EVALUATION OF A HYBRID PROBLEM-BASED AND JUST-IN-TIME INDUCTIVE TEACHING METHOD EXAMPLE FOR RISK ANALYSIS INSTRUCTION
Why Risk Education?
Overview

- Project Introduction
- Risk Case Study Project Plan
- Risk Case Study Project Progress
  - IDE 20 – Engineering (Product) Design
  - IDE 120 – Materials Testing Laboratory
  - EMGT 137 - Engineering Economy
- Future Work
Project Introduction

- **Goal**
  - Test the hypothesis that expert knowledge can be leveraged to promote undergraduate risk analysis instruction.

- **Motivation**
  - Current undergraduate engineering instruction does not actively promote the understanding of potential risks inherent in every engineering discipline.
  - Students unprepared to prevent disasters upon graduation, yet are often given tremendous responsibilities.
Risk Case Study Project Plan

- It is often thought that EXPERIENCE is a requirement to performing a high quality risk assessment.
- Use the Risk in Early Design (RED) theory to provide EXPERIENCE to the students Just-in-time to educate them on Risk Identification and Assessment.
Risk Case Study Project Plan

- Develop “How to” training materials for the RED theory
- Develop/Deploy 3 Case Studies
  - Product Design – IDE 20
    - 1200 Students/year
  - Materials Testing Laboratory – IDE 120
    - 400 Students/year
  - Engineering Economics-EMGT 137
    - 600 Students/year
- Assess Case Study Effectiveness and RED tool effectiveness
Risk Case Study Project Progress

- RED Instructional Materials
  - Available in Google Sites
  - Fall 2011 it was tested and evaluated by 22 students
  - [https://sites.google.com/a/mst.edu/red-workshop/](https://sites.google.com/a/mst.edu/red-workshop/)

- Survey Development
  - Student survey is now developed for students who did the case studies assignments as part of a class.
  - Not yet deployed
Product Design Case Study

CASE: Cordless Drill Direction Selector Failure

Deployed in both Fall 2011 & Spring 2012

Control group: http://ide20.com/?page_id=693

Group using RED: http://ide20.com/?page_id=712

Null Hypothesis for ANOVA:

Expert knowledge obtained from the RED tool does not significantly increase a team’s ability to isolate and diagnose the failure mode considered in the experiment.
Students are first tasked with identifying the functionality of specific components of the drill’s power control assembly.

<table>
<thead>
<tr>
<th>Component</th>
<th>Correct Function</th>
<th>Plausible Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Connection</td>
<td>Export Electrical Energy</td>
<td>Transfer Electrical Energy</td>
</tr>
<tr>
<td>Battery Connection</td>
<td>Import Electrical Energy</td>
<td>Transfer Electrical Energy</td>
</tr>
<tr>
<td>Reverser Switch</td>
<td>Import Control</td>
<td>Convert Human Energy to Control Signal</td>
</tr>
<tr>
<td>Trigger Switch</td>
<td>Import Control</td>
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</tr>
<tr>
<td>Speed Control</td>
<td>Transistor Regulate Electrical Energy</td>
<td>Convert Electric Energy to Thermal Energy</td>
</tr>
<tr>
<td>Heat Sink</td>
<td>Export Thermal Energy</td>
<td>Regulate Thermal Energy</td>
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They must then identify likely failure modes by using an FMECA approach (control) or FMECA+RED (experimental) approach with a common worksheet.

Measures recorded:
- % teams in a lab section that correctly identified the actual failure mode
- % teams in a lab section that identified the correct, or other plausible failure mode
- % of teams that selected the actual failure as a top 3
- % of teams that selected the actual failure or other plausible failure mode as a top 3
IDE20 Risk/Failure Case Study

- Results were generated using a standard t-test

- Measures
  - % of teams in a lab section that correctly identified the actual failure mode: Significant (p=0.047) +15.6%
  - % of teams in a lab section that identified the correct, or other plausible failure mode: Not significant (p=0.098)
  - % of teams that selected the actual failure as a top 3: Not significant (p=0.113)
  - % of teams that selected the actual failure or other plausible failure mode as a top 3: Not significant (p=0.387)
## IDE20 Risk/Failure Case Study

### Correct Identification of Functionality

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Students misunderstood the context of the assembly.
## IDE20 Risk/Failure Case Study

- Correct Identification of Functionality

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Students selected non-conservative transformations (energy to signal)
Risk Case Study Project Progress

- **Conclusions**
  - Fall 2011 experiment was highly successful (126 teams)
    - Most teams completed the study during class time
    - Data was easily collected and processed
    - One significant result was found
  - Spring 2012 experiment will be identical
    - Data will be added to the FS2011 set
    - Semester blocking effect will be analyzed
  - Hypothesis currently supported by data
    - FMECA+RED **significantly increased** (+15.6%) a team’s ability to isolate and diagnose the exact failure mode considered in the experiment
    - A conference paper has been submitted to ASME IDETC2012
Materials Testing Laboratory Case Study

CASE: Reverse Case Study Development

Status: Deployed

Synopsis:

- Students will be given broken samples and given the evidence provided to them, they must create a plausible case study to explain what led to the broken item.
Materials Testing Laboratory

Failure and Fully Plastic Action

This week we’ll look at the definition of failure, failure theories, and real-life examples of failed components. You will yield a piece of steel in flexure and refer back to your previous tests in order to compare the tensile, torsion, bending and direct-shear yield points of this material. We’ll compare these experimental results to the maximum shear stress, maximum octahedral shear stress, maximum principal strain, and maximum principal stress theories. ...and estimate which theory works best for this material. Finally, we will investigate failed components, estimate what caused the failure, and propose a remedy.

Video Lecture (20 minutes)

Notes

- Objectives
- Failure Analysis
  - lab2 lesson
  - asm handbooks
    - see Volume 11
  - procedure
    - by Dr. J. P. J. L. Kapp
  - risk in early design
    - by Dr. H. S. Dorn

- Failure Examples
  - general
  - news
  - s&t examples
- Failure Theories
  - video
  - notes
- Fractography
  - asm handbooks
    - see Volume 12
  - failure in bending
  - cleavage and fracture
- Fully-Plastic Action
  - short version
  - full version

Assignment
Materials Testing Laboratory
Materials Testing Laboratory

- Visits: All Visits 25,258, Missouri 7,090
- Unique Visitors: All Visits 17,895, Missouri 1,804
- Time on Site: All Visits 1254:42:47, Missouri 968:41:46
- Avg. Time on Site: All Visits 00:02:59, Missouri 00:08:12
- Pageviews: All Visits 88,542, Missouri 57,237
- Pages/Visit: All Visits 3.51, Missouri 8.07

Graph showing visits and pageviews from Jun 1, 2011 to Mar 12, 2012.
Materials Testing Laboratory

Class Web Site Usage (hours)
June 1, 2011 - March 12, 2012
(344 students + 15,000 visitors)

Type of Content
- Lecture Notes
- Lecture Videos
- Demonstration Videos
- Assignments
- Policies, Instructors, Etc

Day of the Week
- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday

Missouri
Not Missouri
Materials Testing Laboratory Case Study

CASE: Reverse Case Study Development

Status: Deployed

Synopsis:

Student teams choose three broken items, identify failure modes, and write a creative story that combines all three failures.
IDE 120 Reverse Case Study

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Assignment
Car Crashes through Eddy’s Sports Store

Monday, February 20, 2012 – Eddy’s Sports Store was closed Saturday afternoon after a vehicle crashed through the front entrance. Jack Horton, 72, of Spring Creek was out for a cruise in his 1980 Corvette when he allegedly hit a pothole on Main Street. Horton lost control of the vehicle and careened off the road into the local sports store owned by Susan and Eddy Heinz.

There were no serious injuries in the one-vehicle accident, although several pieces of merchandise were damaged in the accident, including a $3800 bowling ball and a priceless equestrian bat that were both signed by Jackie Chan. Both items were on display at the front of the store, and were on sale for collection. The retail was hit directly by the car, but the bowling ball fell off its pedestal and broke into several pieces. Owner Susan Heinz is calling for compensation, but there is a discrepancy as to who is responsible for the accident. Horton claims that the city is to blame, since he has a perfect driving record and was not driving irresponsibly.

An investigator is looking into the incident. One important clue is the broken steering column in Horton’s Corvette. Since the car is fairly old, the steering may have broken just from use. However, Mr. Horton thinks differently.

“I bought my 360 here 30 years ago and have treated her right. There is no way this is just a coincidence. The pothole broke my steering, and the city had boats to see a new one,” Horton told reporters late Saturday afternoon.

Tractor Trailer Involved in Major Accident, One Victim Displays Great Courage

At 3:47 this afternoon, a tractor trailer was involved in a major traffic accident on West Interstate 44. The tractor trailer driver lost control of the vehicle when a couple of cows ran onto the road in front of him, and the trailer toppled over in the middle of the road. Three cars were unable to stop fast enough to avoid hitting the tractor trailer. There were seven people involved in the accident, two of which were taken by helicopter to University Hospital in Columbia, Missouri. The other five were taken to Phelps County Regional Medical Center to receive treatment for minor injuries. The cows were startled but somehow were not harmed in the accident.

The tractor trailer was carrying a shipment of music supplies, including several large crates of wooden drumsticks. Upon impact, the drumsticks were dislodged from the trailer and were damaged abrasively from scraping against the nearby trees and fence posts. A local dog was found on the scene chewing on one of the drumsticks. Inside the trailer, several of the hex bolts used to assemble the trailer had failed due to extreme shear stress from the intense loads (several thousand pounds) applied when the trailer flipped over to an unusual position. This led to internal collapses of supports...
Ray Rolla Post

Frozen Man on 63

Featuring: [Image]

After yesterday’s record-breaking snow storm, a man was found frozen to death inside of a vehicle in the middle of Highway 63. He was discovered inside of his red Corvette by two city workers while they were finishing clearing the street of the five feet of snow from the disasterous blizzard. Why was the man stuck in the center of Highway 63 and why frozen in his car? After thorough investigation, police have found striking evidence which might place the blame on failure components from his vehicle.

After analyzing clues, the failure components, and the conditions given, the police were able to put together the events of the night that led to the man’s unfortunate death.

It was found that earlier during the night of the blizzard, the man lost control while driving. While trying to correct his course, the wheel was turned abruptly causing the steering component to stress rupture due to the low temperature, high stress of the turn, and abrupt wheel correction.

With his loss of control, the man thought that the lines were flat and he was forced to step out of the car to change it. While using a socket wrench to remove his front tire, the socket cracked. The cause of the crack was thought to be from weakness in the metal after having crevice corrosion in one of the socket’s corners.

Police found three different components of failure from the man’s Corvette. First was a cracked socket from a socket wrench used to remove lug nuts from wheels, to replace tires. The next component was a broken steering mechanism found after thorough investigation of the car’s interior parts. The third failure component was a copper water line with a medium-sized crack at one end of it.

The Rolla Rolla Express

Volume 3, Issue 1
February 20, 2012

The Tornado Disaster Kills Local Children

The tornado that struck the Midwest on March 2nd was a tragedy that struck the local community. The small town of Rolla, Missouri, was hit hard, with several people losing their lives. Among those who perished were local children.

One of the victims was a young boy, John Smith, who was playing outside when the tornado struck. Another victim was a girl, Sarah Johnson, who was at home with her family. Both of these children were killed instantly.

News of the disaster was met with shock and grief throughout the community. The town came together to support those who had lost loved ones and to help those who had been displaced.

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Traffic Jam in Illinois

Due to the tornado disaster, the streets of Rolla were jammed with traffic. Drivers were left stranded for hours, unable to get to their destinations.

The tornado itself caused significant damage to the city, destroying homes and businesses. Many residents were left homeless and without power.

The downtown area was especially hard hit, with several businesses destroyed and the streets filled with debris. The local government worked tirelessly to clear the path for emergency vehicles and to restore power to the area.

The tornado was a reminder of the power of nature and the vulnerability of human life. It serves as a testament to the resilience of the community, who came together to support each other during this time of need.
The Bad Breakup

Once upon a time in the Land of Oz, there was a princess named Natalie. Her evil arch enemy Paul hates her because he is socially awkward, while she is the most beloved in all the land. Paul is a scrawny and lanky, but his most repugnant feature is the grotesque mole on his left cheek. He was envious of Natalie’s wondrous beauty.

Among Natalie’s many amazing talents, she had a passion for drumming. One Thursday afternoon Natalie was composing a new musical masterpiece in the highest tower of her magnificent palace. Paul had recently grown more jealous and devised a plan to capture the princess and hide her away so no one

“A Bad Day in the Life of John McEnroe”

“You cannot be serious!” These were the famous last words uttered by John McEnroe as he was surrounded by officers of the Malibu, CA police department. It was the appropriate ending to a day that had started out bad and progressively gotten worse for the former tennis great-turned racquetball player. After a restless night’s sleep and a sub-par breakfast, John had headed down to the Malibu YMCA for his daily racquetball game to turn the morning around. While he was stretching, however, John’s mood went from grouchy to agitated after he spotted his old tennis nemesis, Jimmy Connors,
Results

36 of 52 items chosen
- 33% bowling ball, 25% highway sign, 19% racquet, 19% transmission cluster, 17% Corvette steering mechanism

?? correctly identified failure mode
- 36% impact, 24% rupture, 15% fatigue, 7% creep
- 25% impact fracture, 15% brittle fracture, 10% high cycle fatigue, 8% ductile rupture, 8% impact deformation

only 19% revised decisions upon reflection
- 6% picked new items just to help narrative
- 26% used class terminology instead of failure taxonomy

creative writing
IDE 120 Reverse Case Study

Jun 1, 2011 - Mar 12, 2012

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- Missouri: 7,090

Unique Visitors
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IDE 120 Reverse Case Study

Lesson and Video Usage (hours)
June 1, 2011 - March 12, 2012
(344 students + 15,000 visitors)

- Spring Testing
- Tension Testing
- Hardness Testing
- Torsion Testing, Direct Shear
- Failure, Fully Plastic Action
- Flexure Testing for Elastic Constants
- Beam of Two Materials
- Beam Deflection
- Fastener Testing, Wood Connections
- Strain Transformation
- Pressure Vessels
- Eccentric Loading

Missouri ◼ Not Missouri
IDE 120 Reverse Case Study

- **Timeline**
  - F10-W11: 17 items, Control vs RED (33/34 teams)
  - S11-F11: improved Google Analytics approach
  - W12: 52 items, RCS (49 teams)
  - S12: additional functional models
  - F12: 52 items, RCS+RED
  - ????: 100 items
Business Risk Case Study

- Engineering Economics (Eng. Mgmt. 137) Case Study
  - CASE: LED Luminaire Technology
  - Status: To be deployed April 2012, 250 students
  - Synopsis:
    - LED luminaire technology is of increasing interest for roadway lighting solutions to state DOTs and local communities due to proposed benefits in fiscal and environmental stewardship, as well as safety and useful life.
    - The case will detail the implications of LED technology across the three pillars of sustainability (economic, environmental, and social) and provide opportunities for economic and business risk analysis by student teams.
Business Risk Case Study

High Pressure Sodium

LED Luminaires

Students will analyze current data and report:

- Results of a systematic economic analysis
- Assessment of environmental impact
- Potential business and economic risks
- Recommended action – high pressure sodium or LED luminaires
Future Work – Spring 2012

- Publish 3 Case Studies
- Publish Results of Teaching Method Testing
QUESTIONS?