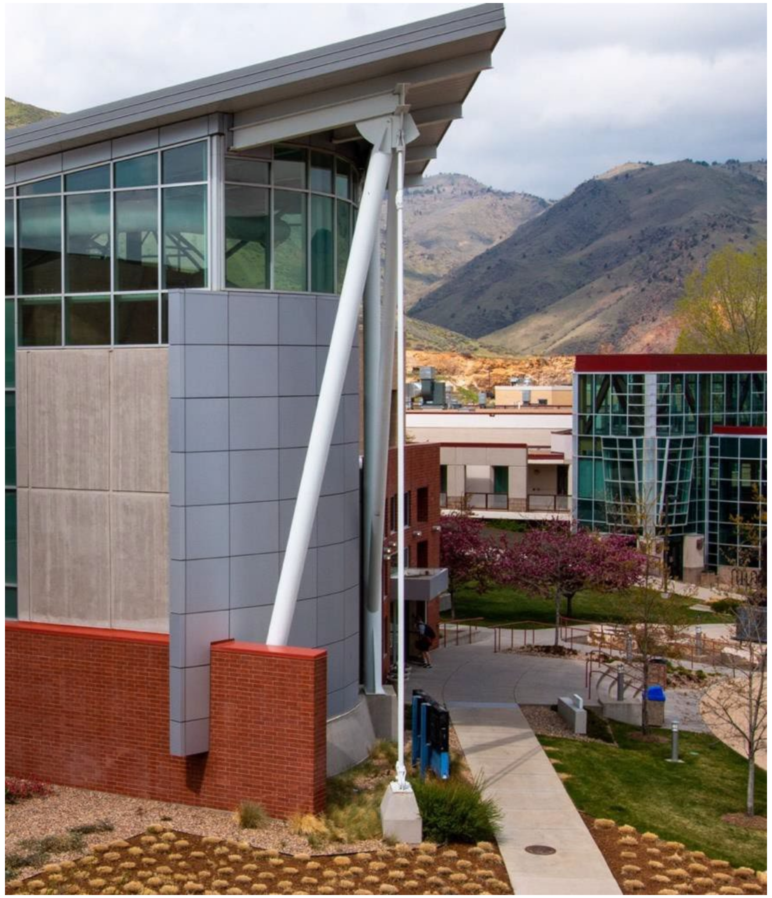

# *Incorporation of Standards into a New Ceramic Engineering Degree Program*

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Mines undergraduates funded on project:
**ViAnna Hollis and**
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**Funding: National Institute for Standards and Technology, Standards Coordination Office**

**Dates of Award: Jan 1, 2024 – Dec 31, 2026**

**Standards Education Summit**
**Virtual Platform**
**September 10 & 12, 2025**

# Outline

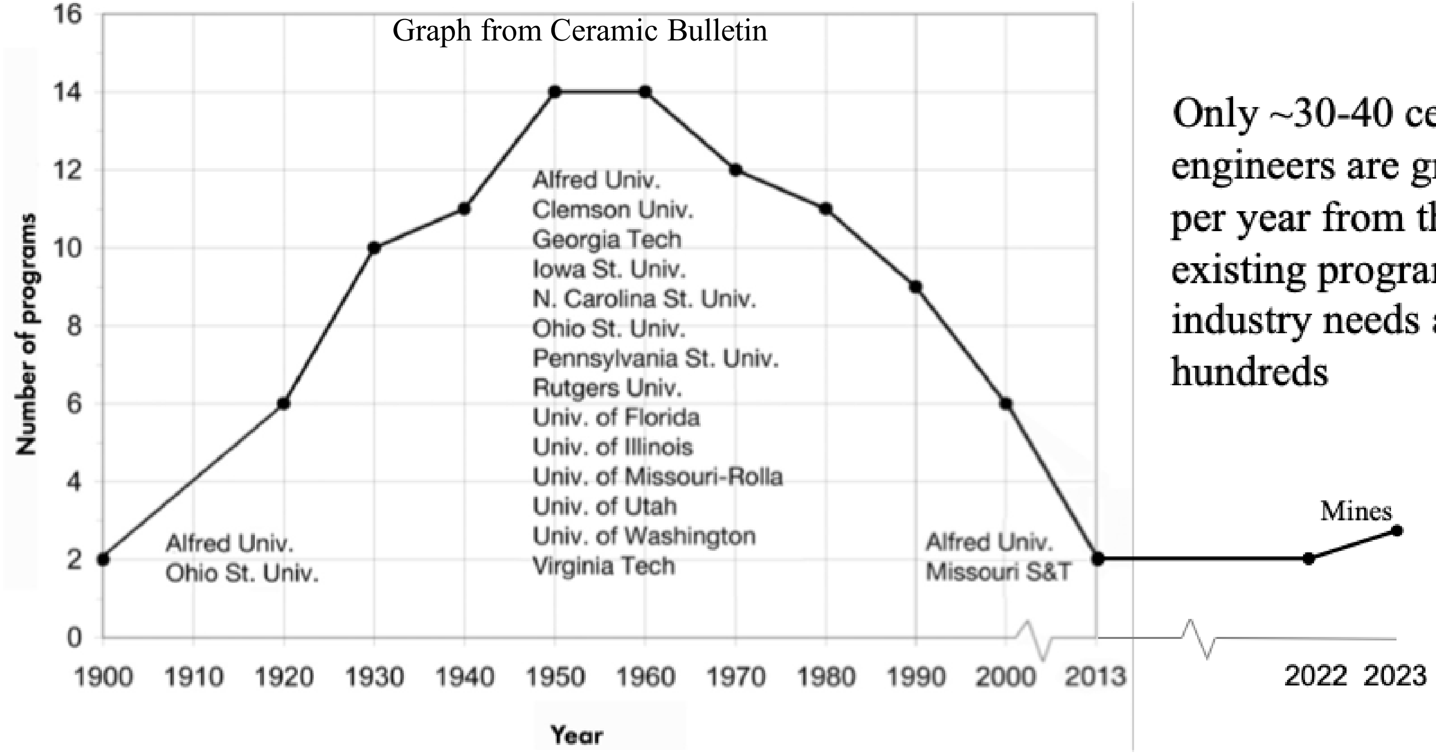
- Goals and potential impact/deliverables
- What is ceramic engineering?
- Brief module descriptions (the core of the project)
- A university level survey on use of standards
- Development of Module 1
  - Field Session course MTGN272
- Assessment of undergraduate students
- Example of video interviews with industry professionals
- Draft example of Module 1 (Kim Scott)

# Project Goals and Impact

- Develop three modules to provide instruction on the use of standards in ceramic engineering
- Modules will have broad aspects that are transferable to other disciplines
- Part of module development is to survey the campus on current use of standards in instruction

- *Impact:* the modules will provide instructors with resources to engage students in the education of standards

# What is Ceramic Engineering?




Only ~30-40 ceramic engineers are graduating per year from the 2 existing programs, but industry needs are in the hundreds

Activeminerals.com

Allied Mineral Products

Traditional ceramics: bricks, tile, whiteware, cement, refractories…

# What is Ceramic Engineering Today?

**Process engineer at plant manufacturing architectural, automotive, & display glasses**

- Glass processing and properties
- NDE, Weibull, SPC
- Polishing, finishing
- Coatings

**Selecting vendors / validating components for hypersonic vehicles**

- Mechanical / Thermal / Electrical Properties
- NDE, Weibull, Composites
- Diffusion, microstructure, joining and stresses
- Machining, finishing

**Technical Sales of Artificial Joints**

- Biology
- NDE, Weibull, SPC
- Mechanical, chemical, and optical props; wear and degradation
- Machining, finishing

**Packaging engineer for solar energy system (PV, thermal, new, …)**

- Coatings, joining, sealing
- Thermal, optical, electronic properties
- (constrained) Sintering
- Stresses, degradation

**Fabricating wafer carriers, windows, and other components for microelectronics fabrication**

- (high purity) Sintering and vapor phase fabrication
- Optical, mechanical, electrical, chemical props
- Semiconductor properties, defects

**Raw materials supplier for technical component manufacturing**

- Purity and particle size measurements, effects
- Powder fabrication and processing
- Broad properties
- Extractive aspects

Needs: **thermo, phase, kinetics, structures, data/SPC,** powder processing / forming, sintering & microstructure, film growth, properties, NDE, machining, composites, bio…

# Ceramic Engineering – a New Bachelor of Science Degree Program at Mines, launched Fall 2023

- Utilizes many courses in the 120 year old Bachelor of Science in Metallurgical and Materials Engineering

# Brief Module Descriptions

- Module 1
  - Sophomore level
  - Generic level introduction to materials engineering standards
  - PowerPoint format with embedded video statements from practicing engineers
- Module 2
  - Senior level; presented in capstone senior design
  - Format is combined lesson plan with short videos
  - Specific example standards covered in detail (conception to implementation)

# Brief Module Descriptions (con't)

- Module 3
  - Senior level; to be administered in Mechanical Properties of Ceramics and Composites
  - Deep dive into one or two standards with a focus to highlight the importance in comparing specifications from different manufacturers that used different standards or did not use them
  - Assistance from Dr. Kristin Breder (Saint-Gobain) and Dr. Jonathan Salem (NASA-Glenn)

# University Surveys

## Campus-wide survey to faculty: three questions

### NIST Standards Educational Curriculum Development

General assessment of current university usage of standards within academic curriculum.

Hi, Ivar. When you submit this form, the owner will see your name and email address.

1. Do you teach the use of standards in your course(s)

- Yes
- No

2. If yes, what is (are) the course number(s) (format: XXGNXXX)

Enter your answer

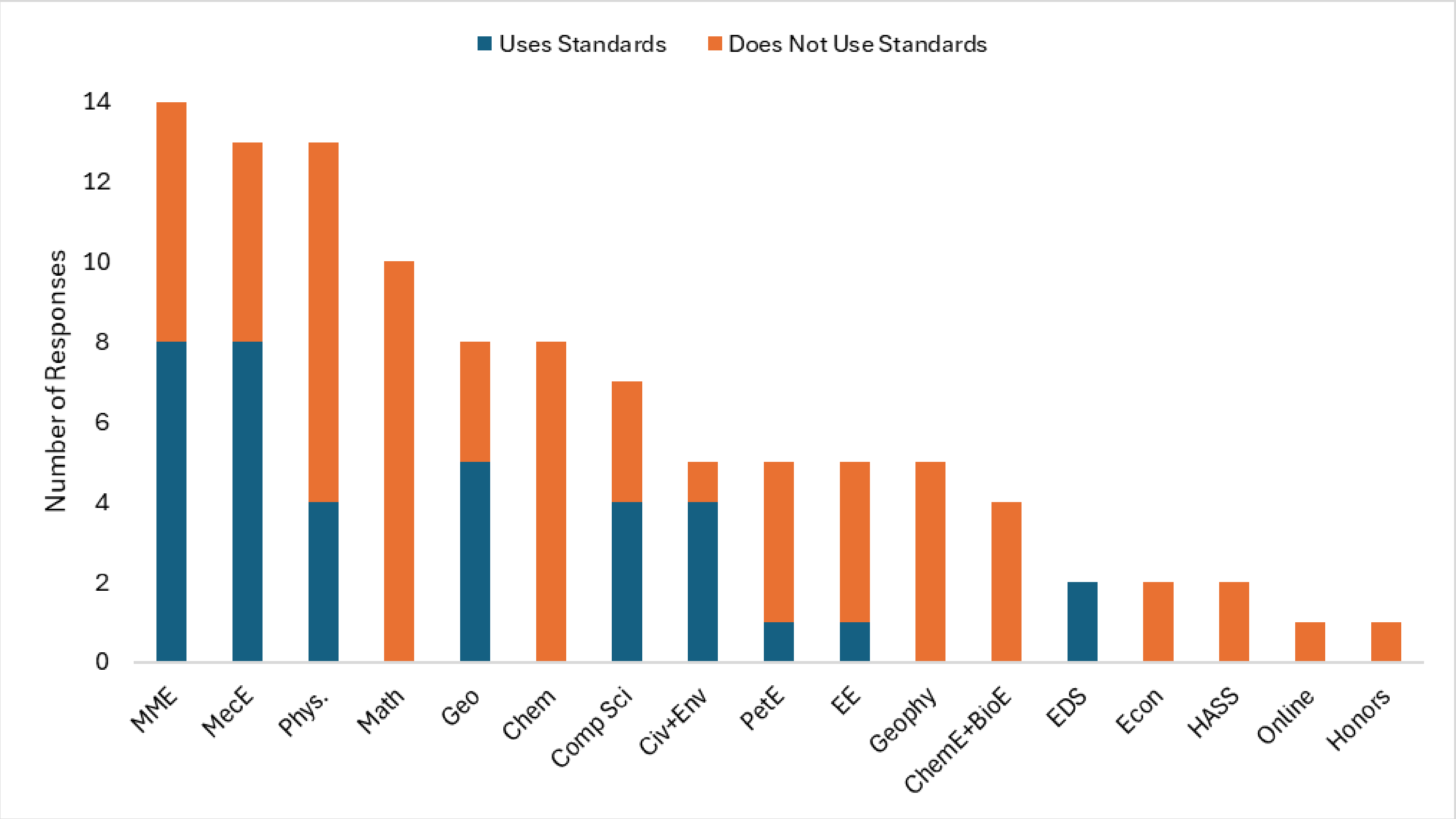
3. If yes, what is (are) the standards organization(s) that oversee the standards that you cover?

- ASTM International
- ISO
- SAE International
- NFPA
- IBC
- IEEE
- ICC
- Other

# University Survey Results (slide 1 of 5)

## Responses by Department

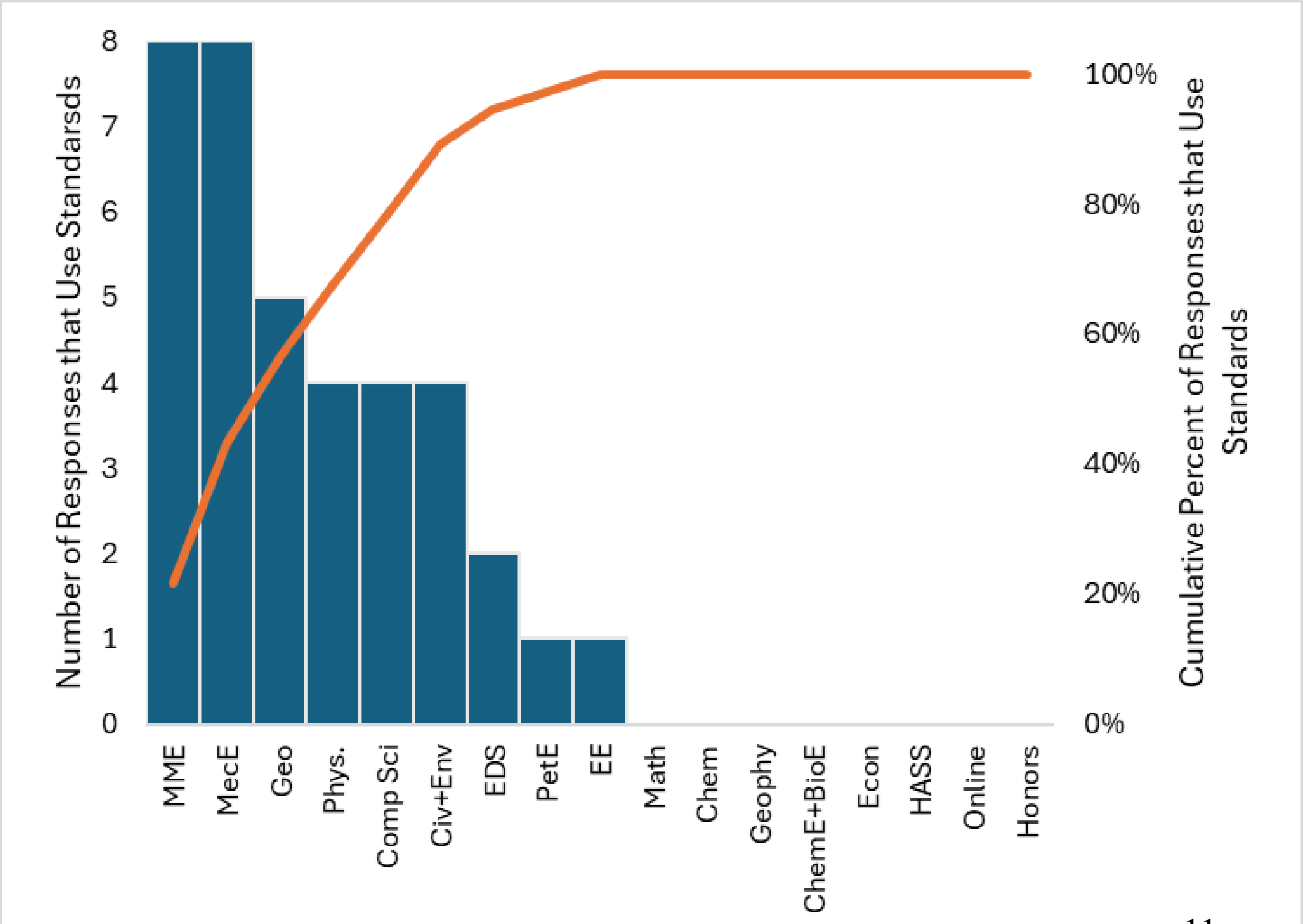
- Wide range in the number of responses
- No one from Mining Engineering responded
- EDS, Civil and Env. Engineering, and Computer Science had highest percentage use of standards



# University Survey Results (slide 2 of 5)

## Responses by Department

- Half of departments had no responses that used standards
- 90% of the responses that used standards were from six departments



# University Survey Results (slide 3 of 5)

- Six standard development organizations were the most common: ASTM, ISO, IEEE, SAE International, NIST, ANSI

# University Survey Results (slide 4 of 5)

## Responses by Department

- MME and Mechanical primarily use ASTM and ISO, but also use other standards
- Computer Science primarily uses IEEE
- ASTM and ISO are used most across departments

| | ASTM International | ISO | IEEE | SAE International |
|---|---|---|---|---|
| Metallurgical and Materials Engineering | 8 | 4 | 1 | 2 |
| Mechanical Engineering | 6 | 6 | 2 | 2 |
| Geology and Geological Engineering | 0 | 0 | 0 | 0 |
| Physics | 0 | 1 | 1 | 0 |
| Computer Science | 0 | 1 | 4 | 0 |
| Civil and Environmental Engineering | 1 | 2 | 0 | 0 |
| Engineering, Design, and Society | 2 | 2 | 1 | 0 |
| Petroleum Engineering | 0 | 1 | 0 | 0 |
| Electrical Engineering | 0 | 0 | 1 | 0 |

| Key | 0 | 1 | 2-3 | >3 |
|---|---|---|---|---|

# University Survey Results (slide 5 of 5)

## Courses Employing Standards

Of the unique courses listed in replies that used standards:

- 39 were 300 or 400 level
- 17 were 500+ level (not including cross listed courses)
- 8 were 100 or 200 level (listed right)

Only two classes were part of core curriculum (CHGN121 and EDNS151)

| | |
|---|---|
| CHGN121 | Principles of Chemistry |
| MEGN212 | Introduction to Solid Mechanics |
| CSCI210 | Systems Programming |
| MEGN201 | Introduction to Mechanical Engineering: Design & Fabrication |
| EDNS151 | Cornerstone - Design I |
| GEGN212 | The Rock Cycle |
| GEGN101 | Earth and Environmental Systems |
| CSCI200 | Foundational Programming Concepts & Design |

Outline (con't)

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# Module 1 Development

## Field Session course (summer in between years 1 & 2)

- Activity – Strongest Cement Competition
  - Small groups will be fabricating small cement discs and allowed to choose between 3 re-enforcement materials
  - Loose constraints:
    - Min/Max ratio of cement: re-enforcement material
- Post-activity survey focusing on analysis of activity
  - Definition of standards; why are they important?
  - Where is the use of standards in engineering design important?
  - Are there areas where standards are not important?

# Module 1 Development

## Field Session course – activity: cement fabrication

- Groups of 4-5
- Team decides what will be re-enforcement material
- Given basic recipe for cement composition
- Given size constraints
- Given time for fabrication
- Teams produce 2 specimens for testing

# Module 1 Development

## Field Session course

- Compression Test
  - 1 submission from each team
  - Undergo mechanical testing until failure
  - Teams analyze differences from samples vs strength
  - Observations of how testing method is standardized for data collection
- Drop Testing
  - 1 submission from each team
  - Undergo parking lot drop testing
  - Teams analyze differences in samples
  - Observations of how testing method NOT standardized and needs improvement

# Surveys – Student Responses

- Given to early undergraduate students (1st & 2nd yr MME students) after the strongest cement competition
- Responses collected over 2 cohorts (2024 & 2025) roughly 65 students
- Analysis via AI (ChatGPT) to identify common definitions, themes, and responses

# Definition of a Standard & Why is It important

## AI Analysis Summary

A standard is an established norm, often used to obtain and maintain consistent measurements. A standard is a constant comparison point that is critical to consistent science.

A standard is a guideline to be followed to ensure reliability and quality control. For research, it is used to ensure the different samples can be compared to each other. Without it, the samples can be too different physically (shape, size, etc.) or measured differently (i.e., empirical or metric measurements) which make it impossible to truly compare them. A standard ensures this doesn’t happen.

Standards are the minimum requirements to build something, or the specifications and characteristics for different materials. Standards are important because they ensure consistency and safety in different engineering disciplines. They provide a comprehensive foundation for engineers to work within, ensuring everything is manufactured/built safely, compatible, and performs correctly and efficiently.

# Where is engineering design with standards important?

## AI Common Themes Identified

- **Safety & Risk Prevention**
  - Repeatedly emphasized in civil, aerospace, mechanical, materials, and chemical engineering.
  - Examples: bridges, buildings, airplanes, pipelines, automotive design, and medical devices.
- **Reliability & Functionality**
  - Ensures parts fit together, systems work correctly, and failures are minimized.
  - Essential in mass production, testing, and validation processes.
- **Consistency & Comparability**
  - Enables uniform measurement, repeatable testing, and comparability across research labs and industries.
  - Prevents cherry-picking or biased results.
- **Quality Assurance & Efficiency**
  - Standards streamline processes, reduce costs, and prevent wasted effort.
  - Supports trust in products and engineering outcomes.
- **Public Interaction**
  - Any engineering work that involves human use (consumer products, infrastructure, software) requires standards to ensure safety, usability, and interoperability.

# Are there areas where standards are not important?

## AI Common Themes Identified

- **Early-Stage Creativity & Brainstorming**
  - Idea generation and conceptual design stages don’t always need standards; creativity can be unrestricted here.
- **Research & Development (R&D)**
  - When pushing boundaries of knowledge or exploring completely new materials/technologies, existing standards may not apply (new standards often emerge from this work).
- **Prototyping**
  - First-version prototypes or one-off experimental builds may not strictly follow standards, since they’re used for feasibility testing, not public use.
- **Aesthetic/Subjective Design Choices**
  - Cosmetic elements (e.g., color, shape preferences) may not require standards since they don’t impact safety or function.
- **Personal/Small-Scale Projects**
  - Some respondents noted that personal, non-commercial work doesn’t always require formal standards, unlike professional engineering.

# Overall Takeaway

## AI Analysis Summary

- Most respondents view **standards as critical to nearly all engineering design**, especially where **safety, reliability, and consistency** are involved.

- The **few exceptions** are in **creative, early-stage, experimental, or aesthetic contexts**, where flexibility and exploration may outweigh strict adherence to standards.

# Module 1 Development - Video Interviews

- Video interviews of ceramic engineers on how they and their companies use standards

  - Dr. Kristin Breder, Saint-Gobain
  - Dr. Nicholas Faenza, Exponent
  - Dr. Shay Harrison, Free Form Fibers
  - Allen Flageolle, CoorsTek
  - Liz Hunter, Nucor Steel
  - Mary Dougherty, Canopy Aerospace
  - Dr. Jonathon Salem, NASA-Glenn
  - Dr. Scott Campbell, Allied Minerals
  - Samanta Baumann, Heraeus
  - Dr. Andy Slifka, NIST in Boulder
  - Justin Eaker, Johns Manville

# Module 1 Development - Example Lesson Plan

- Example Lesson Plan
(see NIST Module 1.ppt)

# Questions?

## Thank you to NIST!