Critically Thinking for Engineers

The Live Webinar will begin shortly…….

Upcoming PE Institute Live Webinars

Wednesday, April 19 at 2pm

Engineering Ethics: Objectivity and Truthfulness

Wednesday, April 26 at 2pm

We Don't Talk Anymore...

Communications Skills for Navigating the Modern Workplace

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Critically Thinking for Engineers

Lighthouse Force

"Preparing individuals and organizations to thrive in the workplace of the future"

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Consulting, Speaking, Writing
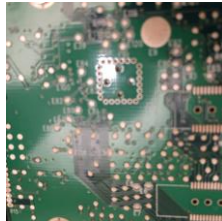
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What we will learn

Why is critical thinking important?

A process for critical thinking:

- Identify and refine complex problem types

- Gather information through Inspection and Questioning

- Identify ways to control bias

- Identify ways to stimulate working teams

New Era: Rapidly Changing Business World

Fast Paced Technology Changes

Increased Globalization

Demographic Shift

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Workplace Automation

McKinsey&Company

- Future work ___ re-definition
- Impact is on ___

< 5% occupations will be replaced by technology

___vities will be needed or ___e spent on some

Replaced:
- Preparing ___
- Preparing staff assignments
- Analyzing client's financial situation
- Ordering materials

___e solutions
___x problem solving
___sensing, reacting to emotions
- Nuances

Important Skills:

- **Critical thinking**
- **Innovation**
- **Agility**
- **Emotional Intelligence**

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Types of Thinking

Outside the

Critical Thinking

Analytical

Using analysis and evaluation to form judgement

- Manual Thinking (not automatic) with process

- Purposeful and aware of partiality

Creative

Ingenious

Original

Experimental

- M. Kallet, *Think Smarter*

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Critical Thinking

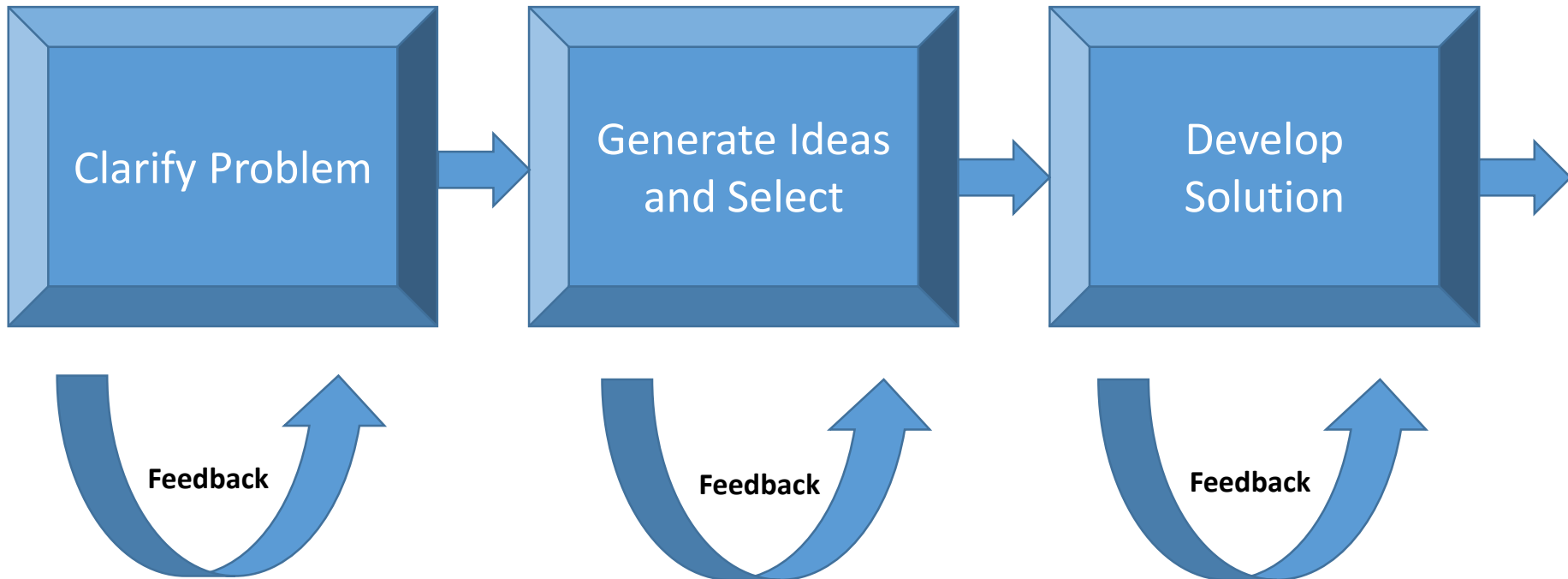- Pursuing curiosity, in impartial way
- Questioning to understand, expose

With good intention

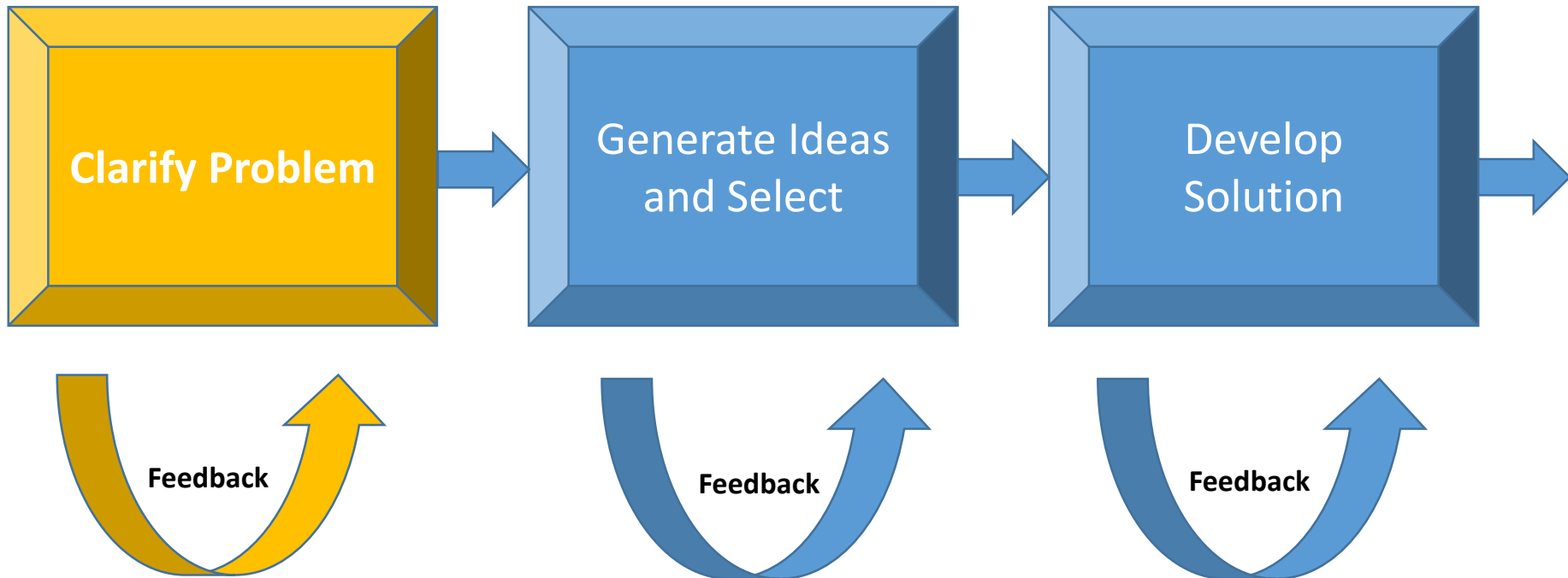As an individual: Open minded, consider alternatives, listen to your gut

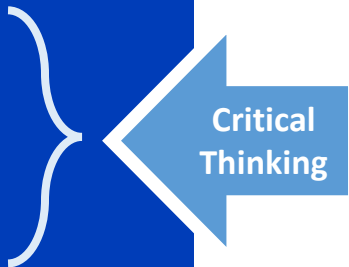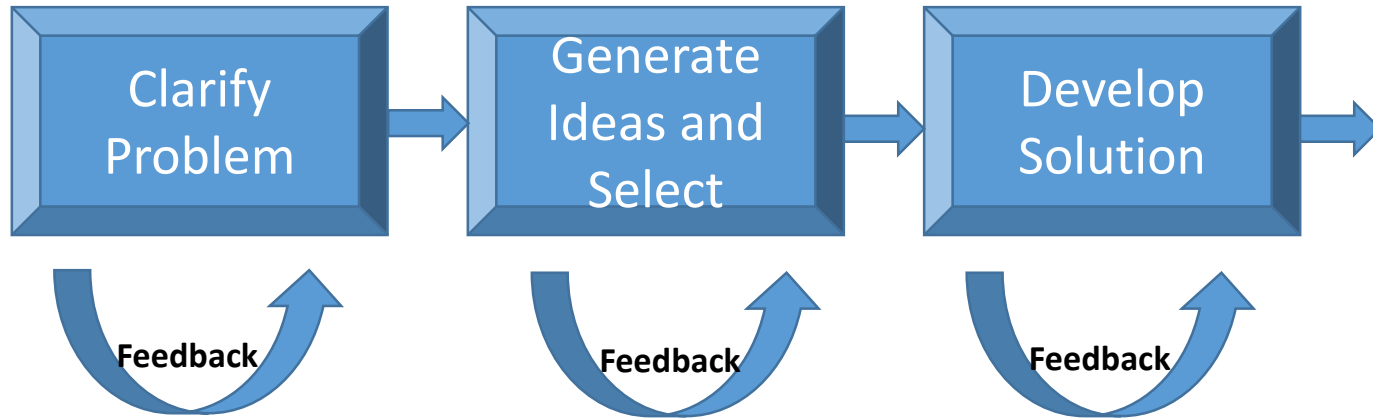Within a team: Questioning, challenging the team

???

Problem Solving

| Clarify Problem | → | Generate Ideas and Select | → | Develop Solution | → |

Feedback

Feedback

Feedback

Problem Solving

Where is the time spent?

| Clarify Problem | → | Generate Ideas and Select | → | Develop Solution | → |

Feedback   Feedback   Feedback

	Clarify Problem	Generate Ideas and Select	Develop Solution
Novice:	5%	15%	80%
Expert:	>25%	25%	<50%

When is critical thinking needed?

Problem Type	Description
Simple	• Easy to do
Complicated	• Know how, requires time and analytical thinking
Complex	• Solution not obvious

Critical Thinking

What problem type?

- Simple
- Complicated
- Complex

Problem 1: Need 5 additional sensors
Problem 2: Need new provider for the sensors
Problem 3: Delay caused by problem 2 will put the project in jeopardy to finish on time

Critical Thinking
Problem Inspection

Problem statement should be clarified
- Look for ambiguous terms
- Pronouns – We, They
  Question: Who is "we"?
- Should be measurable
- Should not imply a solution

Problem is… conveyer staff has down time

We need a faster conveyer belt

We need higher quality!

Who is "we"? What is "high quality"?

Not fast enough!

How fast is needed?

Must improve deliveries!

What constitutes improvement?

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Critical Thinking

Information Inspection

All information related to the problem should be inspected

- Current and accurate?
- Biased? Sources verified?
- Substantiated or opinion?
- Complete?

The problem always happens when we bring the system up.

Who said this? Is it a complete statement?

The problem doesn't happen on every startup. Maybe 1 out of 5. But only occurs during startup.

Inspection Questions:

Who, What, Where, When, How

Problem Statement:

We are not catching as many largemouth bass in the streams as we used to

Using inspection, what questions can you come up with?

Who is "We"? Who is not catching the bass?
　　Game fishers, commercial fishers?

Where was the problem seen? What streams?

When did this occur? As compared to when?

How much decrease are you seeing?

Critical Thinking – Questioning
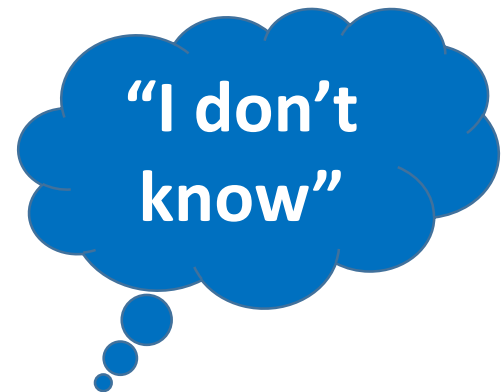## 5 Why's – Getting to "I don't know"

Root Cause Analysis

Why?

      Why?

            Why?

                  Why?

                        Why?

"I don't know"

Critical Thinking – Questioning
5 Why's – Getting to "I don't know"

Root Cause Analysis

A robot on the assembly line has stopped

Why? ➔ Because the circuit overloaded

Why? ➔ Because the bearings locked up
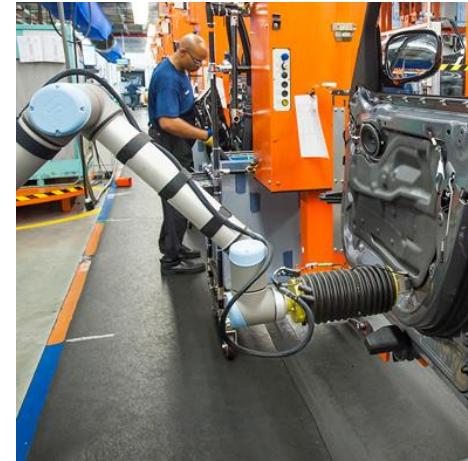
Why? ➔ Because of insufficient lubrication

Why? ➔ Oil pump clogged with metal shavings

Why? ➔ Why metal shavings?

"I don't know"

Critical Thinking – Questioning
So What?

- Searching out clarity and reason
  - What is the reason?
  - What is the rationale?
- Asking up the line (goals, assignments)
- When to ask
  - Unexpected problem
  - New data available
  - Ask even when you know

Kevin is out sick! He may be out for 2 weeks!

So what?

We need him to get the design done by Friday to stay on schedule

Critical Thinking – Stimulation

What about when there is no idea where to start?

- Starting with a "blank sheet"
  - List what you do know
  - List what you do not know
  - What are likely outcomes? (So What?)
  - What from your list is likely correct, what is likely in error? Why is it in error?
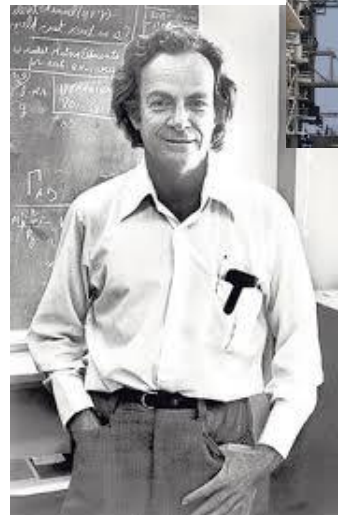 - Experiment!

Critical Thinking - Experimentation

When you need to know more…

Experiments

- testing possible solutions
- provide you with more information about the problem

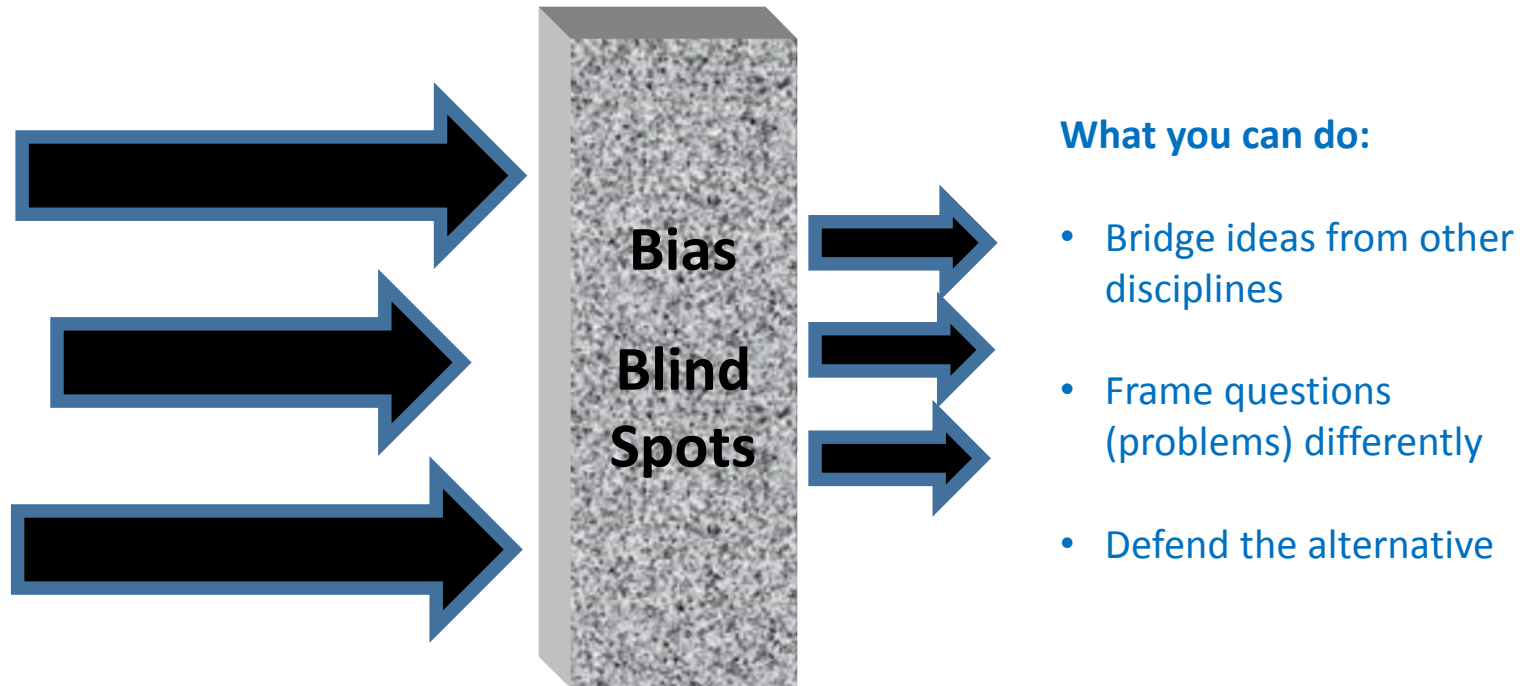# Problem Questioning Checklist

Questions to ask

- What is the problem?
- Who has seen or reported the problem?
- When does it happen?
- How often or long? How much or how little?
- What is missing from the problem statement?
- So what? (is it valid, important?)

Information needed

- What is missing?
- What information is needed to solve?
- Is any testing needed?
- Are any experiments needed?

Critical Thinking – Our filter

What you can do:

Bias

Blind

Spots

- Bridge ideas from other disciplines

- Frame questions (problems) differently

- Defend the alternative

Solutions finding a problem…
## A project manager's bias story

Hardware/Software delivery

- Defective chip – occasionally framing errors when hot
- Beta customer had the bad hardware, reported framing errors
- Deferred any action (considered existing problem)
- After fix was in production, customer again saw framing errors
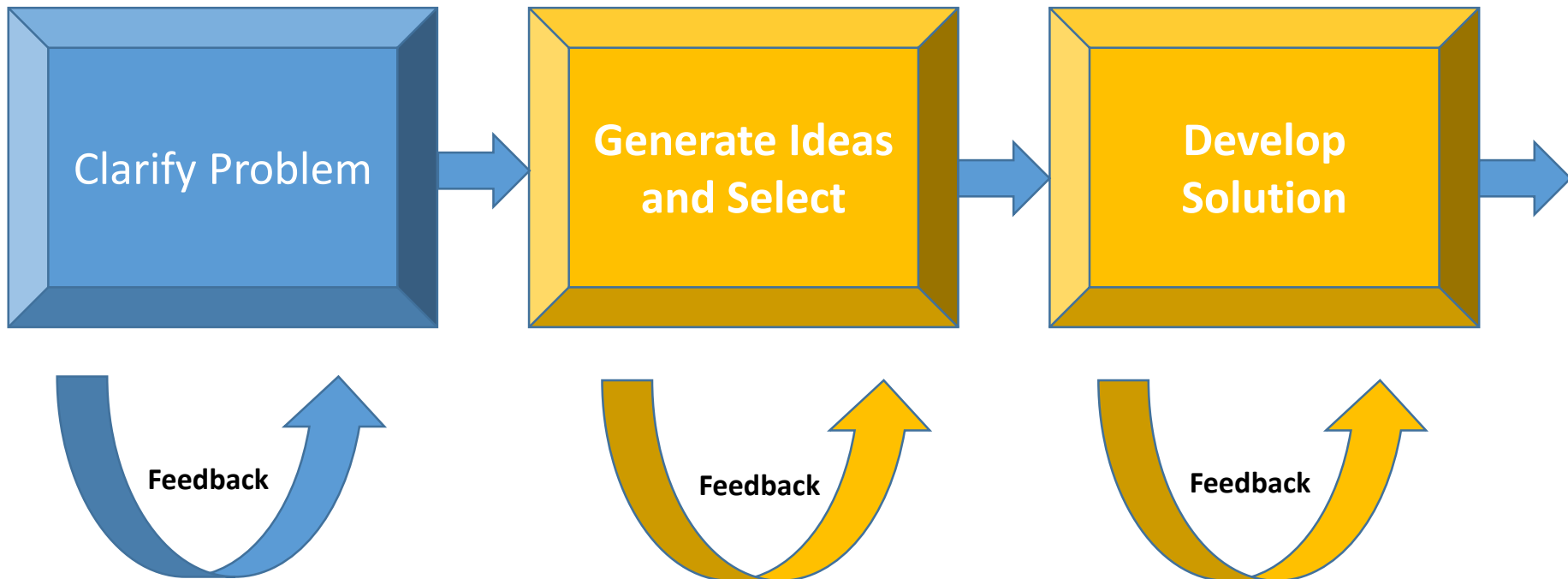- Elusive software problem, expensive to fix

Because of biases, did not:

- Investigate data
- Test, experiment
- Question assumption (that problem was the same)
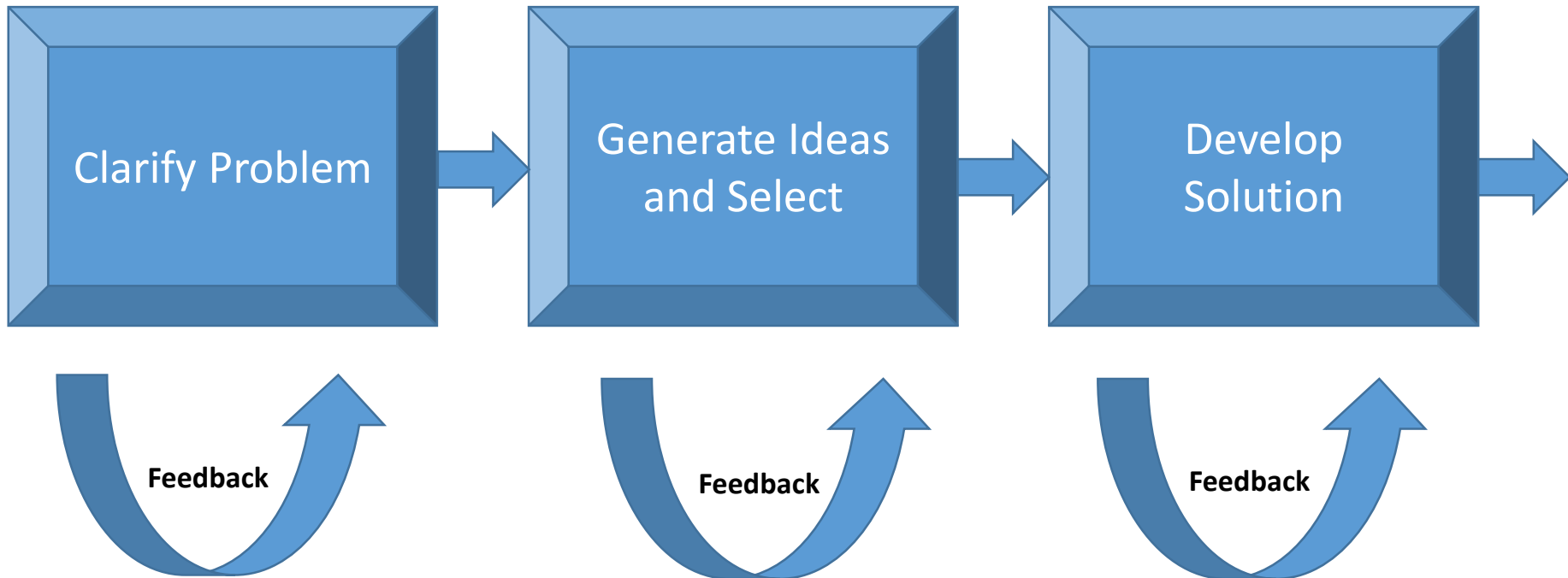
Problem Solving

Generate Ideas and Select

Questions to ask

- What does the idea require to succeed?

- What is missing from the idea?

- What effort is required to implement (H, M, L)?

- What is the impact of the solution on the original problem (H, M, L)?

Information needed

- Does the idea require some pre-testing?

- Should we seek input from others – crowdsourcing?

- Are any experiments needed?

For selection:

Compare
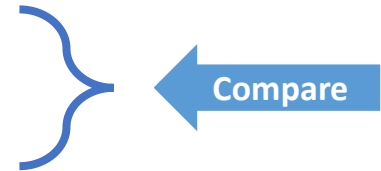
Supporting your Work Team

When team thinks critically, they are more productive and improve quality.

- Use Questioning, Inspection, Stimulation, Experimentation

- Force questions from the team

- Don't ignore irrelevant statements

Be Curious!

Takeaways

- Critical thinking is a purposeful process that individuals and teams must practice and support

- Problem types should be identified when clarifying a problem

- Take a deep dive – inspecting, questioning, experimenting, always moving forward

Critical thinking is critical for engineers today and in the future!

The Ultimate Compliment!

Q & A

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FORCE

References

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- B. Johansen, *Leaders Make the Future – Ten New Leadership Skills for an Uncertain World,* Berrett-Koehler, 2012

- Michael Kallet, *Think Smarter*, 2014

- Edward Burger, Michael Starbird, *The Five Elements of Effective Thinking,* Princeton University Press, 2012

Critically Thinking for Engineers

To receive credit for this course, each registrant will need to take the quiz below and pass with a score of 70 or above. Click link

http://quiz.nspe.org/quiz/critically-thinking-for-engineers.aspx

to take the quiz.

Critically Thinking for Engineers

NSPE would like your feedback regarding this live webinar. Click link
https://www.surveymonkey.com/r/9NV38HD

to take a short survey.