Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #46038

Teaching materials testing concepts and best practices using micro-credential framework

Mr. Justin C Willis, University of Maine, Advanced Structures and Composites Center.

Justin Willis is a Materials Testing Technician at the Advanced Structures and Composites Center, a research center within the University Of Maine. Research interests include materials testing, composites for marine applications, and statistics education for engineering students.

Teaching materials testing concepts and best practices using micro-credential framework

Abstract

The Advanced Structures and Composites Center (ASCC), the largest university-based research center in the state of Maine, employs hundreds of undergraduate and graduate students every semester. These student employees work on various governmental and industry-funded projects, with many focusing on the formulation and testing of new composite materials and structures. The ASCC provides design, engineering, and hands-on experience that these students would not otherwise obtain during their formal university degrees.
As part of the greater university, the center also provides training for students to perform research on projects sponsored by the university, but not directly administered by the ASCC.

To recognize these student experiences in a measurable, tangible and demonstrable manner, the ASCC worked with the University of Maine System to develop micro-credential pathways. One such pathway developed as a pilot is aimed at concepts related to performing standardized ASTM mechanical tests on materials. The pathway consists of badges earned by demonstrating competency in various concepts related to accurately and safely performing mechanical tests, such as universal test frame operation, instrumentation and measurement tools, experimental design, and test documentation procedures. Students demonstrate mastery of these skills and practices through summative assessments, practical demonstrations in lab environments, and finally, in a research project as part of their paid laboratory work.

Development of this pathway also allows for standardization of student training and assessment of testing skills, making collected data quality more consistent. Upon completing the badges and the overall pathway, students gain digitally curated credentials showing demonstrated mastery of mechanical testing concepts and skills, which can be presented to their professional supervisors at the ASCC and at their future employers. These pathways can also be used for workforce development and continuing education, to update current worker skills and knowledge in a directed and efficient manner.

1. Introduction and Objectives

As advanced manufacturing continues to mature and evolve, the development of effective tools to interface with the manufacturing equipment, materials, and post-processing is essential. Micro-credentials are a growing mechanism for teaching, training, and professional development both within the University of Maine system and the larger academic and industrial community.

The primary objective of the effort outlined below was the development of a mechanical testing micro-credential and evaluation of effects on student outcomes and skills through participation in the pathway. This micro-credential pathway serves to address the following:

- Provide standardized and coherent training in mechanical testing best practices.
- Inform and refine micro-credential content and structure to maximize student learning and skill development, across a diverse population of students.
- Improve and ensure safety, accuracy and quality of testing regimens performed by students at the ASCC, for federal and industrial projects.
- Develop student expertise in the full holistic scope of the mechanical testing process, from test development and setup to test execution and data analysis.
- Provide students with a quantifiable and transferable record of training in mechanical testing as part of their ASCC work that can be shared with future and potential employers.

2. Literature Review

Micro-badges and micro-credentials have emerged both as a complement to and as a competitor of more established credentialing mechanisms present in higher education, such as degrees. Micro-credential awards and content are developed both by higher education institutions and by private companies specializing in industry or educational design [1]. In all cases, the core tenets behind a micro badge include being directed at a particular skill or operation, having verifiable outcomes and assessments of mastery, and digital curation, which allows transfer and recognition across various institutions [2]. Micro-credential awards are shorter term than most collegiate degrees and are often asynchronous, allowing students to complete them at their preferred pace. These characteristics mean that micro-credentials are often desirable for both working professionals looking to develop a skill and for those changing workforce roles during their career [1]. These populations may not be able to devote the time and funds towards taking/retaking a full collegiate program of study. In a survey conducted of learners enrolling and completing Coursera Specializations and edX Micro Masters credential pathways, two common and established online micro badging programs, over 75% of participants had already earned a bachelor's degree or higher, but less than 25% were currently enrolled in a degree program [3]. These micro-credential pathways are developed by research institutes, universities and private businesses, and administered by Coursera or edX. Some credential pathways have been accepted by universities for course credit towards undergraduate and graduate programs [3].

These credentials can also be more specialized and directed than most collegiate content, allowing for more input from industrial employers of students [4] [5]. A stated need of the agency funding this effort was to improve the employability of graduating students on "day one," providing skill training that would allow the new students to contribute meaningfully and quickly upon hire, minimizing onboarding training needed. As practices and theories used in engineering and industry change rapidly as new manufacturing technologies develop, micro-credential

pathways are set to emerge as an agile and rapid way to address these skill gaps as they emerge for graduating and mature workers. [4] While several undergraduate programs in engineering and technology at the University of Maine provide courses that involve the theoretical properties derived in mechanical tests of materials, student workers at the ASCC are in a unique position to develop the skills to safely and accurately carry ASTM mechanical tests out to actual clients. The micro-credential framework developed provides a tangible and transferable record of these unique skills developed, with the aim of distinguishing and preparing these students for further engineering employment. In the survey referenced above, only 27% of learners anticipated learning something new when starting the credential pathway, but 94% of those completing the pathway listed learning something new as a benefit [3].

Challenges in micro-credential acceptance include verifying skills and accepting nonstandard certifications like micro-credentials across varied institutions and companies. Without direct control of the content or measure outcomes of a micro-credential, colleges or companies may be hesitant to accept micro-credentials at a legitimate face value. This is compounded by no set accreditation scheme in place for micro-credentials to ensure a certain level of quality and rigor, as exists for collegiate degrees [1]. This can lead to micro-credentials of varying quality and acceptance that need to be evaluated by the learner and by the potential employer on a case-by-case basis, negating many of the proposed benefits of the micro-credentialing system. To help alleviate some of these challenges and concerns, the micro-credential effort outlined in the following document provides transparent documentation of content modules and evaluation, and methods of assessment. A reflective survey is also provided as part of the learner work in every dedicated micro badge in this pathway, allowing learners to rate and comment on the utility of the material and activities in developing the skill in question and evaluate perceived benefits in their future work/employment.

3. Pathway Requirements

For each level of the micro-credential, a list of pathway requirements has been identified to assess student skills and knowledge. These requirements are presented in Table 1, Table 2, and Table 3 for Level 1, 2, and 3 respectively. Three categories of requirements have been identified as shown below:

- Fixed - Common to all ASCC pathways
- Shared - Created for another micro-credential pathway under development, included for credit in the Mechanical Testing pathway as well
- Unique - Core to this topic

Fixed requirements are those determined to be beneficial for student learning and employability, regardless of research area or specialization students work in during their ASCC research. These include 21st century, safety and soft skills, in addition to work hour requirements. While the hours worked at the ASCC by the student will not all be spent working on micro credential content, they are used to demonstrated continued and cumulative research experience. If the student wishes to complete more than one micro-credential pathway, some or all fixed or shared requirements will not need to be satisfied twice.

Table 1. Micro-credential level 1 foundational learner pathway requirements

Requirement	Training/Evidence	Assessment
Lab Safety & Security	Micro-badge	Micro-badge
Career Essentials-ASCC	Micro-badge	Micro-badge
Measurement Systems	Micro-badge	Micro-badge
Work Hours	100 hours of work on any assigned task	Timesheet Report

Table 2. Micro-credential level 2 developing learner pathway requirements

Requirement	Training/Evidence	Assessment
Experimental Design	Micro-badge	Quiz, Work Instruction Activity
Intro to Electronics	Micro-badge	Micro-badge
Experimental Documentation	Micro-badge	Quiz, Datasheet Activity, Testing Conduct Rubric
Hydraulic Instron Operation OR EM Instron operation	Micro-badge	Quiz, Lab Demonstration
EDL Micro-badge Selection	Review EDL options	Register for online class
Work Hours	200 hours of work on any assigned task	Timesheet Report

Table 3. Micro-credential level 3 established learner pathway requirements

Requirement	Evidence	Assessment
Testing Regimen	Report on mechanical testing completed for ASCC project	Testing Regimen Rubric
Scientific communication experience	Abstract book, agenda, announcement, etc.	Participation verified
Positive Supervisor review of work	ASCC Student Evaluation	Rubric within Evaluation
EDL Micro-badge	Micro-badge	Micro-badge
Work Hours	300 hours of work on any assigned task	Timesheet Report

4. Requirements Description

More detail on unique requirements for each level is provided in this section. Each level outline includes essential questions the level seeks to answer and a list of developed content modules. Requirements identified in the previous section as Fixed or Shared are not presented in detail here, as they are general modules provided by the University of Maine System, developed

and presented in other/all micro-credential pathways. All requirements are aligned to the University of Maine System Micro-Credential Initiative framework.

4.1. Level 1: Foundational Learner

Level one of the micro-credential pathway is meant to build a foundation for a learner without assuming any prior background in mechanical testing by addressing essential questions through the presentation of the outlined content and evaluation of the learner's retention of that content through multiple evaluation methods.

4.1.1. Essential Questions

Essential questions for the unique content presented at level one are outlined in the following numerical list:

1. What is measurement?
2. How are measurements made?
3. How can you display measurements as data?
4. How can you tell if your measurement or data is accurate or useful?

4.1.2. Content Outline

The level one content outline of unique content is given below. When a subject area is presented as a micro-badge, it will be identified in the list header in parenthesis.

Measurement Systems (micro-badge)

- What is a measurement
- Measurement tools
- Units
- Tolerance and Accuracy
- Choosing the correct measurement tool
- Evaluations
    - 20 Question Quiz on learning management system
    - In Lab Practical: Caliper and micrometer dimensioning of specimens
        - Evaluated according to created rubric
    - Practical: Dimension Spreadsheet for width and thickness of specimens
        - Evaluated according to created rubric

4.2. Level 2: Developing Learner

Level two of the micro-credential pathway is meant to build on the level one foundation by presenting more specialized technical content, aiming to expose the learner to processes needed to fully complete a sample of mechanical material testing. Learner development and understanding is demonstrated and assessed across several micro-badges, each including both theory-based assessments and practical laboratory demonstrations.

4.2.1. Essential Questions

The essential questions for the unique and shared content presented in level two are outlined below:

1. What considerations should I make when planning a material test for physical or mechanical characteristics?
2. How can I use standardized testing procedures to make my testing safe and replicable?
3. How can hydraulic or electromechanical test frames at the ASCC be used to perform mechanical testing?
4. What measures can I take to ensure the accuracy of electrical signals collected as part of my measurement and testing system?
5. What information is necessary and prudent to document as part of completing a testing experiment?

4.2.2. Content Outline

The level two content outline is divided into three subject areas. When a subject area is presented as a micro-badge, this will be identified in the list header in parenthesis.

Experimental Design (micro-badge)
- Planning and design of physical and mechanical tests
- Selecting ASTM and other standardized test methods
- Common ASTM tests used at the ASCC
- ASCC Work instruction components and format
- Evaluations
    - 10 Question Quiz on learning management system
    - Work Instruction Activity
        - Evaluated according to a created rubric

Experimental Documentation (micro-badge)
- Documentation for pre-test conditions and parameters
- Datasheet requirements and components
- Methods for ensuring collected data traceability and quality
- Interpretation of force-deflection and stress-strain data
- Evaluations
    - 10 Question Quiz on learning management system
    - Datasheet Activity
        - Evaluated according to created rubric
    - Testing Conduct activity, on mock testing
        - Evaluated according to created rubric

Hydraulic Instron Operation *OR* Electromechanical Instron Operation (both micro-badges)
- Parts and components of a hydraulic or electromechanical Instron test frame
- Safe manual operation of test frames for testing setup
- Use of position and load limits to ensure operator safety and prevent frame/fixture damage
- Test method development for executing static and quasi-static mechanical tests
- Operation and running test methods for repeated tests
- Evaluations (for each of the micro-badges, each badge has separate evaluations)
    - 20 Question Quiz on learning management system
    - In-Person Laboratory Instruction and Demo

4.3. Level 3: Established Learner

Level three of the micro-credential pathway allows the learner to demonstrate the full scope of the mechanical testing process, synthesizing and combining concepts presented and evaluated in levels one and two. As no new material is to be presented at this level, instead of essential questions and a content outline a final evaluation method is outlined. This is applied to real research work the learner conducts to apply, develop, and prove their competency in mechanical testing design and execution.

4.3.1. Final Evaluation Methods

1. Testing Regimen: Plan, document, execute, and report on a regimen of physical or mechanical testing conducted during lab or project work. This should include:
    - Choosing and developing a test method,
    - Documenting any pre-test parameters and information,
    - Selecting data measurement tools and systems,
    - Training on and set up of any test frames or machines
    - Execution of the tests with documentation of test data
    - Analysis of the data for required calculated values
    - Presentation of this data to your supervisor in requested format

4.4. Overall Micro-Credential Pathway

Overall content organization between Levels one, two and three is presented below in Figure 1 showing expected student order of completion, and organization of unique, shared and fixed content modules.

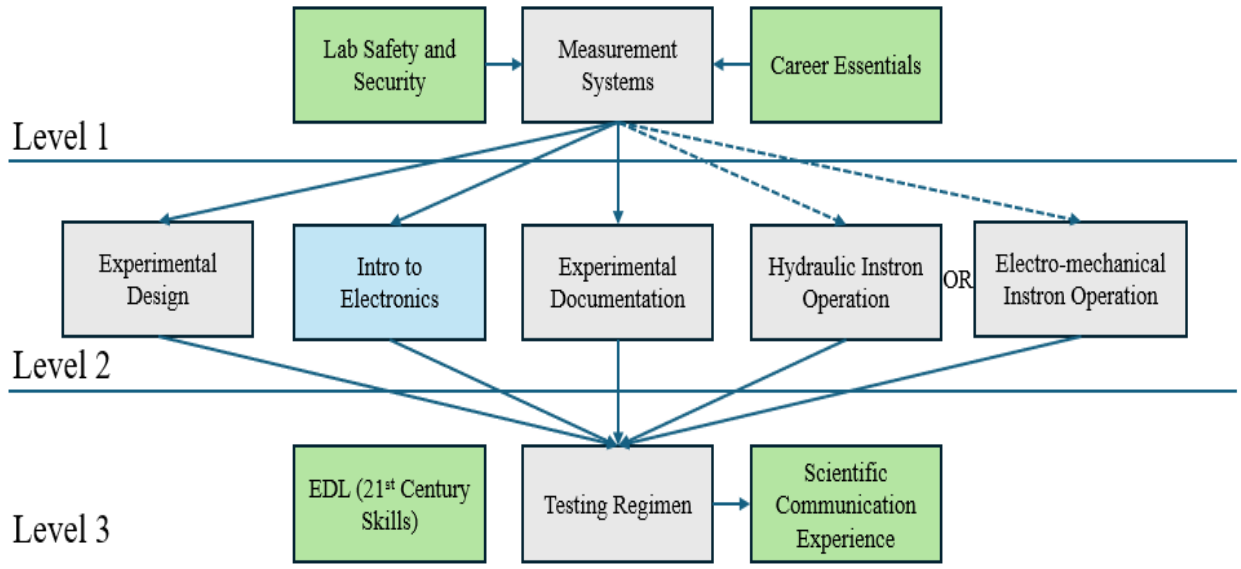

Figure 1: Micro-Credential Pathway Outline

5. Research Methods and Data

Evaluation of student work on content for each micro badge module was conducted using Brightspace quizzes, or through rubrics completed by ASCC testing staff or the supervisor of the working student. These completed rubrics and quiz results are retained for evidence supporting the micro badges and credentials awarded.

As part of each micro badge component of this micro-credential pathway, students complete a reflective survey, which requests they record their level of agreement with statements regarding the utility of the micro badge content in developing new skills, and perceived changes to their employability after college. These questions are provided on a 5-point Likert scale (Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree) [6], and an additional comments entry is provided for any other comments or observations the student would like to add. Subjects completing the Measurement Systems micro badge and the accompanying survey for this initial study include:

- ASCC student employees engaged in mechanical testing
- UMaine mechanical engineering students as part of a mechanical testing course lab, centered around ASTM E8/E8M-24
- ASCC staff electing to complete the micro badge for auditing or professional development purposes

Initial findings from students completing the Measurement Systems micro badge in Level one of the mechanical testing credential pathway are provided in

Table . The percentages listed record the percentage of students who indicated they agreed or strongly agreed with the listed statement.

Table 4: Student Reflection Data (Agree or Strongly Agree) (n=45)

The content presented in this micro badge was informative and taught me new things.	**88.8%**
The content presented in this micro badge was presented clearly and effectively.	**97.8%**
The content presented in this micro badge taught me about concepts and techniques outside of my college courses.	**68.9%**
The content presented in this micro badge improved my confidence and ability as an ASCC employee.	**62.3%**
The content presented in this micro badge improved my confidence and ability as a UMaine graduate.	**68.9%**
The content presented in this micro badge will be valuable to me as I enter the workforce as a professional.	**88.9%**

Based on the data above, a substantial majority of students assessed the micro badge content as effectively presented and taught them valuable and new information. One hypothesis regarding the lower percentage of students agreeing with the third question, is that the question was of little relevance to students completing the micro badge for mechanical engineering lab while not being an ASCC employee. The micro badge content was also assessed to be valuable by a substantial majority of students as they graduate and enter the workforce.

Data collected at this point is mostly exploratory in nature and is based on self-reporting by the student. As students complete the pathway and graduate, further data collection and surveying of graduates and employers is planned. Current plans include a survey issued to graduating student employers and supervisors and assessing student academic and retention values for students completing the micro badges.

6. Conclusions and Future Work

Future development of this micro-credential may include recording and generating slide narrations of presented content, improving accessibility of content for diverse learners. With the micro-credential pathway being opened, initial students working through the pathway will be asked to provide feedback on the content and their experience earning the micro-badges and credentials. This feedback will be used to improve content presentation and pedagogy on a recurring basis.

This micro credential pathway is planned to be one of several developed at the ASCC for student workers, to reflect the varied research conducted by these students. Planned micro credential pathways include additive manufacturing, thermal analysis of materials, precision measurement and metrology, and digital image correlation methods. Some of the micro badges developed in this mechanical testing pathway may be reused in other pathways if relevant, allowing students to possibly earn badges and credentials across several pathways.

Based on the experience and data resulting from the development and launching of this initial pathway, the development team makes the following recommendations for generating and using micro credentials within a university research center.

- Focus on practices and concepts used by student workers regularly at the center, that are not commonly practiced in university curricula
- Align expectations and requirements of micro badge work with work students will already be conducting for research as much as possible
- Standardize assessment and evaluation methods with rubrics or point scales, for evaluation consistency and repeatability.
- When micro badge content involves use of externally made equipment, consult or align with manufacturer tutorials and training where relevant and possible.

References

[1] B. Oliver, "Making micro-credentials work for learners, employers and providers," Deakin University, 2019.

[2] EU, "A European Approach to Microcredentials," European Union, 16 June 2022. [Online]. Available:https://education.ec.europa.eu/education-levels/higher-education/micro-credentials. [Accessed Nov 2022].

[3] F. M. K. A. J. K. &. G. Y. C. Hollands, "Benefits and Costs of Participation in MOOC-Based Alternative Credentials: MicroMasters and Specializations.," *EdResearcher,* vol. 1, 2023.

[4] M. N. M. B. E. &. M. L. C. Brown, "The global micro-credential landscape: Charting a new credential ecology for lifelong learning," *Journal of Learning for Development,* vol. 8, no. 2, pp. 228-254, 2021.

[5] R. &. S. M. Selvaratnam, "An integrative literature review of the implementation of micro-credentials in higher education: Implications for practice in Australasia," *Journal of Teaching and Learning for Graduate Employability,* vol. 12, no. 1, pp. 1-17, 2021.

[6] J. Carifio and R. J. Perla, "Ten Common Misunderstandings, Misconceptions, Persistent Myths and Urban Legends about Likert Scales and Likert Response Formats and their Antidotes," *Journal of Social Sciences,* vol. 3, no. 3, pp. 106-116, 2007.