of the Memphis workforce is employed in transportation and utilities, the highest percentage among the top 100 largest metro areas in the U.S.

For these reasons, a packaging program located in Memphis is logical and rife with opportunities. CBU's undergraduate packaging education program [1] started with a packaging elective for engineering students in the spring of 2001, which has since grown into a Packaging Engineering Certificate and B.S. in Engineering

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Management (Packaging Concentration). The CBU packaging program is one of the following seventeen packaging schools listed on the website of the Institute of Packaging Professionals (www.IoPP.org):

- American University of Beirut (Beirut, Lebanon)
- California Polytechnic University (San Luis Obispo, California, USA)
- Christian Brothers University (Memphis, Tennessee, USA)
- Clemson University (Clemson, South Carolina, USA)
- Dunwoody College of Technology (Minneapolis, Minnesota, USA)
- Fox Valley Technical College (Appleton, Wisconsin, USA)
- Hennepin Technical College (Brooklyn Park and Eden Prairie, Minnesota, USA)
- Indiana State University (Terre Haute, Indiana, USA)
- Michigan State University (East Lansing, Michigan, USA)
- Missouri University of Science and Technology (Rolla, Missouri, USA)
- Mohawk College (Hamilton, Ontario, Canada)
- Rochester Institute of Technology (Rochester, New York, USA)
- San Jose State University (San Jose, California, USA)
- University of Florida (Gainesville, Florida, USA)
- University of Wisconsin – Stout (Menomonie, Wisconsin, USA)
- Virginia Tech (Blacksburg, Virginia, USA)
- Wisconsin Indianhead Technical College (Shell Lake, Wisconsin, USA)

Challenges for Undergraduate Research at Primarily Undergraduate Institutions

Primarily undergraduate institutions face many challenges in developing meaningful undergraduate research, including:

- Expensive lab equipment is needed in many areas of research, especially in engineering and science. Even if equipment is obtained from grants or donations, maintaining it can become difficult.
- The teaching load of faculty members is usually high. Thus, they have no time for meaningful research or even to keep up with the current state of subject areas.
- Promotion and tenure considerations are often based on teaching performance. Thus, there is no incentive for research and development effort.
- Financial support for research effort is usually insufficient. Competing for external funding has often proven to be difficult.
- Lack of research vision from administrators has contributed significantly to lack of research at these institutions.
- Lack of research interest from the faculty is another factor. Some faculty members have the view that they are there just to teach.
- It is hard to find research mentors.

To develop a meaningful undergraduate research program in engineering and science, the following key success factors must be met:

- State-of-the-art and well-maintained lab equipment
- Current knowledge about subject areas
- Sufficient funding
- Highly motivated group of faculty members
- University policy that encourages entrepreneurship and innovation

The next sections describe how CBU's undergraduate research in healthcare packaging has developed over the last few years, during which these success factors were built one by one.

CBU Packaging Lab: The First Success Factor

From 2003 to 2005, CBU acquired many pieces of state-of-the-art packaging equipment through a $3M grant from the Assisi Foundation of Memphis as part of its engineering lab renovation project [2]. Some of the packaging-related equipment is shown in Figure 1.

Figure 1. Packaging Related Equipment at CBU Packaging Lab
Top Row (L – R): Drop Tower, Vibration Table, Shock Machine
Middle Row (L – R): Akonak Chamber, Temperature/Humidity Chamber, Curing Table
Bottom Row (L – R): Thermoformer, Rapid Prototyping Machine, Injection Molding Machine
Note: Thermoformer was donated by Plastic Ingenuity. Other pieces were from the Assisi Grant

For education purposes, lab equipment can be used for many years without costly calibration. However, well-maintained equipment is needed for R&D work. In 2009, the CBU packaging lab became a commercial lab certified by the International Safe Transit Association (ISTA, www.ista.org). It is currently one of seven such certified packaging labs and the only one in an academic setting within the tri-state area of Tennessee, Arkansas, and Mississippi. All seven certified labs are located in Tennessee:

- Christian Brothers University (Memphis, Tennessee, USA)
- FedEx Corporation (Memphis, Tennessee, USA)
- Global Testing Laboratories, LLC (Knoxville, Tennessee, USA)
- Medtronic (Memphis, Tennessee, USA)
- Oneil Manufacturing (Cookeville, Tennessee, USA)
- Sonoco Products Company (Nashville, Tennessee, USA)
- Triad Packaging (Bristol, Tennessee, USA)

During its first year of certification, the CBU lab generated less than $1,000 of gross revenue. However, during its second year the gross revenue went up to almost $13,000. During the current year (3rd year of certification), almost $9,000 of gross revenue was generated during the first three months as the lab customer base expanded. At this rate,

the gross revenue for the current cycle will be $36,000. Forty percent of the gross revenue is used for equipment maintenance. Even though the revenue is still considered small, the trend shown in Fig. 2 is very promising.

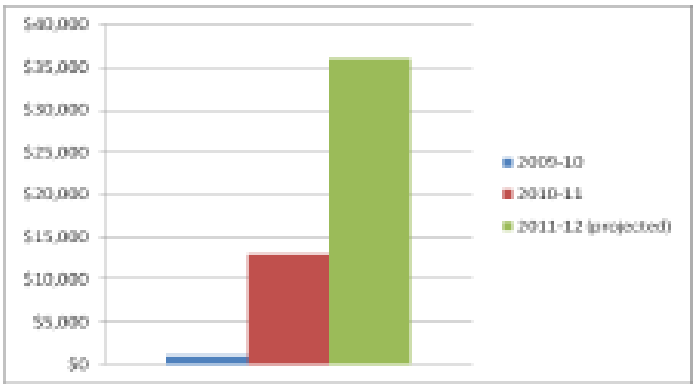

Figure 2. Certified Packaging Lab Gross Revenue

So far undergraduate students have not been involved with commercial package testing due to the desire of customers to complete tests as soon as possible. Scheduling students to work on test projects would result in delays. Furthermore, these tests are not R&D projects and follow certain test procedures outlined by ISTA.

However, undergraduate students have benefited indirectly from the packaging lab's commercial revenue. The net revenue provides funds for equipment maintenance and calibration, which is essential for R&D projects that do involve undergraduate students. About $3K has already been spent this cycle on maintaining/calibrating the drop tester, vibration table, altitude chamber, temperature/humidity chamber, compression table, and cutting table. The drop tester, vibration table, and compression table are used on a regular basis for commercial testing; thus, they are calibrated/maintained on a yearly basis. Other pieces are maintained/calibrated on a two-year or three-year cycle.

Healthcare Packaging Consortium: The Second Success Factor

The Healthcare Packaging Consortium [3] was established at CBU on June 1, 2010, with seven founding member companies: Evergreen Packaging, FedEx, Medtronic, Merck Consumer Care, Plastic Ingenuity, Smith & Nephew, and Wright Medical. Its mission is to advance knowledge in healthcare packaging through education and research.

At the beginning of the consortium year, consortium representatives meet to discuss R&D projects to be executed by CBU. They provide some guidance, needed materials, and equipment not available on campus. Some CBU packaging students work on these projects as their required packaging project, while some are hired at $12.50/hour if they do not get academic credit for their work. There are three groups of packaging students who participate in consortium projects:

- B.S. in Engineering Management with Packaging Concentration
- B.S. in other engineering disciplines with Packaging Engineering Certificate (Mostly from B.S. in Chemical Engineering and B.S. in Mechanical Engineering)
- B.S. in other engineering disciplines with Packaging Minor (This minor will become effective next academic year. Currently, one civil engineering major has applied for the minor.)

Current consortium R&D projects include:

- Peel Testing Analysis (Sponsored by Smith & Nephew): There are three peel testing techniques within ASTM F88. Often suppliers, contract packagers, and OEM's do not communicate the specific technique and therefore are not speaking the same language when setting acceptance criteria. This project will attempt to determine if there is a formula that can be applied to translate across the peel testing techniques (90° unsupported vs. 180° supported).

- Seal Width Integrity (Sponsored by Marsh Consumer Care): General rules of thumb exist for minimum seal widths on thermoformed packages. These rules of thumb are anecdotal and not supported by data. A large study is required to develop water vapor permeation curves at incremental seal widths.

- Correlation between Burst Testing & Peel Testing (Sponsored by Smith & Nephew): There is not a correlation between peel testing and burst testing, but there is a common formula that is stated to translate burst test values into 1.0 lbf peel values. This project will evaluate the robustness of this formula across varying sizes packages.

- Distribution Tote Testing (Sponsored by Marsh Consumer Care): Products in "big box" retailers (Wal-Mart, Target, etc.) and large drug chains (Walgreens, CVS) are typically distributed in large plastic totes. Each tote contains a variety of individual products destined for a specific location in the store. There are no standards in place to perform distribution testing on such configurations; there is a need to standardize these procedures. This project's goal is to develop new ISTA procedures and/or make formal recommendations to retailer distribution centers.

- Impact of 100% Recycled Packaging Content on Performance (Sponsored by FedEx): This project compares the performance of packaging materials such as corrugated materials, cushioning peanuts, and various foams when the humidity and temperature are elevated. It also includes low and high temperature & humidity tests to determine the difference in cushioning and compression strength properties between 100% recycled and non-100% recycled packaging materials.

- Performance of Different Pallet Materials and Styles under Diverse Handling and Environmental Conditions (Sponsored by FedEx): There is a great variety of design and materials used for pallets that are sourced all over the globe. Pallet materials such as recycled molded pulp, particle board, and corrugated materials have influenced handling in the global supply chain. This project determines if temperature and humidity have an impact on performance of these pallet materials, while comparing them to the typical soft wood GMA pallet used in the United States.

Each consortium project requires undergraduate student involvement. In the first cycle of the consortium (2010-2011), there were two undergraduate students involved with consortium projects. Currently, the number has increased to seven, with more expected in the coming year. Results from these projects have started to appear in various publications [4, 5, 6], and more are in the pipeline. Students are listed in these publications as co-authors.

The Healthcare Packaging Consortium has contributed greatly to undergraduate research in healthcare packaging at Christian Brothers University:

- Consortium member companies are major companies. Their packaging professionals have up-to-date knowledge of the field, and they know the current problems faced by the industry. Thus, the topics sponsored by these companies are timely and relevant.
- The consortium annual membership fee (a total of $21,000 for each cycle with the current membership) provides financial support for these projects, including compensation for students who do not work on the project for credit, small equipment acquisition, etc.

- Students are invited to project meetings with the sponsoring company. This gives them an opportunity to network with company representatives, who are typically at the managerial level. This can lead to future job opportunities for students.
- Having student names on publications enhances their resumes.

Five seminars and a one-day conference are arranged for consortium members with no charge each year. These events are also open to the public for a fee. This additional income is used primarily for travel expenses to present R&D results. During the first cycle of the consortium, these seminars and conference generated about $3,000 of net income.

University Support: The Third Success Factor

Any program or effort would not possible without support from the university. The author has received a ¼ time release from his teaching load to coordinate packaging activities, which include the certified lab and consortium. Even though the amount of work could justify a full-time position, the release time demonstrates a positive gesture from the university.

The most significant support is from a special account set aside for packaging operations. Typically, an overhead of 40% from any income generating activities goes to the university's general fund. The university allows the special account for packaging operations to be exempt from this general rule. All packaging income stays in the account, which helps make equipment maintenance possible. 100% of net income from seminars/conferences, as well as consortium membership fees, also remains in the account. In this way, the packaging operation at CBU is semi-independent and self-sustaining.

Motivated Faculty & Staff: The Fourth Success Factor

Last but not least, a group of motivated faculty and staff is needed. They believe in the opportunity packaging will bring to the university. They believe in the importance of undergraduate research. They are willing to take on challenges by stepping out of their comfort zones into a new arena. They work with students on consortium projects as senior project and packaging projects. Currently, this group consists of:

- Ray Brown, Ph.D., Professor of Mechanical Engineering with expertise in thermal systems
- Siripong Malasri, Ph.D., P.E., Professor of Civil Engineering with expertise in structural engineering and solid mechanics
- Robert Most, Mechanical Lab Technician
- Asit Ray, Ph.D., Professor of Chemical Engineering with expertise in polymeric materials
- Henry Rhodes, Electronics/Computer Lab Technician
- Larry Rutledge, retired packaging manager from FedEx and currently in charge of ISTA commercial package testing at CBU
- Paul Shires, Ph.D., Professor of Mechanical Engineering with expertise in dynamics, manufacturing and solid mechanics

Conclusions

To have a successful and meaningful undergraduate research program, many success factors must be met. It is very important for a primarily teaching institution to select a niche area, such as packaging for CBU. Industry connections are also essential, since they can provide support in terms of hi-tech, real-world problems, and financial resources. In CBU's case, the Healthcare Packaging Consortium has successfully drawn seven major companies together. Revenue generating activities are critical. Grants are fine but they are usually for a limited duration; a continuous revenue stream like the CBU certified packaging lab is needed. Finally, university support

and a motivated group of people are crucial. Without any of these components, it will be very hard to develop a meaningful and successful undergraduate research program.

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