# Development of Standards Education Modules for Additive Manufacturing

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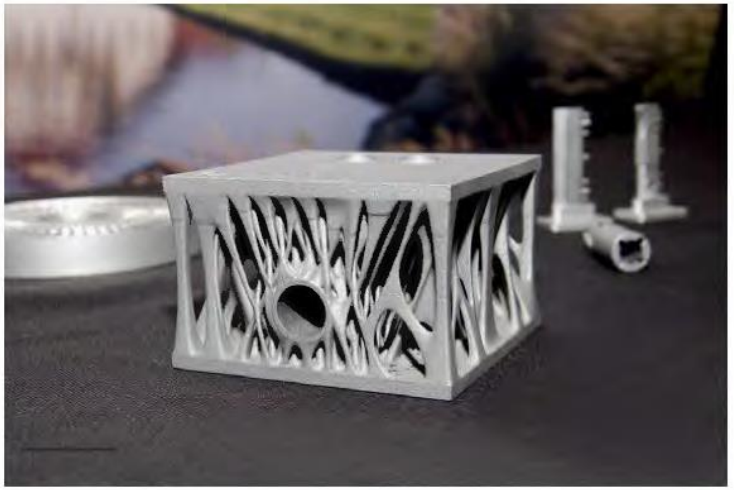
THE UNIVERSITY OF ARIZONA

# How can we improve the design and production of parts manufactured using additive manufacturing?

3D Printing + COVID

Metal AM applications



# About us

| Name: | Hannah Budinoff | Andrew Wessman | Cholik Chan |
|---|---|---|---|
| Background: | **Department:** Systems & Industrial Engineering<br>**Research**: Engineering design; makerspaces<br>**Industry**: Honeywell Aerospace<br>**Teaching**: Ugrad/grad Design for AM course | **Department:** Materials Science & Engineering<br>**Research**: Metallurgy; high-temp alloys<br>**Industry**: GE Additive<br>**Teaching**: Ugrad/grad Metal AM course | **Department:** Aerospace and Mechanical Engineering<br>**Research**: Heat transfer; Energy storage<br>**Industry collaborators**: Raytheon, Air Force Research Laboratory<br>**Teaching**: Ugrad/grad Intro to AM course |

# Our overarching goal:

To prepare engineers who can utilize technical standards to guide their use of additive manufacturing technologies

# Our 5 specific objectives

| | |
|---|---|
| 01 | Develop 4 e-learning modules with a total of 36 hours of content |
| 02 | Deploy each of the developed modules in one or more courses at UArizona |
| 03 | Improve students' ability to identify, locate, evaluate, and use standards for technical problems related to AM |
| 04 | Distribute e-learning modules to other institutions of higher education with guidance for they can replicate our methods |
| 05 | Disseminate project results in a final summary paper to a wide audience |

# Institutional resources we're leveraging

Office of Instruction and Assessment

OIA Office of Instruction & Assessment

*Building capacity for excellent teaching*

Instructional Design Team for Digital Learning

### Instructional Design

From the creation of your objectives to the refinement of a well-designed experience, our Instructional Design and Continuous Improvement teams are here to help you create an online course that is learner-driven, innovative and academically rigorous.

**Learn About Instructional Design**

### Multimedia Production

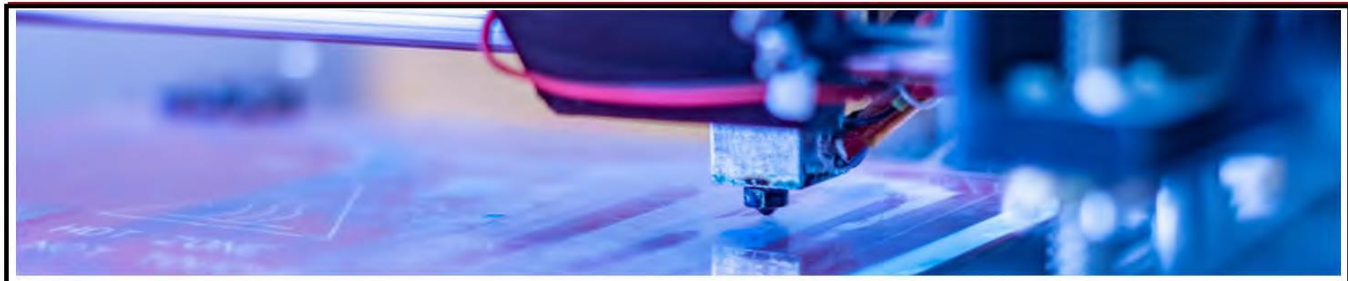
Our team of creative professionals collaborate with instructors to create clear, cohesive and engaging student-centered content that ranges from studio sessions and on-location video production to audio recording and illustrations.

**Learn About Multimedia Production**

# Topics in our e-learning modules

| Learning module focus | Topics and relevant standards |
|---|---|
| **Module 1**: Introduction to engineering standards | **Topics**: Standards development organizations; standard development process; How to identify and access standards; ASTM F42 committee |
| **Module 2**: Use of standards in the design-for-additive-manufacturing process | **Topics**: AM terminology; Design and data formats; AM test samples; GD&T; AM applications<br>**Relevant standards**: ISO/ASTM52900-15, ISO/ASTM 52921-13; ISO 17296-4; ISO/ASTM 52915-13; ASME Y14.5; ISO/ASTM 52942-20 |
| **Module 3**: Additive manufacturing process development | **Topics**: AM processes; AM feedstocks; Preparing and testing test specimens<br>**Relevant standards**: F2971-13; ISO/ASTM52904-19; F3049-14 |
| **Module 4**: Testing and evaluation for additively manufactured parts | **Topics**: Mechanical properties; Requirements for purchased AM Parts<br>**Relevant standards**: ISO/ASTM52901-16; F3302-18; F3122-14; ASTM A370 - 20 |

# Our learning module format



## Introduction

### Module Introduction

In this module, you will learn about t
explore the range of technical standa
standards.

### Learning Outcomes

At the end of this module, you will be

## Activity List

1. **Watch and Do:** Follow along with the interactive tutorial *Standards: How Do I Find & Use Them?* (15 minutes)
2. **Read:** Development Process for Technical Standards (5 minutes)
3. **Read and Reflect:** Case Study (20 minutes)
4. **Do**: Complete Module 1 reflection (20 minutes)
5. **Bonus Resource:** To learn more, check out the Additional Resources at the end of the module

# Scope of 2-year project

| | |
|---|---|
| Modules | 4 online learning modules |
| Courses | 3 courses across 3 departments at UArizona |
| People | 150 students impacted in 2 yrs |

# Early results are promising

Improvements in % of students' who feel confident in identifying and using standards from pre-test to post-test

- I feel that I can **define** what a technical standard is
  (Pre: 37% Post: 77%)
- I feel that I can **locate** technical standards in online databases
  (Pre: 33% Post: 73%)
- I feel that I can **determine what type of technical standard** to use as I conduct engineering work
  (Pre: 36% Post: 59%)
- I feel confident that I can **utilize technical standards** as I conduct engineering work
  (Pre: 44% Post: 68%)

# Comments give us ideas for improvement

- “The best activities were the interactive videos and quizzes.”
- "Even though the material is necessary and every engineer will use standards, it is a bit dry to dive into.”
- “Honestly, I like short readings (1-8 pages), after that it starts getting harder to retain the information”
- “ I liked the case studies from Monday the most since it was a real-world problem and it had me thinking about what standards could be applied to solve it- I looked at the COVID mask one.”

# Spreading the word

- 10 page summary paper in Y2
- Feedback from industry at TMS Conference (Wessman)
- Share with engineering educators more broadly at annual conference for American Society for Engineering Education 2023 (Budinoff)
- Local dissemination among design faculty, COE, engineering librarian

# Thanks!

Suggestions? Questions?