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NIST Standards Services Curricula Development Cooperative Agreement Program Awardee Meeting

Emergency, Disaster, and Crisis Management Standards Education for Engineering Students: Needs Assessment and Delivery of a 3-week Module

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Project period: 2024-2026



Outline

- **Introduction**
- **Background**
- **Motivation**
- **Objectives**
- **Method**
- **Findings**
- **Implications**
- **Ongoing Work**
- **Future Plan**

Introduction

- **Growing Threats from Emergencies, Disasters, and Crises**

9/11 WTC Attack (2001)

$95B*

$125B*

Hurricane Katrina (2005)

Deepwater Horizon (2010)

$145B*

$180B*

Fukushima Daiichi Nuclear Meltdown (2011)

CA Camp Fire (2018)

$422B*

And the list goes on…

* Economic losses without inflation in US Dollar

Background

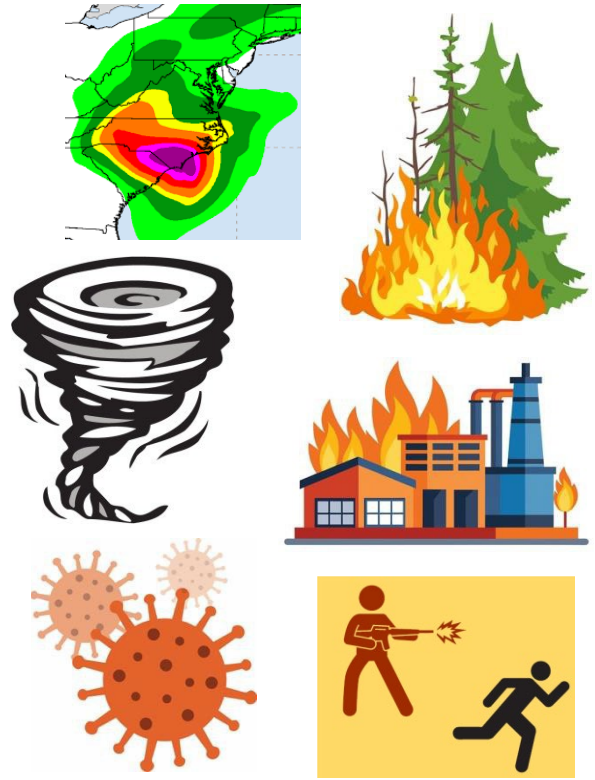
- **Engineers responsible for emergency, disaster, and crisis management (EDCM)**

Different engineering training

- Industrial engineering
- Mechanical engineering
- Civil engineering
- Chemical engineering
- Electrical engineering
- Other Eng.

Engineering sectors

Emergency, disaster, and crisis



Background (con't)

- **Complexity of EDCM**

Natural threats
- Hurricane
- Wildfire
- Flooding
- Tornado
- Winter storm
- et cetera

Technical threats
- Incidents at work
- Fire and explosion
- Hazardous materials release
- Workplace violence (e.g., mass shooting)

Public health threats
- Public pandemic
- Opioid crisis

Emergency (local)

Disaster/crisis (large-scale)

Associated EDCM guidelines and standards

- Federal Emergency Management Agency (FEMA)
- National Fire Protection Agency (NFPA)
- Occupational Safety and Health Administration (OSHA)
- Environmental Protection Agency (EPA)
- National Institute of Occupational Safety and Health (NIOSH)
- Centers for Disease Control and Prevention (CDC)
- Department of Transportation (DOT)
- Pipeline and Hazardous Materials Safety Administration (PHMSA)

Motivation

- **Limited education for engineering students on EDCM standards**

- Only 6.5% of over 5,300 US Higher Education Institutes offer emergency management programs [1].

- Existing safety courses in engineering departments are limited to engineering and technical safety:
  - Occupational safety
  - Chemical process safety
  - Construction safety
  - Industrial hygiene
  - Lab safety

- Previous standards education efforts were focused on teaching occupational safety and health standards such as ISO 14001 (environmental) and ISO 45001 (OSH) [2,3]

Goals & Objective

- **Overall Goal**

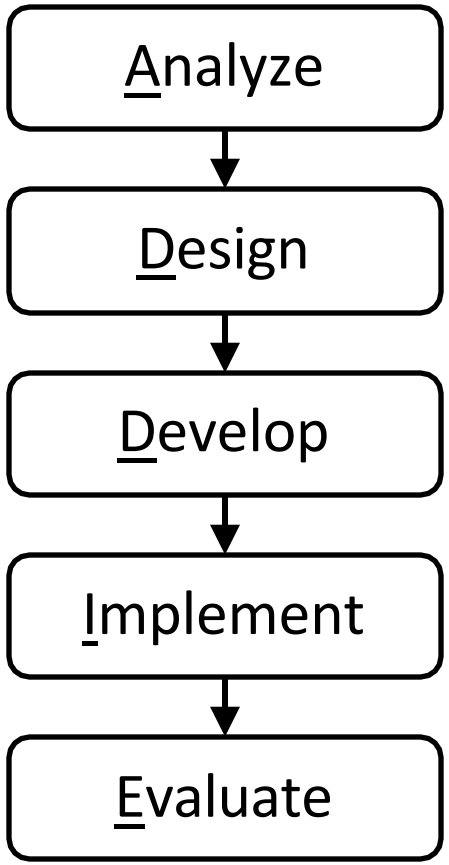
  - To enhance engineering students' knowledge of emergency, disaster, and crisis management (EDCM) guidelines and standards

- **Objective of the current task**

  - To identify educational needs for EDCM guidelines and standards among engineering students
  - To develop and deliver a 3-week education module for engineering students

Overall Project Approach

- **Instruction Design: 'ADDIE' Model [4]**



- **Assess educational needs**
- **Identify problems**

- **Determine educational objectives**
- **Establish course structures**
- **Choose delivery and evaluation methods**

- **Develop flowchart**
- **Create course materials (lecture notes, slides, homework, exam, class activities)**
- **Conduct pilot instruction and seek feedback**

- **Train instructors and teaching assistants (TAs)**
- **Provide courses/course modules to students**

- **Conduct tests and evaluate the results**
- **Survey student feedback and recommendations**
- **Revise the course plans**

Method (slide 1 of 3)

- **Semi-structured interviews with three stakeholder groups**
  - **Convenience sampling and snowball sampling methods**
  - **In-person and virtual (e.g., Zoom, Teams) interviews**

Engineering students

- N=13 (grad and UG)
- Recruited from Texas Tech

Faculty members

- N=3
- Recruited from multiple institutions

Public safety professionals

- N=4
- Recruited from public safety organizations (fire, EMS, emergency management)

Method (slide 2 of 3)

- **Questions used in the interviews**

  - **Importance, Asset, and Needs approach [5]**

Dimension	Questions
Importance	• How important do you think it is to have an ability to manage emergency, disaster, and crisis as an engineer? • Why do you think it is important? • What emergency, disaster, or crisis made you think so?
Assets	• How much knowledge do you have of emergency, disaster, and crisis management (EDCM)? • What skills and knowledge of EDCM do you think engineering students (or engineers) are lacking? • What courses provided any of EDCM standards and guidelines? • What EDCM standards and guidelines did you learn (teach)?
Needs	• What specific learning elements do you want to see from the future courses? • What learning methods or learning environments do you think would be the best for the courses? • What skills and knowledge do you expect of engineering students when they graduate?

Method (slide 3 of 3)

- **Analysis of Qualitative Data**
  - **Interview recordings (audio) were transcribed by '*Rev*', AI-based transcribing service**
  - **Emerging themes were identified using Thematic Analysis [6] and 'Atlas.ti', a QDA software program**

Findings (slide 1 of 9)

- **High importance of EDCM education**

  - All participants (20/20) stated that EDCM education among engineering students is important.

    ”As an engineer, I know that essential services that we provide to the whole society can't be interrupted. Basically, if your activity is so important, energy production for example, you need to be able to manage the crisis in an overall way." (FG#04-A)

    "For us, engineers play a critical role as subject matter experts per se, and we rely heavily on them when we're in situations that we're unsure of the outcome because of either a structure or a chemical or something along those lines that would impact the safety of us doing our job." (S#003)

Findings (slide 2 of 9)

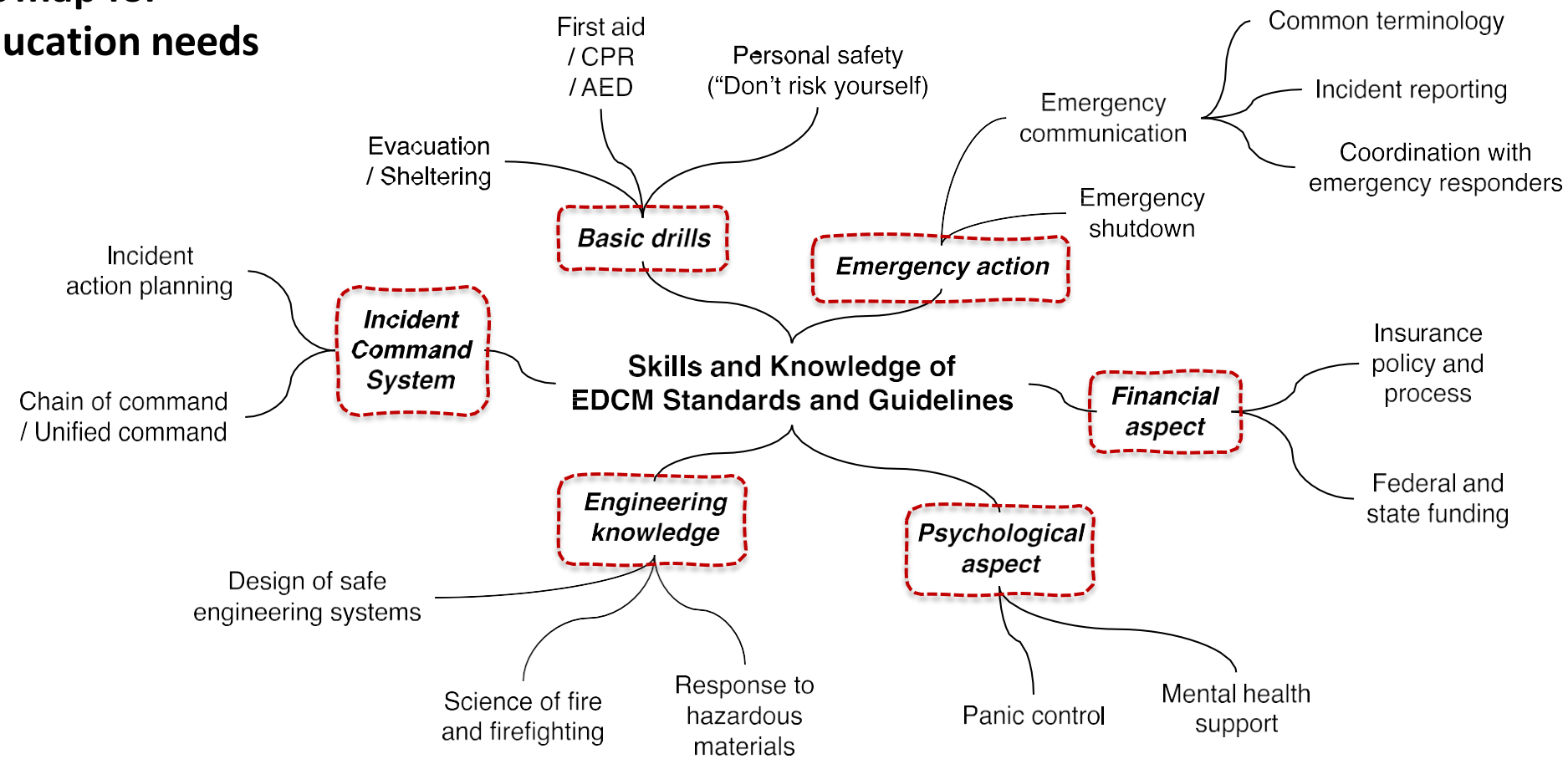
- **Very limited existing EDCM assets among engineering students**
  - Little to no education on EDCM guidelines and standards in graduate and undergraduate courses
  - A few participated in rudimentary drills and training only

    - Fire drill, evacuation drill, active shooter drill

  - Only one (1/13) student took courses related to EDCM (=attended fire academy).

Findings (slide 3 of 9)

- **Huge needs for EDCM education for engineering students**
  - **Thematic map for EDCM education needs**



Findings (slide 4 of 9)

- **Basic emergency drills**
  - **Evacuation from fire, hurricane, and wildfire**
  - **How to conduct first aid and CPR (cardiopulmonary resuscitation)**
  - **How to use AED (automated electric defibrillator)**

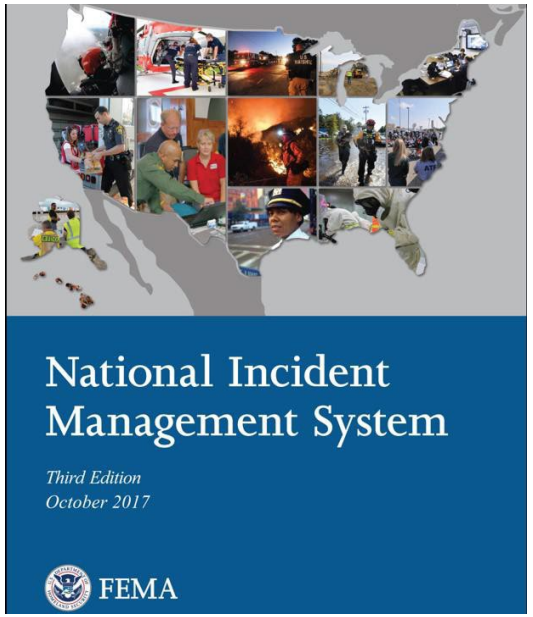
Findings (slide 5 of 9)

- **Emergency actions to mitigate consequences**
  - **Emergency shutdown of a hazardous process or the entire system**
  - **Emergency communication**
    - Common terminology
    - How to report an incident to public safety authorities
    - How to coordinate and collaborate with emergency responders

"That's definitely a good thing to be able to do because they show up and you're not exactly sure how to explain the situation. It might cause the responders to take longer to assess the situation and they may not be knowing exactly what to look for." (FG#02-A)

Findings (slide 6 of 9)

- **Incident Command System (ICS)**
  - **Understanding about core principles of the ICS**
    - Incident action planning process
    - Chain of command / transfer of command
    - Unified command
    - Resource management process
    - ICS structure



"I hope they have a plan. But if they don't incident action planning and how to implement it, it is probably one of the biggest needs I could think of." (S#007)

Findings (slide 7 of 9)

- **Engineering knowledge required for making systems safer**
  - **Public safety professionals view engineers as a subject matter expert (SME)**
  - **How to design safer engineering processes, equipment, and systems**
  - **Understanding of fire science (e.g., fire triangle - heat, fuel, and oxygen)**
  - **Response to hazardous materials (HazMat)**

"Engineers are taught how to design things, but they're not taught to think about failure, whether that's from a disaster or whether that's an accident, or whether that bad design. And so, he said, where's the science of failure?" (S#009).

Findings (slide 8 of 9)

- **Psychological aspects of EDCM**
  - **How to control panic and maintain calmness**
  - **How to deal with mental health problems**

"You don't hear that Control. Panic control. Panic control. It is just apprehension of sorts that things are going terribly wrong, but the situation may be a little bit better than just perceived. So, to regain your own strength and conscience, I would think, "I can manage this situation. I've been trained for it." (FG#04-B).

Findings (slide 9 of 9)

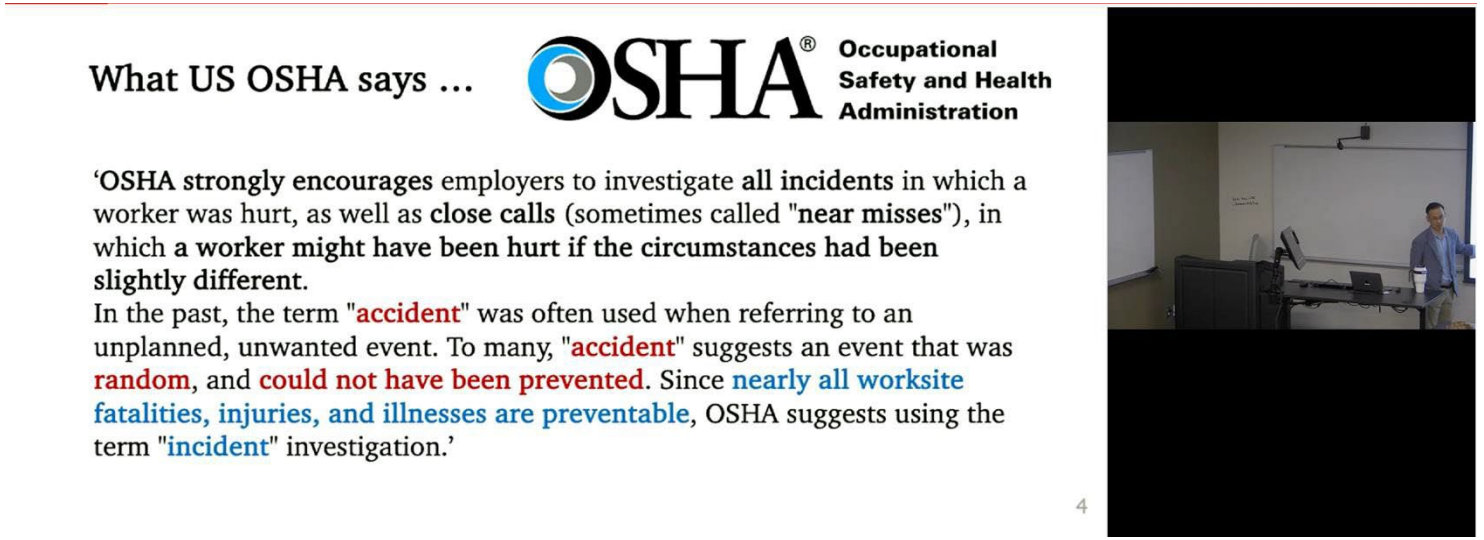
- **Financial aspects of EDCM**
  - **Disaster insurance policies and reimbursement process**
  - **Federal and state financial aids for disaster impacts**
    - US Department of Housing and Urban Development (HUD) Community Development Block Grant – Disaster Recovery (CDBG – DR)
    - National Flood Insurance Program (NFIP)

Implications for EDCM Standards Education

- **Importance of EDCM education for engineering students was clearly recognized.**
- **Very limited EDCM education exists in higher education institutes in the US**
- **Core components for EDCM education include:**
  - Basic skills and competencies – evacuation, firefighting, first aid, and CPR
  - Emergency actions and communication
  - Incident Command System – Incident planning process
  - Psychological and financial aspects of EDCM
- **Our findings justify the needs for incorporating EDCM guidelines and standards into engineering courses and curriculum.**
- **Our findings inform the design of future EDCM courses for engineering students.**

3-week Education Module (slide 1 of 5)

- **Overview**
  - Semester: Spring 2025 (Jan – May)
  - Course No. and Title: IE 4306/5306 Advanced Systems Safety Engineering
  - Students Enrolled: 90 in total
  - 12:30pm – 1:50pm, Tuesdays and Thursdays
    - IE 4306: UG, 35 students, in-person
    - IE 5306: Grad, 37 students, in-person
    - IE 5306D: Grad, 18 students, distance



3-week Education Module (slide 2 of 5)

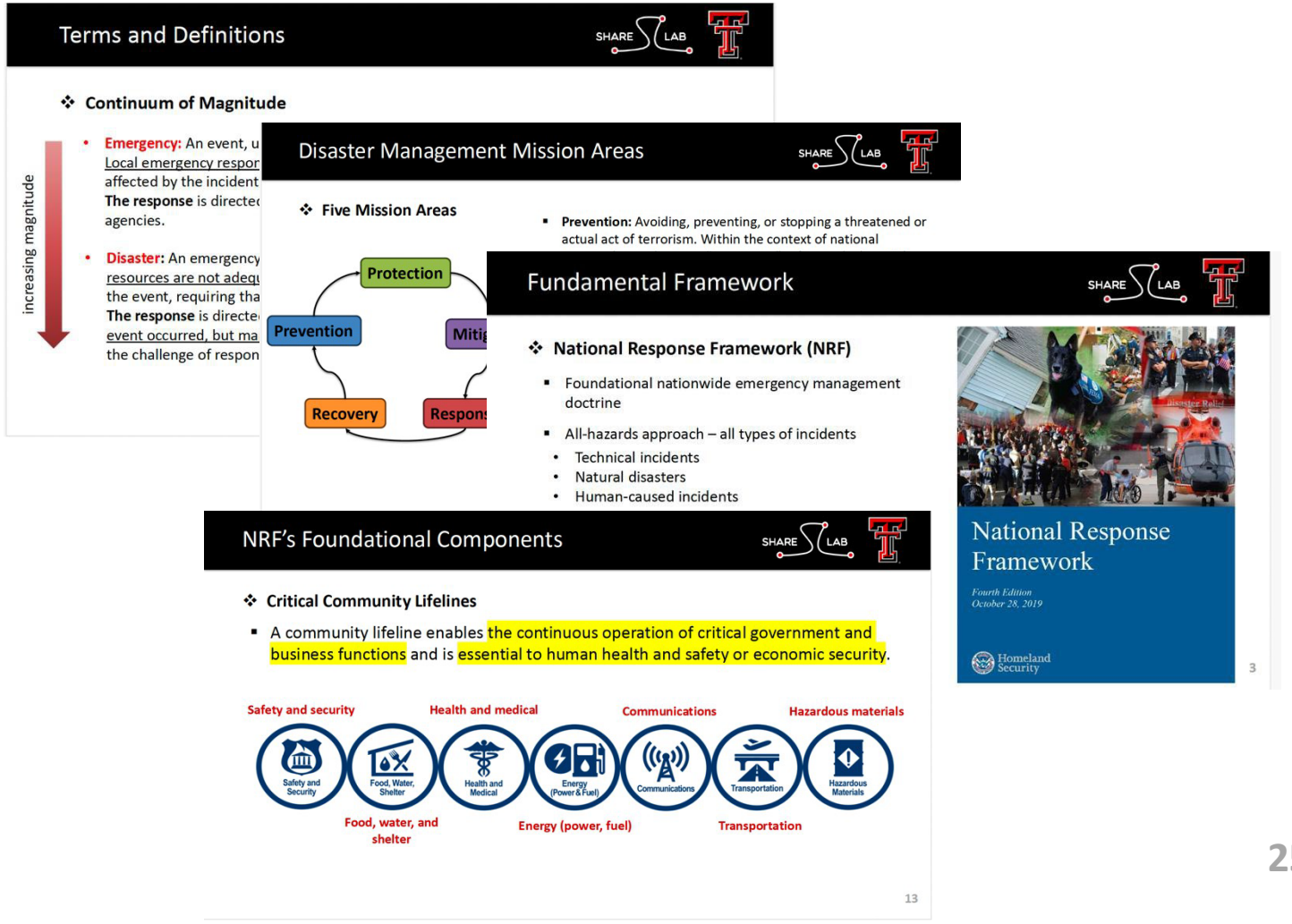
- **Course Syllabus**

3-Week module for EDCM Standards

Date	Topic(s) to be covered / Activity
Jan 16 (Thu)	1. Introduction and course overview
Jan 21 (Tue)	2. Safety terms and definitions
Jan 23 (Thu)	3. Systems safety process and safety management system
Jan 28 (Tue)	4. Safety standards and regulations
Jan 30 (Thu)	5. Safety indicators and incident statistics
Feb 4 (Tue)	6. Hierarchy of control
Feb 6 (Thu)	7. Major industrial incidents
Feb 11 (Tue)	8. Preliminary Hazard Analysis
Feb 13 (Thu)	9. Failure Mode and Effect Analysis (FMEA)
Feb 18 (Tue)	10. Fault Tree Analysis (FTA)
Feb 20 (Thu)	11. Event Tree Analysis (ETA)
Feb 25 (Tue)	12. Bow-tie Analysis
Feb 27 (Thu)	**Midterm exam 1**
Mar 4 (Tue)	13. Process Safety Analysis – HAZOP/LOPA
Mar 6 (Thu)	14. Human Reliability Analysis (HRA)
Mar 11 (Tue)	15. Emergency Management – A. Fundamentals
Mar 13 (Thu)	15. Emergency Management – A. Fundamentals
Mar 18 & 20	*Spring Break, No Class*
Mar 25 (Tue)	16. Emergency Management – B. Pre-incident Processes
Mar 27 (Thu)	16. Emergency Management – B. Pre-incident Processes
April 1 (Tue)	17. Emergency Management – C. Post-incident Processes
April 3 (Thu)	17. Emergency Management – C. Post-incident Processes
April 8 (Tue)	**Midterm exam 2**
April 10 (Thu)	18. Safety-I and Safety-II Approaches
April 15 (Tue)	18. Safety-I and Safety-II Approaches
April 17 (Thu)	19. Resilience Engineering
April 22 (Tue)	19. Resilience Engineering
April 24 (Thu)	20. Systems safety analysis method – AcciMap
April 29 (Tue)	21. Systems safety analysis method – FRAM

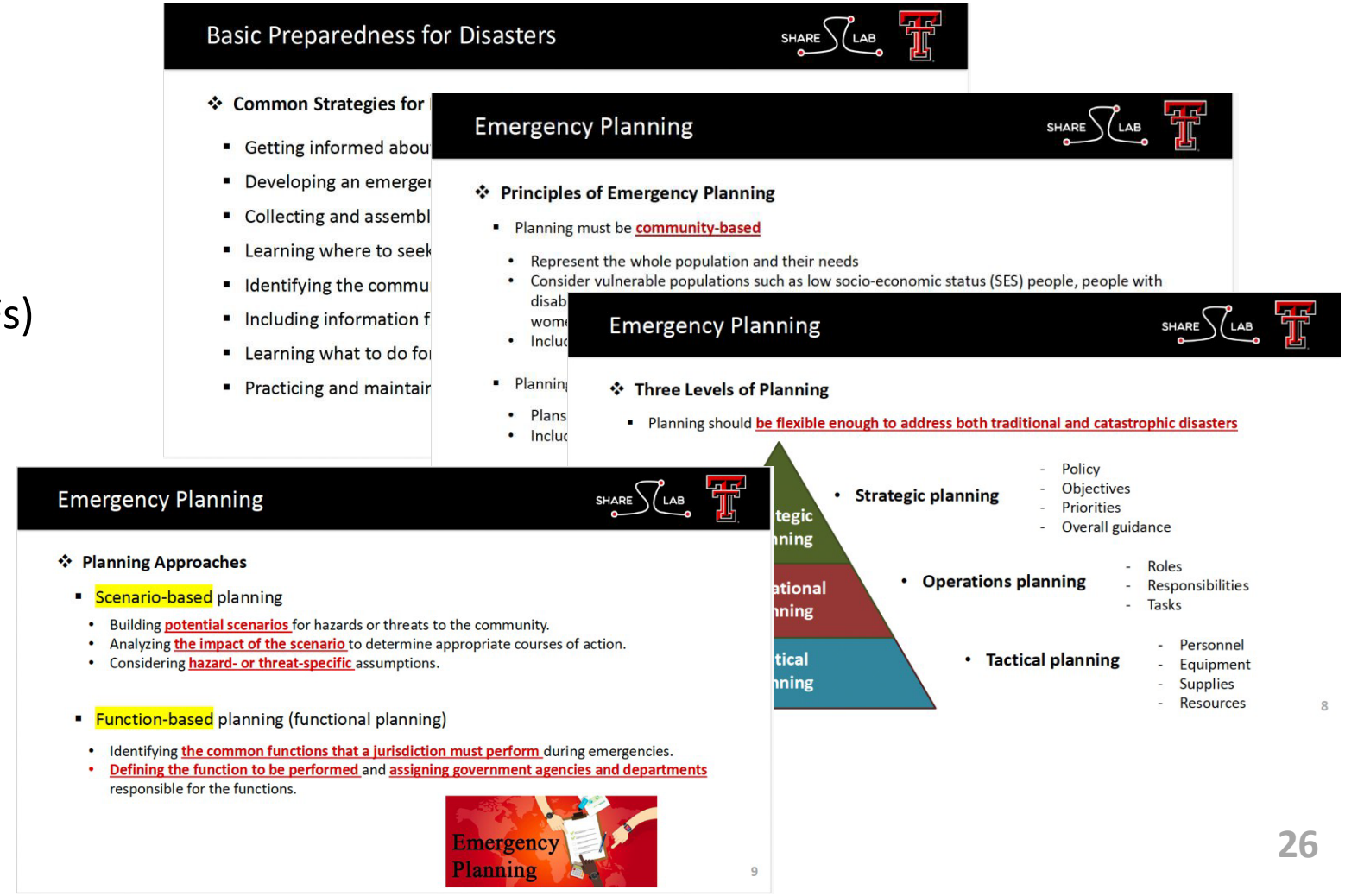
3-week Education Module (slide 3 of 5)

- **Major Components of EDCM Standards – A. Fundamental**
  - Terms & Definitions
  - DHS Organization
  - Major Events
  - Vulnerability and Hazards
  - Mission Areas
  - National Response Framework
  - Critical Community Lifelines



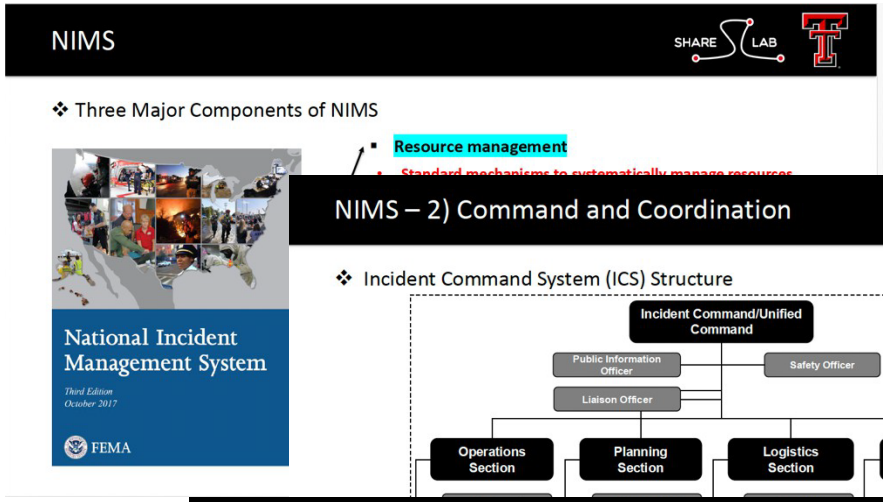
3-week Education Module (slide 4 of 5)

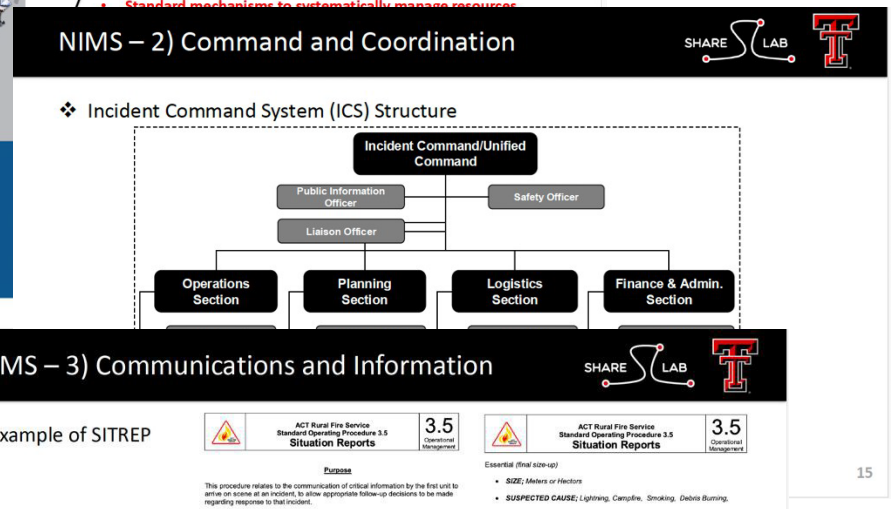
- **Major Components of EDCM Standards – B. Pre-Incident Processes**
  - Basic Preparedness
  - Developing an Emergency Plan
  - Principles of Emergency Planning
  - Three Levels of Planning
  - Planning Approaches
  - Emergency Support Functions (ESFs)

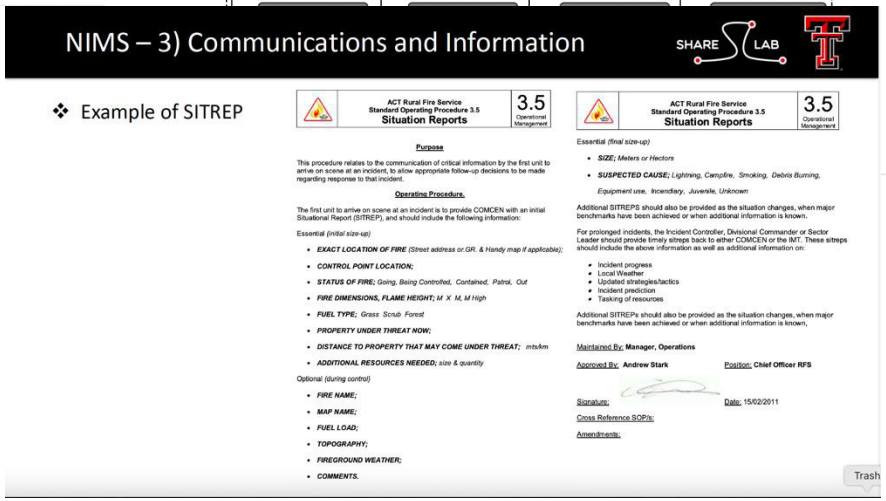


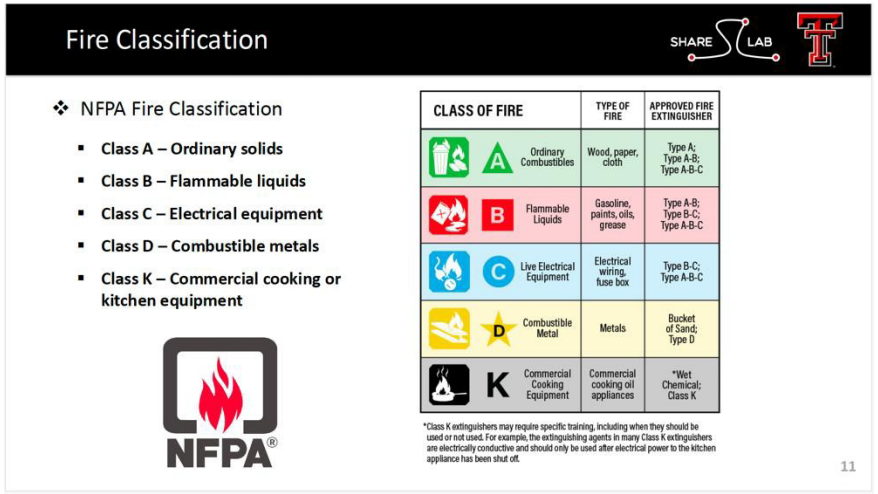
3-week Education Module (slide 5 of 5)

- **Major Components of EDCM Standards – C. Post-Incident Processes**
  - Government Financial Assistance Programs
  - National Incident Management System (NIMS)
  - Incident Command System (ICS)
  - Fire Classification
  - Hazardous Materials (HazMat) Response
  - Psychological Aspects of Disasters









Ongoing Work

- **Analysis of Learning Assessment and Student Surveys**
  - **Adapted Motivated Strategies for Learning Questionnaire (AMLSQ)**
  - **Public Safety Motivation (PSM) Survey**
  - **Learning Strategies Survey**
  - **Class-related Emotions Survey**
  - **Demographics**

Future Plan

- **Spring 2026**
  - **2nd 3-week Module for students (IE4306/5306, Advanced Systems Safety Engineering)**
    - Updating course materials and assessment approaches
  - **A full elective course for engineering students (IE 5331, Special Topics in Engineering)**
    - Course objectives
    - Learning outcomes
    - Teaching topics
    - Course materials (e.g., lecture slides)
    - Assessments

Project Outcome

- **2025 ASEE Conference Paper and Presentation**

Preparing for the Unexpected: Needs for Emergency, Disaster, and Crisis Management Education Among Engineering Students

Mihwa Park, Texas Tech University

Dr. Mihwa Park is an Associate Professor of STEM education at Texas Tech University. Her research interests involve developing measurement instruments to assess students' understanding of scientific concepts and their emotions when learning science. She is also interested in teachers' emotions about teaching science and teacher identity.

Dr. Changwon Son, Texas Tech University

Dr. Changwon Son is an Assistant Professor in the Department of Industrial, Manufacturing, & Systems Engineering at Texas Tech University. Dr. Son is the principal investigator (PI) of a NIST-funded engineering education project that is focused on developing educational contents for emergency, disaster, and crisis management (EDCM) standards for engineering students. Dr. Son is the director of Safety, Human factors, And Resilience Engineering (SHARE) Lab at Texas Tech. He is the recipient of George T. and Gladys Abell-Hanger Faculty Award of Texas Tech University Whitacre College of Engineering.

Dr. Wesley Wehde, Texas Tech University

- A journal manuscript regarding the needs assessment is under progress
- Planning to submit abstract to 2026 ASEE Annual Conference

Preparing for the Unexpected: Needs for Emergency, Disaster, and Crisis Management Education Among Engineering Students

Changwon Son[1], Mihwa Park[2], and Wesley Wehde[3]

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3 Department of Political Science, Texas Tech University, Lubbock, TX

Abstract

The risks of emergencies, disasters, and crises are continuously increasing and making detrimental impacts on communities, especially engineering companies. Thus, engineers are expected to possess necessary skills and knowledge for emergency, disaster, and crisis management (EDCM). However, educational efforts for engineering students, many of whom become engineers, have been lacking in institutions of higher education. As an initial effort, the current study aims to identify importance of EDCM standards and guidelines education, current assets among engineering students, and recommended learning elements for future EDCM education. Semi- structured interviews and focus group discussions were conducted with a total of 19 participants from three stakeholder groups: students, faculty members, and public safety professionals. The interviews and group discussions were audio-recorded and transcribed for a Thematic Analysis, using *Atlas.ti*, a qualitative data analysis software program. Findings indicate that all participants agreed with the importance of education on EDCM standards and guidelines among engineering students. In contrast, students received very basic safety training without having advanced understanding about EDCM standards and guidelines such as FEMA. Further, our study identified six learning elements recommended for future education and training: (i) basic drills, (ii) emergency actions, (iii) Incident Command System, (iv) engineering knowledge, (v) psychological aspect, and (vi) financial aspect. These findings will inform the design and provision of future courses and curricula to enhance EDCM skills and knowledge among engineering students.

Keywords: Emergency, Disaster, Crisis, Standards, Educational Needs

Acknowledgements

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- Participants in our study – students, faculty members, and public safety professionals
- Dr. Mihwa Park, College of Education, Texas Tech
- Dr. Wesley Wehde, Department of Political Science, Texas Tech

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1 Federal Emergency Management Agency, “The FEMA Higher Education College List.” Accessed: Jan. 09, 2025. [Online]. Available: https://training.fema.gov/hiedu/collegelist/

2 L. L. Greenwood and A. Marren, “Hit the Ground Running: Incorporating Risk-based Management Systems Standards in the Curriculum to Enhance Career Readiness,” presented at the 2018 ASEE Northeast Section Conference, Hartford, CT, 2018.

3 L. L. Greenwood, J. Schneider, and M. S. Valentine, “Setting a course for student success: standards-based curriculum and capacity-building across risk prevention management system domains,” presented at the 2018 ASEE Mid-Atlantic Section Spring Conference, Washington, DC, 2018.

4 C. Peterson (2003). Bringing ADDIE to life: Instructional design at its best. Journal of Educational Multimedia and Hypermedia, 12(3), 227-241.

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Thank you

Any Questions?

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