2018 ASEE Annual Conference & Exposition
June 24–27, 2018 Salt Palace Convention Center Salt Lake City, UT
Paper ID #21237

# A Look into Badging Strategies in Engineering Education and Its Application to Energy and Manufacturing Certification Programs

**Dr. Arif Sirinterlikci, Robert Morris University**

Arif Sirinterlikci is a University Professor of Industrial and Manufacturing Engineering and the Department Head of Engineering at Robert Morris University. He holds BS and MS degrees, both in Mechanical Engineering from Istanbul Technical University in Turkey and his Ph.D. is in Industrial and Systems Engineering from the Ohio State University. He has been actively involved in ASEE and SME organizations and conducted research in Rapid Prototyping and Reverse Engineering, Biomedical Device Design and Manufacturing, Automation and Robotics, and CAE in Manufacturing Processes fields.

**Dr. Maria V. Kalevitch, Robert Morris University**

Maria V. Kalevitch, PHD University Professor of Biology and Dean of the School of Engineering, Mathematics and Science (SEMS)

Biosketch

Dr. Maria Kalevitch has a Ph.D. in Biology/Microbiology from the highly regarded Institute of Botany, Lithuanian Academy of Sciences. She earned her BS/MS in Bioengineering/Biotechnology from Moscow University of Biotechnology, and had her post-doctoral experience at the Department of Biology, Humboldt University, Germany and Institute of Plant Physiology, Sofia, Bulgarian Academy of Sciences.

Dr. Kalevitch came to RMU in 2002 as an Assistant Professor of Sciences. In 2004, she became the Founding Chair of the Science Department (degree-offering). The science degrees included: BS/BA in Environmental Science, BS in Biology, Teacher Certification in Biology, Forensics Minor, Energy Minor, and a strong Pre-Health Program with linkages to Drexel Medical School, Philadelphia College of Osteopathic Medicine, Lake Erie Osteopathic School, New York Chiropractic College, and Palmer Chiropractic College. Since 2005 Maria successfully developed and led the Pre-medicine Program at RMU.

Since 2005 she also served as an Associate Dean for the School, and in 2010 became the first female Dean of SEMS. There are currently only 28 engineering female deans in the United States and more than 400 accredited engineering programs. Maria is also the member of WELI, Women in Engineering Leadership Institute.

Dr. Kalevitch is committed to excellence in teaching and always promotes a student-centered learning environment. She has a keen ability to teach, advise, and recruit students. She has proven herself to be a very effective researcher. Her resume has a substantial list of publications, including lab manuals, books, and peer-reviewed articles in national and international journals. Recently her presentation was recognized by a Certificate of Achievement from the International Journal of Arts and Sciences: in recognition of her outstanding research presentation "NSF STEM Scholars" at the Convitto della Calza Conference in Italy. She served as a member of the Editorial Advisory Board for the following national and international scientific journals: Journal of Cell and Molecular Biology (Turkey), Canadian Journal of Pure and Applied Sciences, and American Journal of Sustainable Agriculture. In addition she is an experienced grant writer: served as a PI, Project Director on a 5-year NSF S-STEM grant for $522,000 that brought 21 scholarships to academically advanced, but financially challenged, students. Dr. Kalevitch is an effective ambassador to the community. Under her leadership, she has built strong outreach programs through the SEMS-Research and Outreach Center that educates students about STEM, and she specifically designed programs to encourage underrepresented groups to be involved in STEM disciplines. Dr. Kalevitch is a full member of the prestigious New York Academy of Sciences (that has Nobel Prize winners among its members), American Society for Microbiology (ASM), and American Mycological Society.

Dr. Kalevitch is a life-long learner, and recently participated in a webinar presented by the Harvard Institutes for Higher Education (HIHE). The HIHE offers comprehensive leadership development programs designed for administrators at every stage of their careers.

# A Look into Badging Strategies in Engineering Education and Its Application to Energy and Manufacturing Certification Programs


## Abstract

This paper focuses on previous attempts of badge-based credential assignments in the engineering education and training space for documenting competencies. Even though it was an exciting concept a few years ago with the possibility of offering an alternative to traditional methods, the badge-based systems have not gained much momentum in the engineering education world. Examples of different types including undergraduate and graduate work, comprehensive attempts, and computing and graphics projects are studied in this paper. The sociological impact on students, their families, and prospective employers are also visited by a discussion. This is a critical factor since it ties into the employment after graduation.

The authors have been developing multiple graduate and undergraduate certificate programs to be offered at an off-site location, which is a new and thriving multi-million dollar research, conference, and training center. Three certificates have been developed in the energy engineering technology, basic manufacturing, and additive manufacturing fields along with short-term accelerated training programs. This paper illustrates the structure and details of each certificate program including its admission procedures and requirements, its courses and future rearrangement using badge-based credentials. Utilization of badges will attract additional students to these certificate programs. However, some of the participants may want to only complete a single course or two based on their plans. A macro-badge assigned to an individual course will reflect one of the four levels of competence starting at the lowest passing level of Adequate Performance (AP) followed by Proficient (P), Mastery - Excellent (ME1), and Mastery – Exceptional (ME2) along with a letter grade.

The paper concludes with an assessment discussion, also including how accreditation bodies such as ABET, ATMAE or Middle States should and could see this type of credential assignment efforts.


### Introduction

Even though it was an exciting concept a few years ago with the possibility of offering an alternative to traditional methods, the badge-based systems have not gained much momentum in the engineering education world. Examples of different types are studied in this paper. A few notable attempts, some of which are ongoing, are presented here.

Rowan University employed a gamification platform in a multidisciplinary freshmen design course as the students earned badges by completing assignments that interest them within the platform [1]. In the Fall of 2014, the Purdue University Polytechnic Incubator started a new program based on competency-based-interdisciplinary skills to earn digital badges [2]. The individualized education and ability to explore a wide range of areas drew the interest and support of their freshmen. Purdue Polytechnic also studied the hopes and concerns of the students, parents, and the faculty who are engaged in the program [3]. Badge, Point, and Leaderboard (BPL) gamification was utilized at the University of Connecticut in a game-based chemical engineering course where students were kept in a game-like structure and remained engaged including earning points, special badges to commemorate accomplishments, and progressed up to the leaderboard due to their performances [4]. Literature review has shown that usage of micro-credentials may have a strong place in Computer and Information Technology, ONLINE education, and MOOCs [5][6]. In addition, there are other subjects including Computer Graphics Technology which can be better candidates for micro-credentials [7]. There has been a smaller number of attempts in the graduate education to incorporate micro-credentials [8], while most of the attempts were conducted in the freshmen level due to its lower risks [9].

In this paper, we will discuss utilization of badges at both, the *early undergraduate and graduate levels* through development of *college certificate and short-term accelerated training programs*. Successful completion of each course within the two developmental paths will lead to a *macro-badge* while critical competencies in each course will be awarded in the form of a *micro-badge*. Successful completion of the relevant courses will lead to a *certificate*.

**Development of Certificate Programs**

The authors have been developing multiple graduate and undergraduate certificate programs to be offered at an off-site location, which is a new and thriving multi-million-dollar research and training center, called the Energy Innovation Center (EIC). *Three 18 or 12-credit certificates have been developed in the energy technology (undergraduate), basic manufacturing (undergraduate), and advanced additive manufacturing (graduate) fields*. The marketing and admission processes for these certificates are handled by Robert Morris University (RMU), not the Energy Innovation Center. Prospective undergraduate students have to possess appropriate Mathematics and Science preparation and strong enough credentials (grades and standard test scores) determined by the university, and the graduate candidates must possess a bachelor’s degree in Engineering, Engineering Technology, Industrial Technology or Science fields. Details of the certificate programs are provided in Tables 1, 2, and 3. Programs were designed with appropriate pre-requisites in mind without increasing the credit counts. Graduates of the Advanced Additive Manufacturing Certificate can also further their education through the MS Engineering Management program available at the same department.

The courses will be taught at the EIC facilities, an off-site location. Thus, Substantive Change for Additional Location Request was required and granted by the Middle States Association of Colleges and Schools. A multifunctional 1440 square foot educational space was dedicated to the department by the Innovation Center. The project is supported by a grant worth more than $400K and additional grants are pending to improve the physical facility and expand the square footage. Assessment of the courses will be handled in a similar matter to the regular engineering courses through *Faculty Course Assessment Reports (FCARs) along with Student Course Evaluations*. The FCAR analysis is based on a vector type, which will be explained later in this paper.

**Certificate In Energy Engineering Technology**

**Concentration: Energy Technology Certificate**

| REQUIREMENTS | | | 18 Credits Required |
|---|---|---|---|
| * | 3 credits | ENGR1022 | Energy Fund and Sustainability |
| * | 3 credits | ENGR2012 | Renewable Resources |
| * | 3 credits | ENGS1020 | Intro To Energy Auditing |
| * | 3 credits | ENGS1050 | The Leed Rating System |
| * | 3 credits | ENGS1110 | Intro To Enerty Modeling |
| * | 3 credits | ENGT1030 | Intro To Energy Management |
| * A minimum grade of C must be earned in each course identified with an asterisk | | | |

Table 1. Undergraduate RMU Energy Technology Certificate

**Certificate In Engineering (Manufacturing Engineering)**

**Concentration: Manufacturing Engineering Certificate**

| REQUIREMENTS | | | 18 Credits Required |
|---|---|---|---|
| * | 3 credits | ENGR2160 | Engineering Graphics |
| * | 3 credits | ENGR2180 | Engineering Materials |
| * | 3 credits | ENGR3600 | Production Engineering |
| * | 3 credits | ENGR3650 | Product and Tool Design |
| * | 3 credits | ENGR4801 | Rapid Prototyp & Reverse Engr |
| * | 3 credits | ENGR4950 | Integrated Engineering Design |
| * A minimum grade of C must be earned in each course identified with an asterisk | | | |

Table 2. Undergraduate RMU Manufacturing Engineering Certificate

Utilization of badges will attract additional students to these certificate programs. However, some of the participants may want to only complete a single course or two based on their plans, earning a macro-badge or two. A macro-badge from an individual course will reflect one of the four performance levels starting at the lowest passing level of *60-70% grade or Adequate Performance (AP)* followed by *71-80% grade or Proficient (P)*, *81- 90% grade or Mastery – Excellent (ME1)*, and *91-100% grade or Mastery – Exceptional (ME2)* along with a letter grade published in their transcripts. Students who completed the entire program will also receive a certificate along with macro-badges from each course. In the case of the ENGR 4801 Rapid Prototyping and Reverse Engineering course (an ABET compliant course), multiple micro-badges will be developed to gage each participant's *competency in the certain segment of the course* including:

- *Product Design and Development* (Product Design and Development Process, Intellectual Property)
- *Computer-Aided Design* (SolidWorks competency based on multiple tutorials including drafting, solid modeling, and assembly)
- *Computer-Aided Manufacturing* (G Codes, Mastercam competency for milling and turning operations, Rep-Rap Specific G-Codes, CNC projects)
- *3D Printing Pre-Processing* (Design for 3D Printing and Additive Manufacturing, STL file and support generation)
- *3D Printing Processes and Associated Materials* (Powder, Liquid, and Solid Based Processes, Materials, Sustainability Subjects)
- *3D Printing Post-Processing* (Removal of Supports, Surface Improvement Processes)
- *Applications of 3D Printing* (Rapid Prototyping, Rapid Tooling, Additive Manufacturing, Non-Industrial Applications of 3D Printing)
- *Reverse Engineering* (Tools including 3D Scanning/CMMs and Methodology)
- *Cost Estimation*
- *Environmental, Health, and Safety Issues in 3D Printing and Additive Manufacturing*
- *Practicum* (Rapid Prototyping Project, Reverse Engineering Project)

*Home-works, laboratory exercises, and area specific quizzes* will be used in evaluating participant's micro-badge performances. *Focusing on and evaluating student performance in each area (listed above) without accumulating a lot of course materials will help students learn effectively*. The *Blackboard* System will handle the organization of the course including course materials, assignments, and quizzes. The four levels (AP, P, ME1, and ME2) utilized at the course or macro-badge level will also be employed at the micro-badge level.

**Certificate In Advanced Additive Manufacturing**

**Concentration: Advanced Additive Manufacturing Certificate**

| REQUIREMENTS | | 12 Credits Required |
|---|---|---|
| 3 credits | One from... | ENGR5010 Engr Cost Estimat & Fin Anal<br>ENGR5030 Project Engineering |
| 2 credits | ENGR5810 | Rapid Prototyping/Reverse Engr |
| 1 credit | ENGR5815 | Rapid Protyping Rev Eng Lab |
| 3 credits | ENGR6025 | Health and Safety Management |
| 3 credits | SUST6010 | Industr Ecology/Sustain Syst |

Table 3. Graduate Advanced Additive Manufacturing Certificate

**Development of Short Term Accelerated Training Programs**

With a newly funded project, RMU Engineering Department will continue to utilize its expertise in manufacturing engineering education and industrial training to further assist Pennsylvania's manufacturing industries by retooling unemployed workers, engineers and most notably, veterans, with the appropriate knowledge and skills for employment in the manufacturing sector.

Partnering industrial companies will be asked to identify potential unemployed workers for training as the project team conducts its own recruitment through the contacts from the university's Institute for Veterans and Military Families, veterans' networks along with trade and professional associations including Society of Manufacturing Engineers (SME). After completion of each training activity, the project team will schedule mock interviews and help unemployed participants with job placement. A mentoring service will also be available to the participants who want to further their qualifications through additional training or technical education.

Hands-on and intensive short-term courses (with similar contact hours to semester-long courses based on the 42 hour requirement of the Middle States Association of Colleges and Schools) will be developed, initially in the subjects such as *Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM)/ Computer Numerically Controlled (CNC) Machining, 3D Printing and Additive Manufacturing, Automated Identification, Programmable Logic Controllers (PLCs), Embedded Controls, Product and Tool Design, and Manufacturing Processes*. These courses were determined based on the university's interactions with its industrial partners. Each course will be offered at two different levels based on the educational background of participants (high school or college diploma). The development of the materials will be conducted by the Principal Investigator (PI) and reviewed by the Auditor including the assessment tools. Further course offerings will be determined by the manufacturing skill-gaps in the U.S. /PA [10] and will be based on the Four Pillars of Manufacturing Body of Knowledge given in Figure.1 below [11].

Students will be given *micro-credentials based on their performances in each critical area of a course and macro-credentials based on their overall competency in each course*, i.e. *Adequate, Proficient, (ME1) Mastery -Excellent, and (ME2) Mastery Exceptional Performance, similar to the certificate programs at the Innovation Center*. A series of courses with similar content and relevance will be tied to a certificate. *CAD, CAM/CNC, 3D Printing and Additive Manufacturing courses* will make up the *Digital Design and Manufacturing Certificate*. After earning a macro-badge from each course, the participants of these series of courses will be given *a certificate that will carry RMU and PA Department of Community and Economic Development (PA DCED) seal of approvals*. Additional initial certificates of *Automation and Embedded Systems, Integrated Product, Tool and Process Engineering* are envisioned by assembling of some of the courses listed above.

Each participant will take *a pre-, mid-, and post-test during a course in addition to the area specific home-works, laboratory exercises, projects, and quizzes*. The organization of these courses will also be handled by the Blackboard System. *ABET BS Manufacturing Engineering (EAC) (given below*) and Engineering Technology (ETAC) student learning outcomes will be applied in assessing student learning and the effectiveness of the student program:*

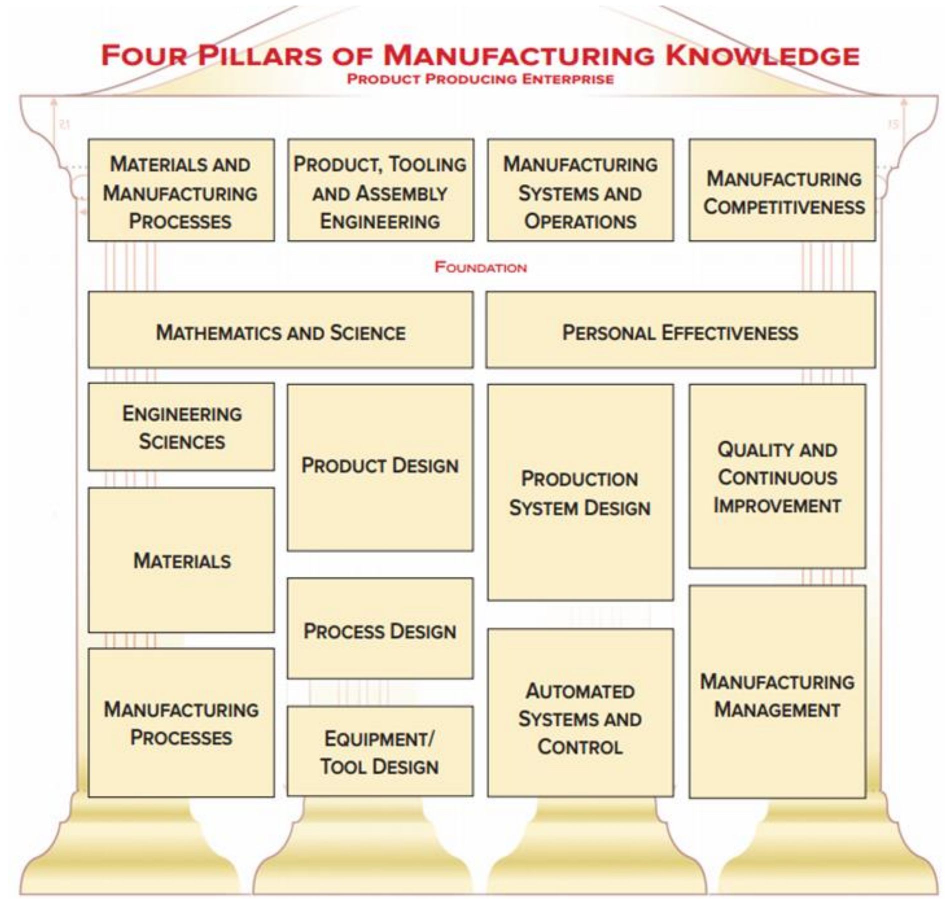


Figure 1. Four Pillars of Manufacturing Knowledge [11]

*"Manufacturing engineering programs [12] must prepare graduates to have proficiency in (a) materials and manufacturing processes: ability to design manufacturing processes that result in products that meet specific material and other requirements; (b) process, assembly and product engineering: ability to design products and the equipment, tooling, and environment necessary for their manufacture; (c) manufacturing competitiveness: ability to create competitive advantage through manufacturing planning, strategy, quality, and control; (d) manufacturing systems design: ability to analyze, synthesize, and control manufacturing operations using statistical methods; and (e) manufacturing laboratory or facility experience: ability to measure manufacturing process variables and develop technical inferences about the process.

After teaching each course, the instructors will prepare a Faculty Course Assessment Report (FCAR). *These FCAR documents will be collected in a repository and will be made available to the industrial partners, PA DCED, and the Auditor. The Auditor will review the detailed and aggregate results and make suggestions for improvements and further development.*

In its early ABET outcomes assessment process, RMU Engineering Department used a binary assessment of 80% of students earning 80% (or B-) grade or better as the only threshold for success on attaining an outcome. In the following years, *a vector analysis was developed and took its current form as shown in Table.1.* The lowest "acceptable" outcome performance is marked with *Adequate (70 – 79% of students getting B- letter grade or better).* As shown in the table below, the faculty members often use color coding to identify degree of challenges or the strength of performance in certain outcomes pertinent to each course. *This program will use the same vector analysis presented in Table 1 in its assessment practices.*

In addition, each participant will also be asked to complete a course evaluation survey. These surveys will be similar to standard surveys used at RMU and will be also utilized along with FCAR reports to see participant feedback and their perception of the effectiveness of the program. In addition to the assessment process, the project team will help with job applications and keep track of its success in the form of statistics.

| **Percentage of Students Getting 80%/B- or Better** | **Conclusion** |
|---|---|
| 90 - 100 | Excellent |
| 80 – 89 | Proficient |
| 70 – 79 | Adequate |
| 60 -69 | Concern |
| <60 | Weakness |

Table.1 Vector Analysis Used in Outcomes Assessment

**Conclusions and Future Work**

This paper described two different educational programs, certificates and short-term accelerated training. They are both needed to boost the credentials of the currently employed workers including practicing engineers and help retool unemployed persons for obtaining jobs in the energy and manufacturing sectors. Participants who want to take a single course will receive a series of micro-badges relating to the critical segments of that course and a single macro-badge while others who complete each certificate will receive a series of macro-badges along with their certificate document. These macro-badges will carry a heavier weight compared to some of the efforts listed in the literature review section. Even though no such programs are accredited by accreditation bodies, each course is prepared to be in compliance to ABET EAC or TAC entities since these courses may also be used by the regular students and the quality of education needs to be monitored, documented, and continuously improved. The short-term accelerated training programs are funded by the PA DCED adding more credibility and a strong seal of approval. The results of these efforts will be presented in the upcoming ASEE conferences (including the 2018 Annual Conference) with updated data and information since this paper is only prepared as a work-in-progress paper.

**References**


[1] Gulotta, J.A., Parisi, N.S., & Bodnar, C.A., *Leveling Up by Gamifying Freshman Engineering Clinic*. New Orleans, Louisiana. https://peer.asee.org/26207

[2] Ashby, I., & Exter, M., *"What's in it for me?" A Look into First-year Students' Perceptions of a Digital Badge System*. Seattle, Washington. https://peer.asee.org/23350

[3] 7] Exter M., Ashby, I. & Shaurette, M., *Entering the First Year of a Multidisciplinary, Hands-on, Competency-based Learning Experience: Hopes and Concerns of Students, Parents, and Faculty*. Seattle, Washington. https://peer.asee.org/24014

[4] Anastasio, D., Suresh, A. & Burkey, D.D., *Impact of Narrative, Character Creation, and Game Mechanics on Student Engagement in a Game-based Chemical Engineering Laboratory Course*. Seattle, Washington. https://peer.asee.org/24225

[5] Fosmire, M., Van Epps, A., & Johnson, N.E., *Badging Your Way to Information Literacy*. Seattle, Washington. https://peer.asee.org/23614

[6] Nissenson, P.M., & Coburn, T.D., *Scaling-up a MOOC at a State University in a Cost-effective Manner*. New Orleans, Louisiana. https://peer.asee.org/26140

[7] Bruce, W. C., & Thomas, T. H. *Work in progress: A First-Year Common Course on Computational Problem Solving and Programming*. Indianapolis, Indiana. https://peer.asee.org/23316

[8] Connolly, P.E., Garcia Bravo, E., Bertoline, G.R., & Hassan, R. P., *Transforming a Computer Graphics Department from Traditional Education Methods to a Polytechnic Approach*. Seattle, Washington. https://peer.asee.org/24937

[9] Joy, L. C. *Looking Ahead: Some Trends in Graduate Education and Their Impact on Engineering and Technology*. San Antonio, Texas. https://peer.asee.org/21660

[10] Boiling point the skills gaps in US Manufacturing. https://www2.deloitte.com/us/en/pages/manufacturing/articles/boiling-point-the-skills-gap-in-us-manufacturing.html

[11] Four Pillars of Manufacturing Knowledge http://www.sme.org/uploadedFiles/Membership/Technical_Communities/Manufacturing_Education_and_Research/Four%20Pillars%20Flyer.pdf

[12] Manufacturing and Similarly Named Engineering Programs student learning outcomes. http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/#outcomes