

# Preventive and Explorative: Two Workplace Problem-Solving Cultures

Jacob Poirier<sup>1</sup>, Vina Macias<sup>1</sup>, Benjamin M Zwickl<sup>1</sup>, Susan L Rothwell<sup>1</sup>, Kelly N Martin<sup>2</sup>

<sup>1</sup> School of Physics and Astronomy, Rochester Institute of Technology  
<sup>2</sup> School of Communication, Rochester Institute of Technology



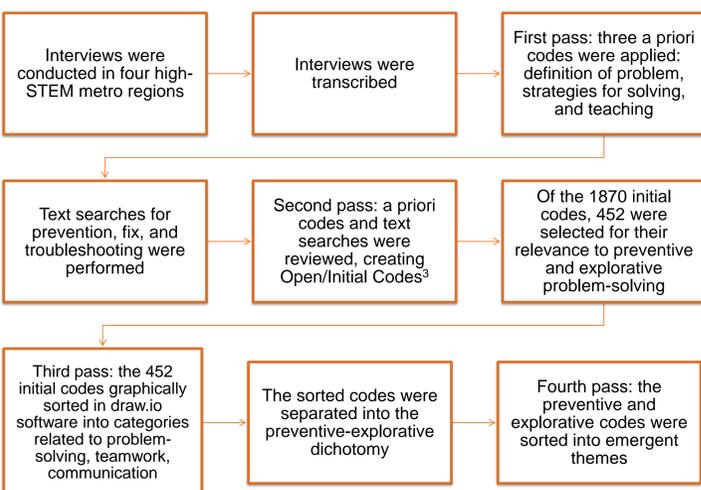
DGE-15611493

## Introduction

The EMPOWER project looked at four 21<sup>st</sup> century skills (**teamwork, communication, problem-solving, and self-directed learning**) are valued and taught across STEM:

- We analyzed how **different industries viewed problem-solving** and compared their perspectives.
- In the initial stages of analysis, we noted **significant differences between how petrochemical processing and computer science** thought of problem-solving.
- These differences lead to the present research questions
  - How were these problem-solving cultures different?**
  - What contextual factors influenced these differences?**
- For the analysis, we adapted Maanen and Schein's definition of organizational culture to consist of the **values and ideologies, language and tools, and processes of an organization**.<sup>1</sup>
- An example of an organizational culture was **safety culture** ("an organization's values and behaviors – molded by its leaders and internalized by its members – that serve to make [...] safety the overriding priority").<sup>2</sup>

## Methods



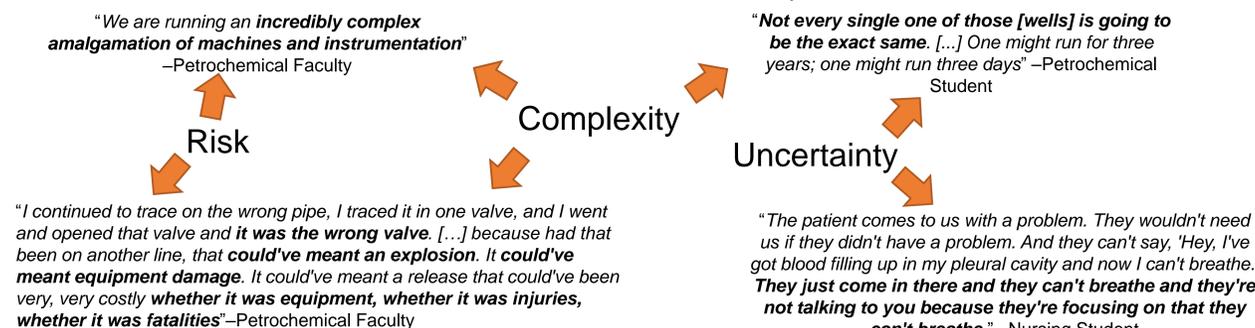
	Student Focus Group	Faculty Interview	Industry Interview
Computing	22	29	7
Energy	14	18	7
Health Care	9	12	3
Manufacturing	24	32	9

Code	# references
Definition of Problem	1010
Strategies for Solving	1257
Teaching	1390

Text searches	# results
prevention	516
Fix	136
troubleshooting	123

## Preventive Problem-Solving Culture

has a desired state to preserve and will focus efforts on maintaining that norm, as extreme variance can lead to catastrophe



### Safety

**Team wide commitment**  
 "It's not just one nurse trying to save this person's life, it's a **whole team** of people who are called in" –Nursing Student

**Necessity of safety**  
 "Fundamentally, people from the outside would **view our job as operating these units to modify a chemical precisely** into something a customer would buy. And we do do that job all period on our 12-hour shift every time we come in. I guess fundamentally, that's our job, **but at the same time, we're responsible for the safety of everyone entering that unit** to perform all the ancillary work that has to be done to keep that unit running" –Petrochemical Faculty

### Analysis

**Problem identification**  
 "You're looking at your board, and all of a sudden, **your pump starts reading high.** [...] Okay, well, if you can't see past, okay, a hot pump and see okay, **am I getting flow to it, when was the last time this pump was maintained?** [...] Okay, why is it reading high? **Is my flow out the tank not working? Is my PSV not cooperating?**" – Petrochemical Faculty

**Big data analysis**  
 "We are looking for problems before they exist by extrapolating the probability they will occur out of this **tremendous amount of data** that you saw on those screens" – Petrochemical Faculty

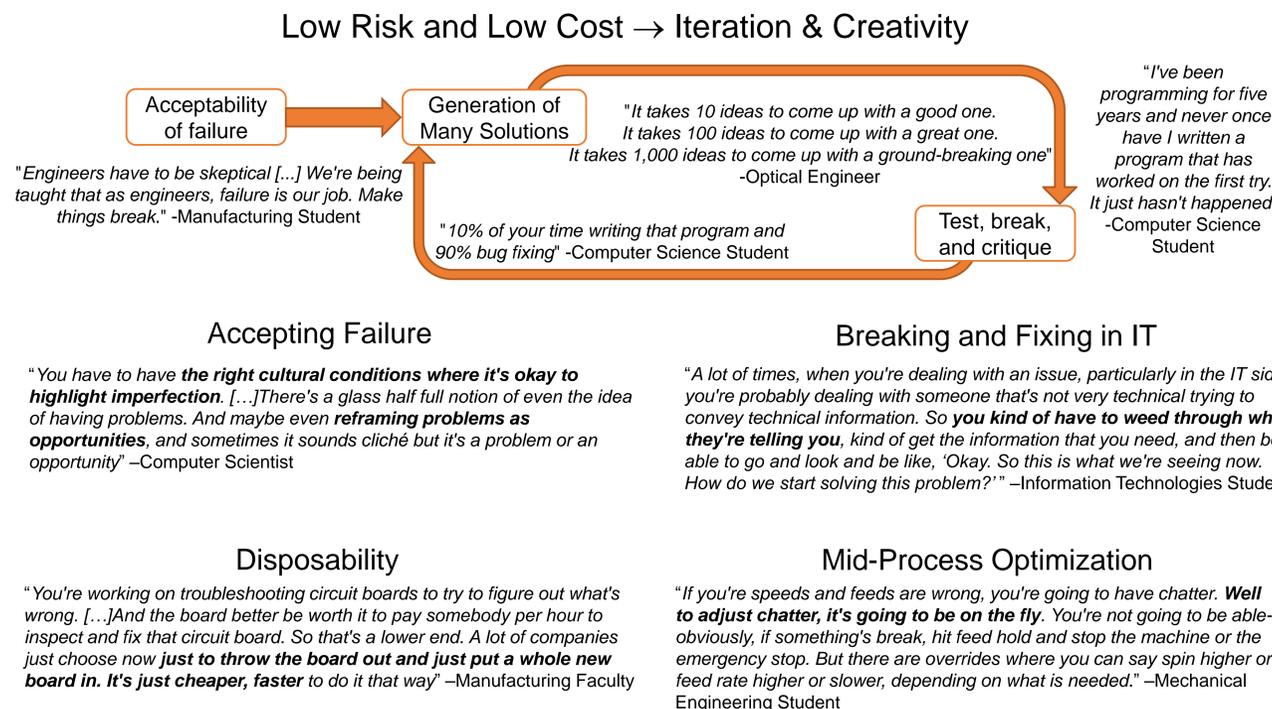
### Preventive Communication

**Repeat-back technique**  
 "Hey, I need you to go out and open a particular valve," then you, as a outside operator, you say, "Okay, you just asked me to open FC10," and then I communicate back and say, "Yes, you need to open FC10 one round." And then the outside operator says, "Okay, I'm opening FC10 one round." –Petrochemical Faculty

**Nonverbal Communication**  
 "they could say "No, it doesn't hurt" or this or that. But if their facial-- they have facial grimacing or they're having signs and symptoms of pain, **we have to look at all forms of communication, not just verbal**" – Nursing Student

## Explorative Problem-Solving Culture

encourages multiple creative solutions & iterative testing, often without worry about failure



## Conclusions

- Major contributors to the type of problem-solving an organization attempted were the **potential for risk** involves, the **cost** of the procedures, and the **implications of failure**.
- Cost was a significant motivator behind the petrochemical processing industry, which lead to the **balancing between continuous operation and safety**
- The problems solved across all of the industries examined were complex and largely dependent on the greater context and affected their views of what problems were
  - A preventive culture**
    - was constrained** by staying within a bounded state (e.g., keeping the plant running)
    - involved diagnosing a variance from the desired state
    - applied a preplanned solution process to return to a **predetermined end goal, maintaining the state**
  - An explorative culture**
    - had a general direction, but a **less specific and malleable end goal**
    - involved **flexible solution paths** to find the best way to reach the goal
- Limitation:** Preventive and explorative are not the only two problem-solving cultures, and their strategies are not mutually exclusive, but the overall organizational approaches were consistent across the industries analyzed.

## Where does Physics Fit?

- Physics is not an industry, it is an academic discipline, which does not specifically fit into a preventive or explorative problem-solving culture.
- Physicists have skills that could let them fit into an organization with either of the problem-solving culture

## Educational Implications

- Neither preventive or explorative problem-solving are particularly prevalent in undergraduate physics education
- An undergraduate research lab can provide learning opportunities that emphasize safety and structured procedures, which are typical in a preventive culture.
- Computational physics and electronics lab courses could be good places to introduce students to explorative cultures where they can quickly try new things with relatively low risk and learn from failure.

## References

- J.V. Maanen and E.H. Schein, Towards a theory of organizational socialization (1979).
- Principles for a Strong Nuclear Safety Culture, Tech. Rep. (Institute of Nuclear Power Operations, 2004).
- J. Saldana, *The Coding Manual for Qualitative Researchers*, second edition ed. (SAGE Publications Ltd, Los Angeles, 2012).

## Acknowledgements

This study design and data collection was done in conjunction with Matt Hora, Ross Benbow, Bailey Smolarek and other collaborators at the Wisconsin Center for Education Research.