

Experiential Learning of Manufacturing Standards: from Lectures to Labs and Industrial Internships

(NIST Award 70NANB21H173)



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Sept. 12th, 2025

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Mechanical Engineering, Mercer University
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Main Goals

- Create a systematic framework that includes lectures, labs, and industrial experience to strengthen education and learning about **robotics and additive manufacturing standards** among engineering students.

Project Objectives

1. Develop innovative **course modules** (lecture, lab, and project) to advance students' professional preparedness
2. Develop **virtual learning materials** to improve students' career readiness
3. Create a sustainable **online course structure** to enhance education and learning impacts.

Design of Curriculum

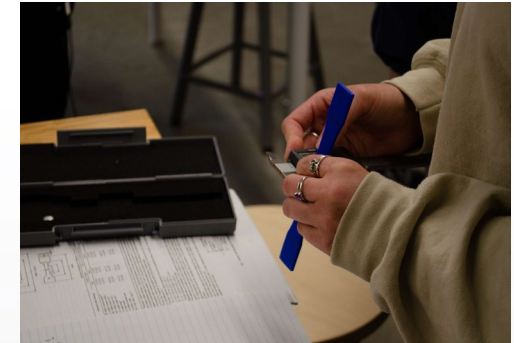
- Six Course Modules
- One New Course
- Plant Tours
- Seminar from Guest Speakers

Curriculum Design

	Additive Manufacturing	Robotics	New Course
Entry Level (<u>Lecture</u>)	MFGE 2421 Introduction to AM (Spr. & Fall 2022-2025)	FYE 1220 First-Year Seminar (Fall 2022) MFGE 4533 Industrial Robotics and Automation (Spr. 2022 & 2024, Fall 2022 & 2023)	
Medium Level (<u>Lab</u>)	MFGE 5333 AM Studio (Fall 2022-2025)	MFGE 4533 Industrial Robotics and Automation (Spr. 2022 & 2024, Fall 2022 & 2023)	
Graduate Level (<u>Project</u>)	MFGE 5334G AM of Lightweight Structure (Spr. 2023-2025)	MFGE 5337G: Advanced PLC Hardware and Programming (Spring 2023)	MFGE 5339G Manufacturing Standards and Standardization (Fall 2022 & 2024)

Course Modules (AM)

- Lecture module in MFGE 2421
 - Lecture topics cover “what is a “standard”?”, “why does AM need standards?”, “how are AM standards developed?”, and “how to use AM standards”.
 - Course assignment requires students to follow AM standards (such as ISO/ASTM 52910) to complete a simple design project.
- Lab module in MFGE 5333
 - Evaluate tensile strength of FDM 3D printed plastic materials (for university without metal AM facility), referring to ISO/ASTM 52903 and 52921, ASTM D638, etc.
- Project Module in MFGE 5334
 - Student developed SOP for the mechanical testing of a polymer lattice structure printed by AM, including lattice design, 3D printing, compression testing, data collection & analysis, SOP development.
 - Existing standards ASTM D695, F3112, and F2971 are referenced for the SOP drafting.



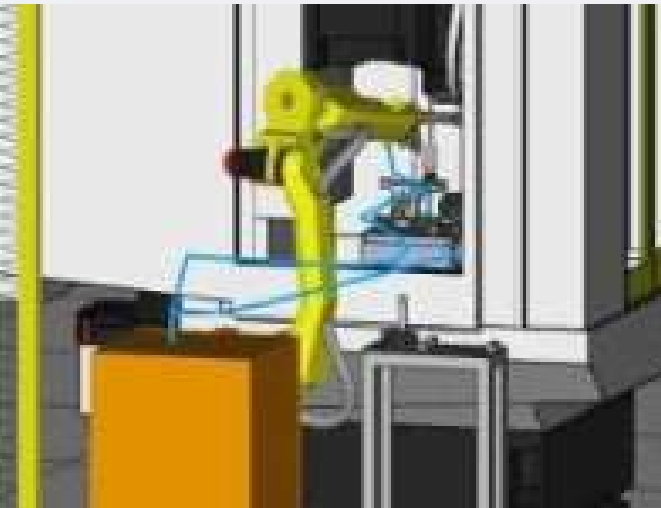
Course Modules (AM) (slide 2 of 2)



Course Modules (Robotics)



- Lecture module in FYE 1220
 - Lecture topics “Introduction of a Standard” covering “what is a standard?”, “why do we have standards”, and “how to locate important standards resources”
 - Course assignment requires students to complete a quiz.
- Lecture module in MFGE 4533
 - Lecture topics “Robots and Safety” covering “Safety Standards for industrial robots”, and “Types of safety options”
 - Hands-on activity: How to recover a robot from singularity.
- Lab module in MFGE 4533
 - Design a robotic workcell using RoboGuide that satisfies the requirements in the ANSI/RIA R15.06-2012 Robot Safety Standard.
- Project module in MFGE 5337G
 - Applies the ANSI/RIA TR R15.306-2016 standard to perform a task-based risk assessment for an industrial robot system within a Flexible Manufacturing System.



Seminars

- Guest Speakers



Plant Tour

JTEKT

Koyo

TOYODA



**HOWMET
AEROSPACE**



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Plant Tour – Briggs & Stratton



Results and Key Findings-Replication

- Demonstration Class
- E-conference
- Project Website



Demonstration Class

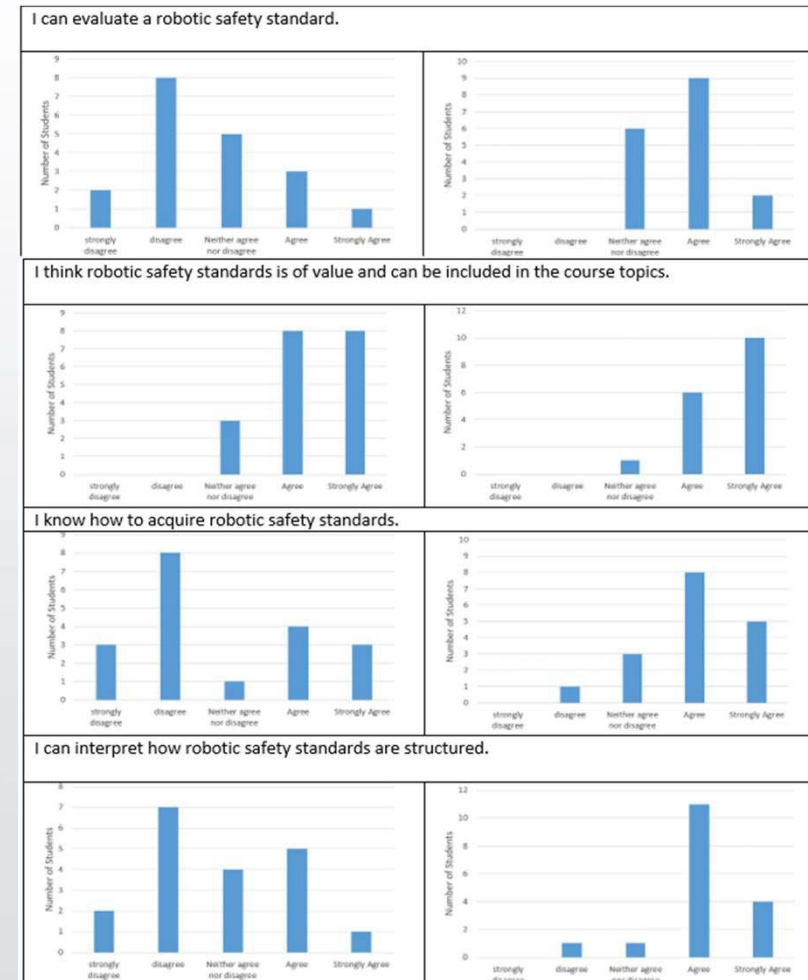
Host University: San José State University

Course: ME192 Robotics and Manufacturing Systems

Topic: Robots and Safety Standards

Students: 19

Platform: Zoom



E-conference

- Two e-conferences: June 2022 and December 2023
- 18 attendees from 16 institutions across 3 countries: U.S.A, India, and Nigeria.

Institutions of Attendees

Purdue University	Omex India Sales Pvt Ltd
Penn State University Erie	University of Nigeria Nsukka
Jackson State University	San Jose State University
Georgia Southern University	Binghamton University - SUNY
University of Alabama in Huntsville	Oregon Institute of Technology
Missouri Western State University	Bradley University
The University of Texas -Tyler	Miami University
Northern Kentucky University	University of Oklahoma



2022 SYMPOSIUM ON MANUFACTURING STANDARDS EDUCATION (SMSE)



Jun. 1ST, 2022
1 – 4 PM (EDT)

- Keynote speakers from ASTM and JTEKT
- Sharing of teaching resources
- Demonstration of using instruction materials
- Advisory on engineering standard education
- Discussions on curriculum development

[Click To Register](#)

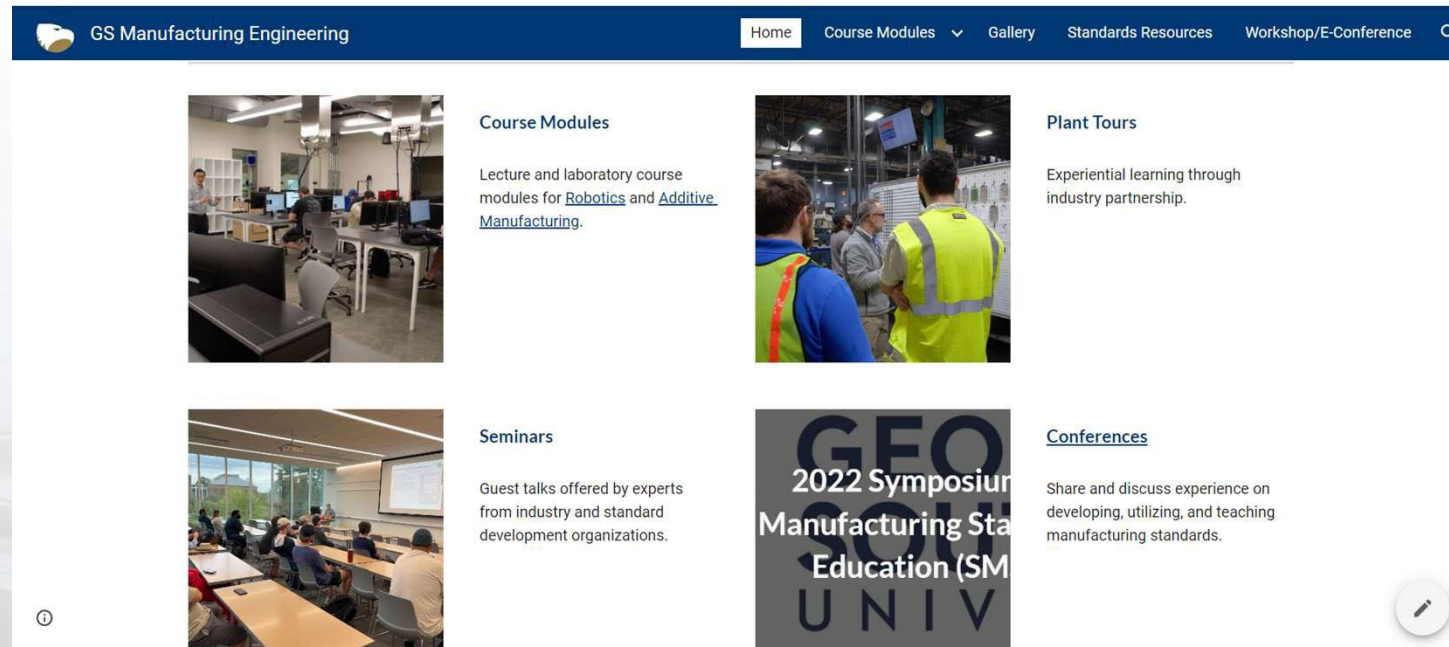


[Scan to Register](#)



NIST funded project
(Award no. 70NANB21H173)

Project Website



- Download Course Modules
- E-conference Registration
- Videos records and pictures
- Student Resources
- Project news and updates



[Website Link](#)



Results and Key Findings- Dissemination

Conferences	2022	2023	2024
Scholarship of Teaching and Learning (SoTL) Commons Conference	<i>Development of Experiential Learning Modules for the Education of Manufacturing Standards"</i>	<i>Integrating Standards Education into the Manufacturing Engineering Curriculum</i>	<i>Empowering Future Engineers: Integrating Standards Education in Manufacturing Engineering Curriculum with a Focus on Additive Manufacturing and Robotics</i>
Solid Freeform Fabrication (SFF) Symposium	<i>Development of Standards Education Modules for Robotics and Additive Manufacturing</i>		<i>Enhancing Standards Education in Additive Manufacturing and Robotics: A Systematic Approach and Curriculum Integration</i>
ASEE Annual Conference		<i>Integrating Engineering Standards into Manufacturing Engineering Curriculum</i>	



Publication

- Publication
 - Zhang, Y.*, Gong, H., & Wu. L. (2023, June). Integrating Engineering Standards into Manufacturing Engineering Curriculum. In 2023 Annual Conference of American Society of Engineering Education.
<https://peer.asee.org/43759>

Results and Key Learnings- Student Feedback from Course Surveys

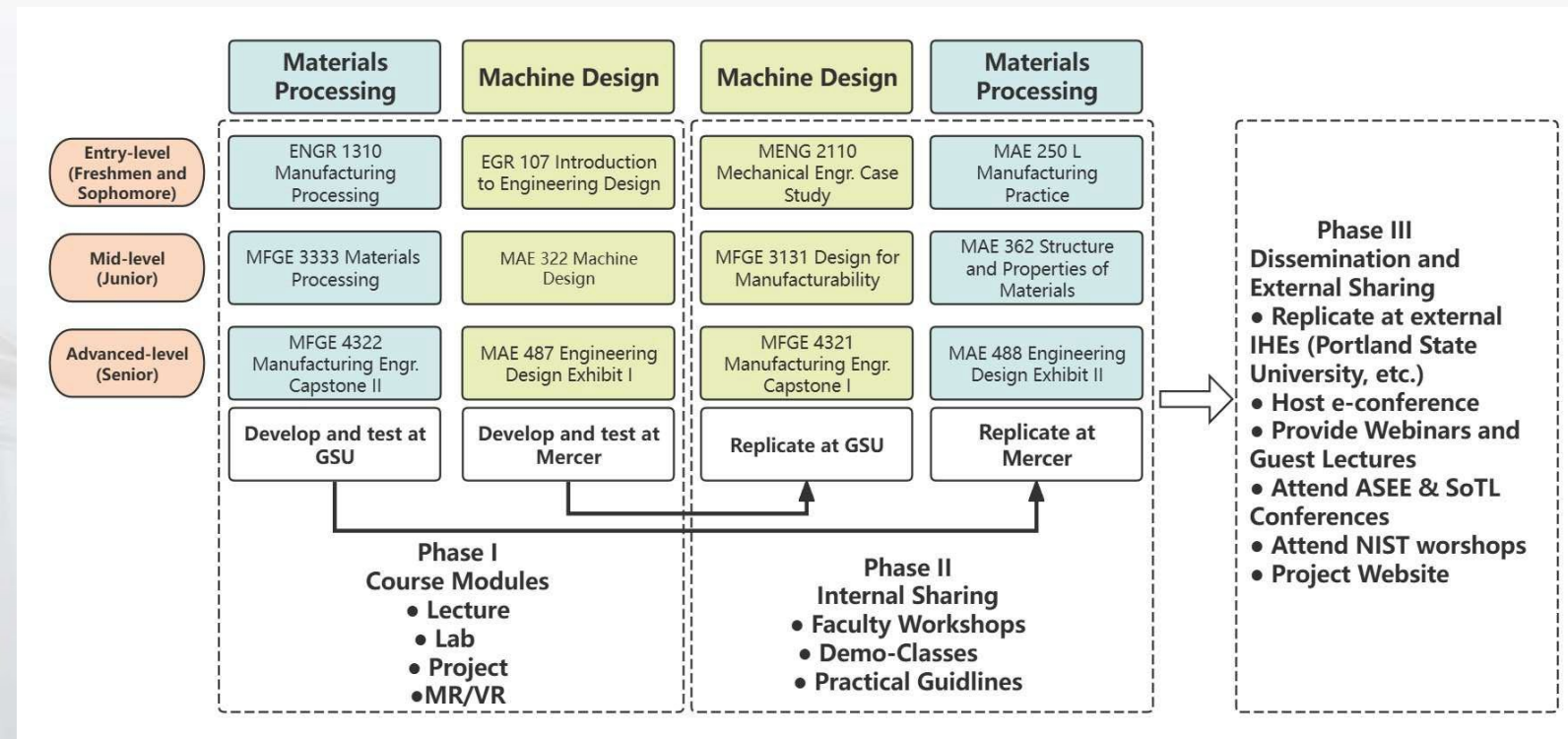
- The course did a great job of helping me understand engineering standards and immediately gave me direction on an ongoing current project in my personal workplace.
- Even as a working engineer I have not dug deep into standards unless it was a safety requirement or keeping up with documentation to quality requirements. This level of insight has really broadened my perspective on the usefulness of standards and their application, as well as given me a deeper understanding of the details surrounding standards. I hope to apply standards more often in my work going forward, both with existing standards and creating internal standards. I think there is a lot to gain from this knowledge and the class/material was pretty cool!

Results and Key Learnings

- Survey during e-conferences (faculty/educator attendees):
 - 8 responses collected
 - All respondents agreed on the value of the course materials
 - 2 of 8 indicated plans to adopt immediately
- What are the barriers that prevent faculty from adopting the materials?
- Reflections: How can we help promote adoption?
 - Provide ready-to-use lesson plans to reduce extra effort?
 - Offer training to build faculty confidence in relevant standards?
 - Share step-by-step guidance on how to tailoring the modules to fit diverse course topics?
 - Foster peer collaboration networks to exchange teaching practices?

Future Work

- Innovating Standards Education: A Dual-University Model for Replicable Modules in Materials Processing and Machine Design
(NIST Award 70NANB25H129)



Thank You!
Questions?



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