

# **The University of Maine's Advanced Manufacturing Center: Lessons Learned During the First Two Years of Operation**

**By**

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## **Abstract**

The University of Maine's College of Engineering has created an Advanced Manufacturing Center with a student-oriented mission. This center provides a distinctive engineering approach to solving manufacturing problems and gives Engineering Technology students hands-on experience working on engineering and manufacturing projects. With much of the center's work coming from off-campus businesses; the students gain practical experience with client communication, teamwork, business and project management and presentations in addition to technical skills.

The program provides a paid internship opportunity for undergraduate students to gain skills in machining, manufacturing processes and fabrication by being involved in these projects. Students usually start by fabricating parts under supervision, move on to training and supervising other students and by the time they're seniors, they will likely be running projects on their own. The objective is to graduate students who have an entrepreneurial vision, combined with experience on industrial machining and fabricating equipment acquired through involvement in this unique experience of an on-campus internship in a real workplace environment.

The paper will discuss the experiences and lessons learned in the first two years of operation with dozens of students participating and hundreds of projects being completed.

## **AMC Mission**

The mission of the AMC program is to directly link the traditional University activities of education and research with active economic development and industrial support programs. The AMC does this primarily by operating an extremely high-level manufacturing facility on the University campus in Orono, Maine. The infrastructure provided by the AMC allows the program to provide extensive outreach programs in support of Maine's manufacturers. Additionally, the AMC provides UMaine's research centers with both direct manufacturing support, and targeted assistance in the commercialization of new technologies. In this sense, the AMC represents a major component of the "D" in UMaine's collective "R&D" efforts.

The College of Engineering chose to support the AMC as a principal program initiative primarily because of the continued decline of the manufacturing sector in Maine, and in the entire country. The manufacturing industry remains the third largest provider of jobs in Maine, with most positions offering higher pay, better benefits and less seasonal variations than other industries. However, increasing competition from a global economy requires that, in order to remain viable, manufacturers

need to both become more efficient, and produce more value-added, innovative products. Both of these criteria require extensive engineering support. This is directly addressed in the mission statement of the AMC program; “*Engineering innovative solutions to real-world problems.*”

Despite the name, the AMC is first and foremost an *engineering* program. The facility provides open access to several key manufacturing capabilities unavailable to smaller manufacturers in the State. However, the primary resource offered by the program is the engineering expertise of the AMC’s faculty, professional staff, and student workers. Engineering is by definition a problem-solving discipline, and the AMC is dedicated to solving the problem of keeping Maine’s manufacturing industry strong while improving the educational experience of University of Maine students.

### **Typical Curriculum Challenges**

While there are many challenges facing engineering faculty members, the AMC concept is focused on addressing the three most common. First, is the challenge to adequately prepare undergraduates to become working engineers within the confines of a faculty reward system that is skewed towards obtaining research funding. Faculty are often lauded for achievements in their research laboratories but not for their service to industry. This reward system is attributable to the introduction of increased federal funding in engineering research after World War II.<sup>1</sup> Funding constraints facing public institutions creates a situation where the golden rule applies. The golden rule states that the person who brings in the gold rules. Thus, the faculty members that bring in the large research grants are rewarded greater than the faculty in the trenches focusing on student development and service to industry.

In the case of engineering technology faculty, this challenge shows up when student contact hours are increased inordinately when research is not required. High teaching loads limit the time faculty have to work with industry. Either an emphasis on research or heavy teaching loads will tend to constrain faculty from interaction with industry and limit their knowledge of current technology. This minimizes the opportunity for faculty members to adequately understand current industrial technology and common applications.

The second challenge is to teach new engineering concepts to students with vastly different preparation than in previous years. The life experience that new students bring to the University today differs greatly from students twenty years ago. The rapid change in technology spurred by solid state electronics and microprocessors has improved the ease of operating ever-complicated equipment. A typical engineering student in 1980 often came to school with experience performing many maintenance tasks on their families’ automobile. Today, most cars require most if not all service be performed by highly trained mechanics. This change in previous experience directly affects the basis that students build new knowledge upon.

Students develop new knowledge and skills based directly upon their preconceptions. If they lack adequate experience or have incorrect preconceptions, their new knowledge structure will be faulty.<sup>2</sup> This can lead to graduates that can correctly solve equations, but do not fully understand what is happening.

A final common challenge for faculty is to provide “hands-on” experience with new technology while teaching core concepts. Typically, this challenge is addressed through the inclusion of laboratory sessions that reinforce concepts taught in lecture. Unfortunately, the laboratories have a tendency to be scientifically-oriented and are often completed on equipment that is not common to industry. Experiments are designed to minimize the effect of assumptions on the students’ analysis of the experiment. This is an effective way to demonstrate a concept, but it does not represent a typical industrial environment.<sup>3</sup>

## **The AMC Solution**

The AMC program was designed to meet all three challenges while also fulfilling the broader goals of the institution and the needs of the state. To meet the first educational challenge, a system had to be developed to increase the opportunities for teaching faculty to interact with industry while providing a reward structure to encourage the interaction. The University campus had to increase its visibility as a source for engineering solutions for industry. While it was common for some faculty in the past to perform computer simulations or models, industry required both design and development services. It was quickly realized that infrastructure additions would be necessary to the University campus to give faculty members the tools to develop working prototypes to solve industrial problems.

The infrastructure requirement was met by a bond issue that was supported by the people of Maine in June, 2003. The University of Maine received \$5,000,000 to put towards construction of the new 30,000 ft<sup>2</sup> facility. With the funding in place, equipment purchases and facility construction began leading to the current facility. The College of Engineering earmarked \$1,000,000 for major equipment purchases. By purchasing used equipment at auctions and then using our staff to modify and upgrade the equipment, we have leveraged that investment to develop approximately \$3,000,000 worth of equipment. The facility now provides the necessary equipment and technician support to allow faculty to build real solutions to industry problems. Additionally, the university provides a convenient payroll process through its Department of Industrial Cooperation that allows companies to provide purchase orders to the University for services. Faculty members just provide time records to DIC and all billing is handled with the faculty member receiving additional compensation in their monthly paycheck. Project funds can also allow faculty to be released from some teaching duties to allow them to focus on particular projects.

The second challenge is met by providing an avenue to enhance students’ base knowledge and correcting faulty preconceptions while students learn new concepts in the classroom. Typically, the AMC employs students in the Mechanical Engineering Technology or Electrical Engineering Technology programs. Table 1 illustrates some of the performance metrics during the first two years. As can be seen, the AMC employed 16 students in the first year and increased student employment to 20 in year 2. As new employees, students are assigned tasks that require minimum engineering experience but they serve as full members on the project design team. This allows them to serve a valuable role to the organization while they learn the new skills necessary to run a project team. It is always interesting to watch a student realize concepts such as the “real world” costs associated with designing something with a precision of .01 inches as compared to a precision of .001 inches. Suddenly, the student begins to understand the

importance of each item on a specification and what it means to the overall project. One of the key challenges for students as they transition from academia to an entry level engineering job is developing the ability to pose the right question to gather data.<sup>4</sup> The experience of participating in the design process from initial concept, to CAD drawing, to machining of an alpha design, to finished product gives the student a frame of reference for their engineering studies which greatly enhances their ability to learn new concepts.

While a formal survey has not been completed regarding student learning outcomes, anecdotal evidence suggests that student alumni of the AMC receive many benefits. Employers have reported that graduates have an easier transition to the industrial workplace over their contemporaries. Also, student graduates demonstrate increased confidence in their engineering knowledge and demonstrate increased ability to tackle new challenges. Graduates report that their familiarity with business concepts compared to their peers has allowed them to function more effectively as project leaders.

**Table 1 - AMC Metrics at a Glance**

	<b>Year 1</b>	<b>Year 2</b>
<b>Student Employment</b>	<b>16</b>	<b>20</b>
<b># of Student Hours</b>	<b>4,000</b>	<b>5,500</b>
<b>Gross Project Income (\$)</b>	<b>100,000</b>	<b>125,000</b>
<b>% of Projects for Campus</b>	<b>49</b>	<b>48</b>
<b>% of Projects for Industry</b>	<b>51</b>	<b>52</b>

The final challenge of providing students and faculty with increased exposure to new technology is met by bringing the new technology to the University campus. Conceptually, this sounds simple but the hidden challenge is finding a way to pay for the new technology. The AMC accomplishes this by acting like a business enterprise within the university structure. New equipment is funded by overhead generated on projects. Cash flow from industrial clients funds replacement of outdated technology with new units that in turn increase the center's capability to engineer solutions for new clients. This allows faculty and students to consistently be exposed to the latest industrial technology.

### **Lessons Learned**

The first two years of center operation have been very educational for the faculty and students involved in the program. For the key faculty members on staff, the development of the business structure has been challenging. While the old adage, "if you build it, they will come" has held true in regards to industrial demand, the experience of growing a new business within an academic environment has been uniquely challenging.

As with any new business venture, an infusion of initial capital is necessary. To attract the capital, a solid business plan is necessary that provides a corporate framework providing confidence to investors. The business plan for the AMC succeeded in attracting the initial funding. What has been difficult is meeting current client demand while at the same time managing construction of a new facility, specifying new equipment purchases and continuing to meet academic teaching demands. The first lesson we have learned is that it is important to

arrange not only funding for equipment, bricks and mortar, but also to arrange base funding for core staff prior to moving forward with a new venture. While we have successfully balanced the demands in the past two years, it has required significant commitment by faculty and staff participants and considerable personal sacrifice. In year two our gross project funding increased from \$100,000 to \$125,000. This has caused us to reach our maximum output based upon current staffing and we expect to increase staffing in year 3 to increase production output.

The second lesson is that while student labor costs are inexpensive, their training requirements are significant. We have learned that if this were a typical business, we would not be able to employ many students at all. To develop a student from first year undergraduate to a project leader that is comfortable leading design reviews, running complex CNC equipment and supervising young engineers, takes a considerable amount of time and training. From a business stand point, it would be far more efficient to invest in fewer employees but utilizing trained technicians and experienced engineers. However, we have found that industrial clients are willing to pay the associated costs due to the unique combination of engineering skills and manufacturing capability are facility offers.

Another lesson we have learned is that for a non-profit business entity to function within a state-funded institution, one must clearly prove that it does not compete directly with existing firms. To ensure that we do not compete with Maine companies, we established a Board of Directors that represents Maine's largest machine shops and industrial manufacturers. Their guidance has been invaluable and their experience has helped us to direct clients to existing companies whenever possible that can provide the needed service. Ideally, we want to take the client through the production of the prototype and then hand the prints and model to an existing company to produce the product.

What we have found is that many machine shops are focused on handling orders for quantities greater than 100 parts. Unfortunately, the setup time necessary to make one or two prototype parts is significant. Thus, many of the shops are not interested in making production runs for less than five parts. The AMC fills this niche for the state. Once a prototype is complete, we provide guidance to the client regarding existing state entities that can provide production services for their product. Thus, our facility provides new work and clients to Maine businesses that would not be available otherwise. If an existing company develops a new product based upon their interaction with us, this can translate to additional company income and production thus leading to more jobs for our state.

A final lesson we have learned is how many indirect benefits that result from this center that we did not initially realize. We have found that our structure not only meets many of the goals of a land grant institution, it also meets the needs of a state facing a dwindling manufacturing base. What started as an educational program to improve student learning has developed into a program that serves three other valuable needs.

### **Additional Program Benefits**

The first ancillary benefit we realized was that the program supports the state's manufacturing operations by providing specific expertise in product development, production improvement and

prototype development. Second, it provides a strong development component to the University research and development mission. Roughly half of our work load has been providing engineering support to research faculty from diverse areas such as Food Science to Climatology Studies to Wood Composite Development. The AMC serves as a resource multiplier that has helped expand the university's ability to undertake additional research activity. Finally, it has provided considerable economic development support for the state. Approximately ten percent of our project load has been in the support of entrepreneurs in the development of new technologies leading to new businesses in the state.

In summary, the program development after two years has been extremely successful and is meeting not only the initial educational goals of our institution but many additional needs as well. Our forecast is for continued program growth with continued growth of staff, student employees and work flow. The model is proving successful in the academic environment and we will continue to track metrics to evaluate program benefits.

## **Bibliography**

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## **Biography**

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