Build Software Safely!

17-313 Fall 2024

Foundations of Software Engineering

https://cmu-313.github.io

Michael Hilton and Rohan Padhye

Learning Goals

- Learn to discuss risk in a project
- Strategize about ways to mitigate risk
- Learn to get early feedback to reduce risk
- Find ways to catch our technical errors

Administrivia

- Midterm Oct 8 in class
  - We will approve ODR requests, reach out if you have concerns
- Review Session: Friday October 4th 5-6 pm in TCS 358
- P2C - Collaborative Development Due Thu, Oct 10th, 11:59pm
- Office hour moved TO 2-3pm

Risk

Risk


Tony Webster
@webster
Follow
I appreciate the honesty.
Pick a password
Don't reuse your bank password, we didn't spend a lot on security for this app.
At least 6 characters
your password
Continue
8:20 PM - 15 Sep 2018
5,868 Retweets 15,672 Likes
58
5.9K
16K

Definition: Risk

Risk is a measure of the potential inability to achieve overall program objectives within defined cost, schedule, and technical constraints.

Conrow, E. 2003. Effective Risk Management: Some Keys to Success, 2nd ed. Reston, VA, USA: American Institute of Aeronautics and Astronautics (AIAA).

Risk is defined by two key components

The probability (or likelihood) of failing to achieve a particular outcome

The consequences (or impact) of failing to achieve that outcomes

Conrow, E. 2003. Effective Risk Management: Some Keys to Success, 2nd ed. Reston, VA, USA: American Institute of Aeronautics and Astronautics (AIAA).

Internal vs. External Risk

Risks that we **can** control

Risks that we **cannot** control

Levels of Risk Management

1. **Crisis management:** Fire fighting; address risks only after they have become problems.
2. **Fix on failure:** Detect and react to risks quickly, but only after they have occurred.
3. **Risk mitigation:** Plan ahead of time to provide resources to cover risks if they occur, but do nothing to eliminate them in the first place.
4. **Prevention:** Implement and execute a plan as part of the software project to identify risks and prevent them from becoming problems.
5. **Elimination of root causes:** Identify and eliminate factors that make it possible for risks to exist at all.

"Rapid Development: Taming Wild Software Schedules," Steve McConnell, 1996

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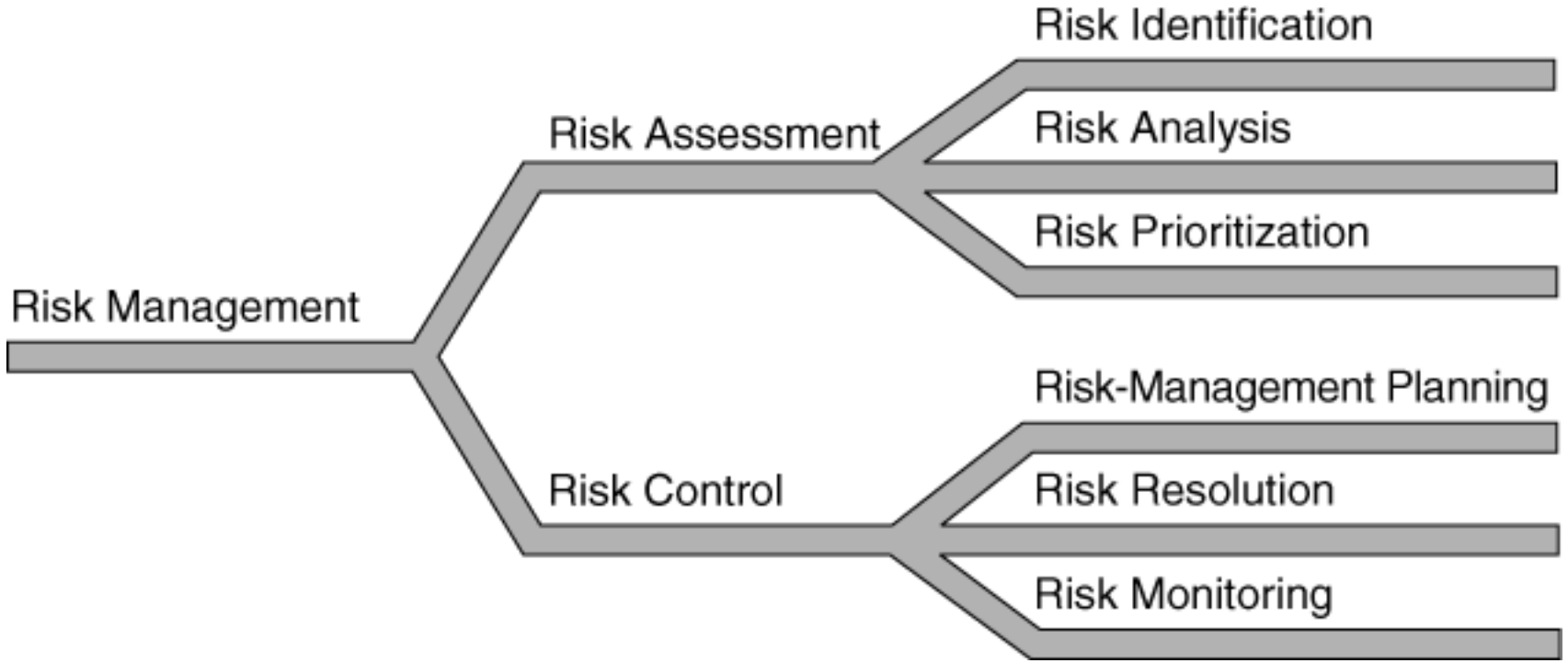
Risk Management



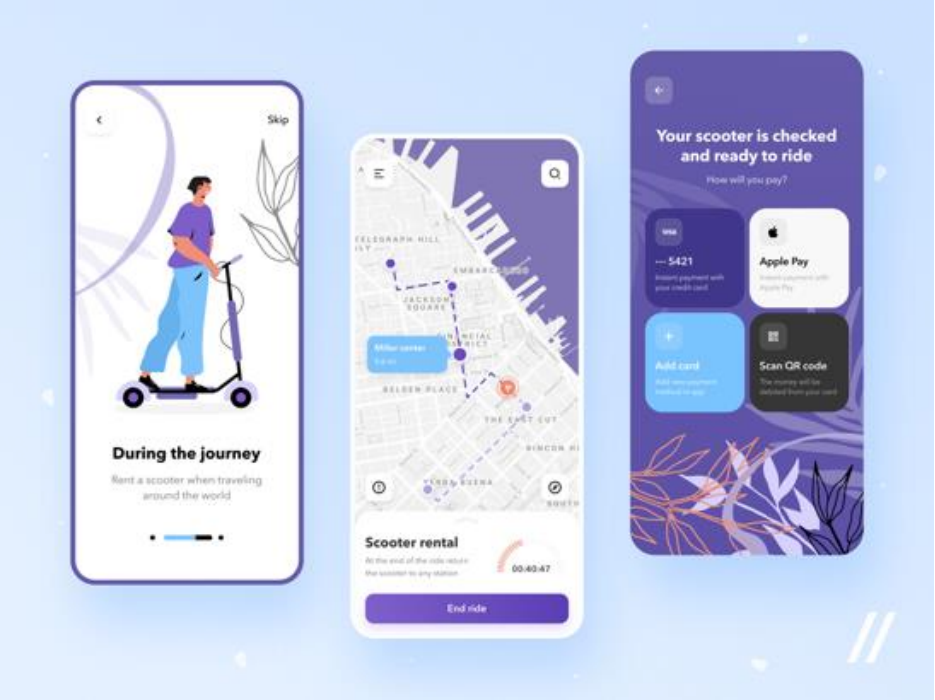
"Rapid Development: Taming Wild Software Schedules," Steve McConnell, 1996


I am once again asking
to not cheat on your participation activiy

Any paper with >3 names will result in 0 score for all participants

Team Exercise: Risk Identification

- What risks exist for the scooter app?



Risk assessment matrix

TABLE III. Risk assessment matrix

RISK ASSESSMENT MATRIX				
SEVERITY / PROBABILITY	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

- MIL-STD-882E

https://www.system-safety.org/Documents/MIL-STD-882E.pdf

Aviation failure impact categories

- **No effect** – failure has no impact on safety, aircraft operation, or crew workload
- **Minor** – failure is noticeable, causing passenger inconvenience or flight plan change
- **Major** – failure is significant, causing passenger discomfort and slight workload increase
- **Hazardous** – high workload, serious or fatal injuries
- **Catastrophic** – loss of critical function to safely fly and land

DO-178b, Software Considerations in Airborne Systems and Equipment Certification, RTCA, 1992

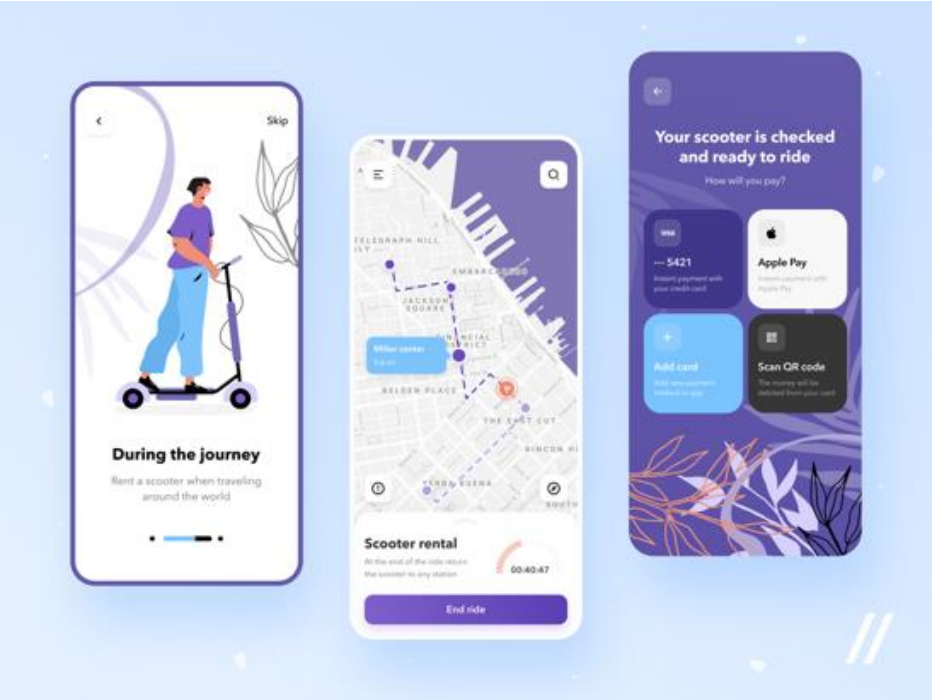
Risk Analysis

Risk	Probability (%)	Size of Loss (weeks)	Risk Exposure (weeks)
Overly optimistic schedule	50%	5	2.5
Additional features added by marketing (specific features unknown)	35%	8	2.8
Project approval takes longer than expected	25%	4	1.0
Management-level progress reporting takes more developer time than expected	10%	1	0.1
New programming tools do not produce the promised savings	30%	5	1.5
…	…	…	…
Total			12

"Rapid Development: Taming Wild Software Schedules," Steve McConnell, 1996

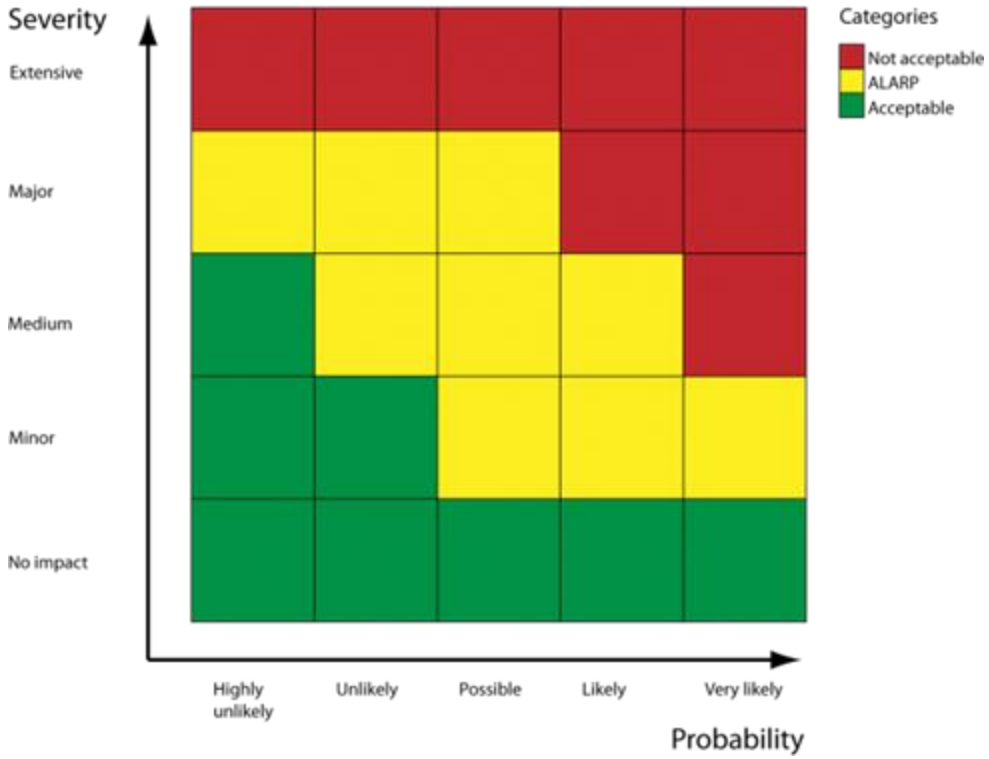
Exercise: Risk Analysis

- What is the risk severity for your scooter app?



Risk Prioritization

Focus on risks with the highest exposure



Risk Control

- What steps can be taken to avoid or mitigate the risk?
- Can you better understand and forecast the risk?
- Who will be responsible for monitoring and addressing the risk?
- Have risks evolved over time?
- Bake risks into your schedule
  - Don’t assume that nothing will go wrong between now and the end of the semester!

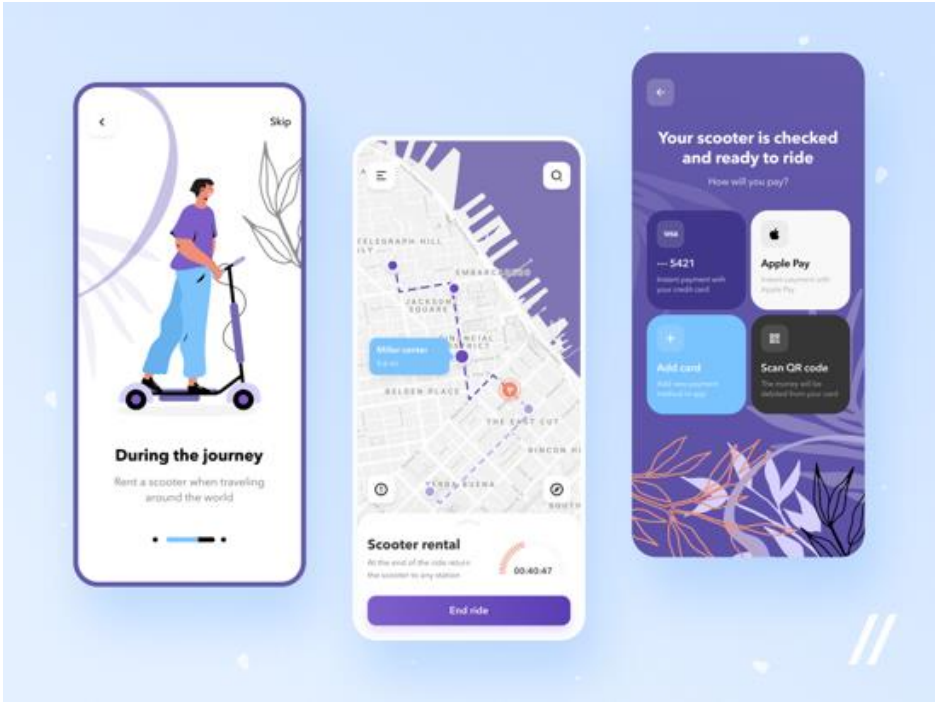
DECIDE Model

Detect that the action necessary
Estimate the significance of the action
Choose a desirable outcome
Identify actions needed in order to achieve the chosen option
Do the necessary action to achieve change
Evaluate the effects of the action

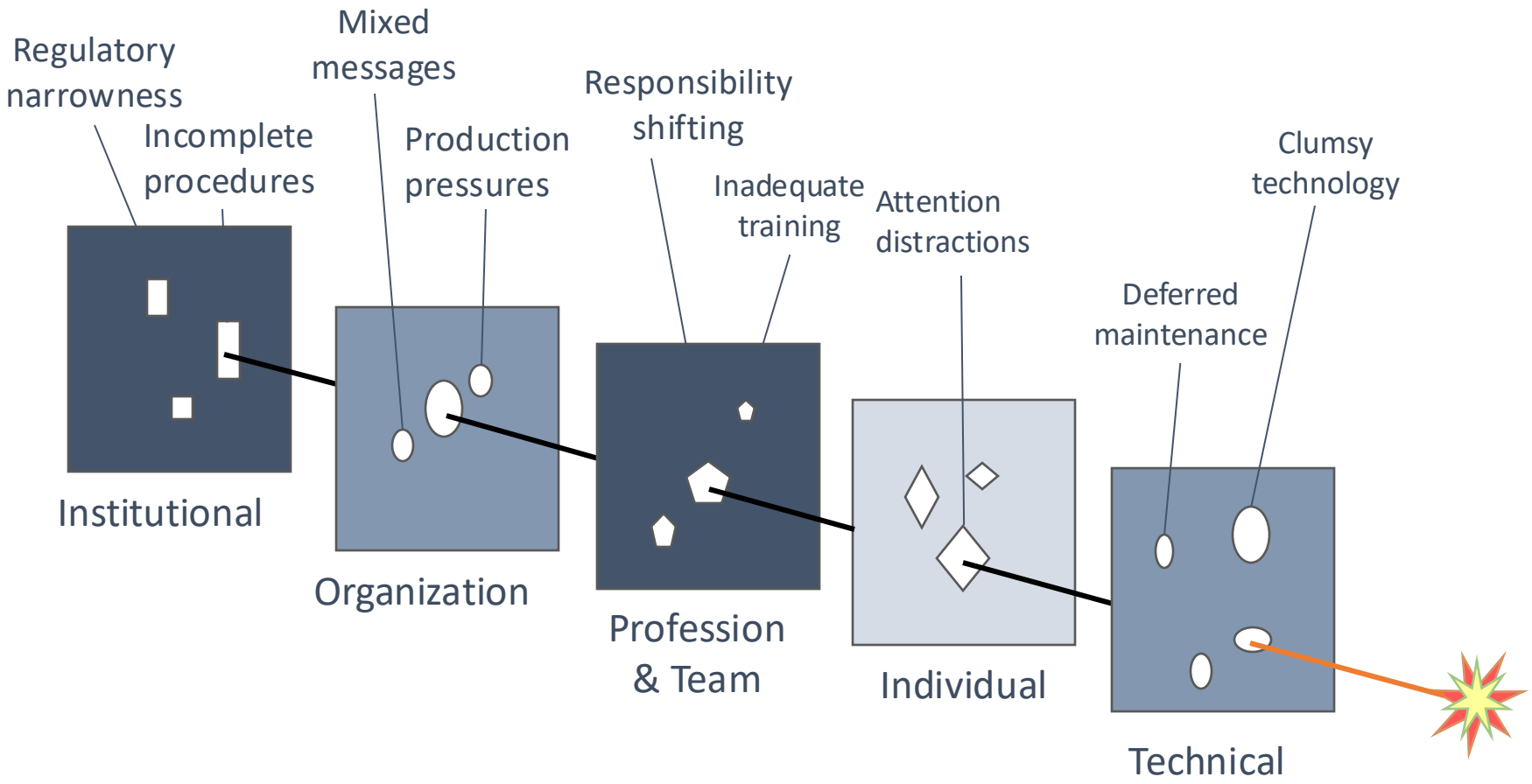
https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/FAA-H-8083-2.pdf

Discussion: Risk Elimination and Mitigation

- How can you eliminate/mitigate risk for your scooter app?

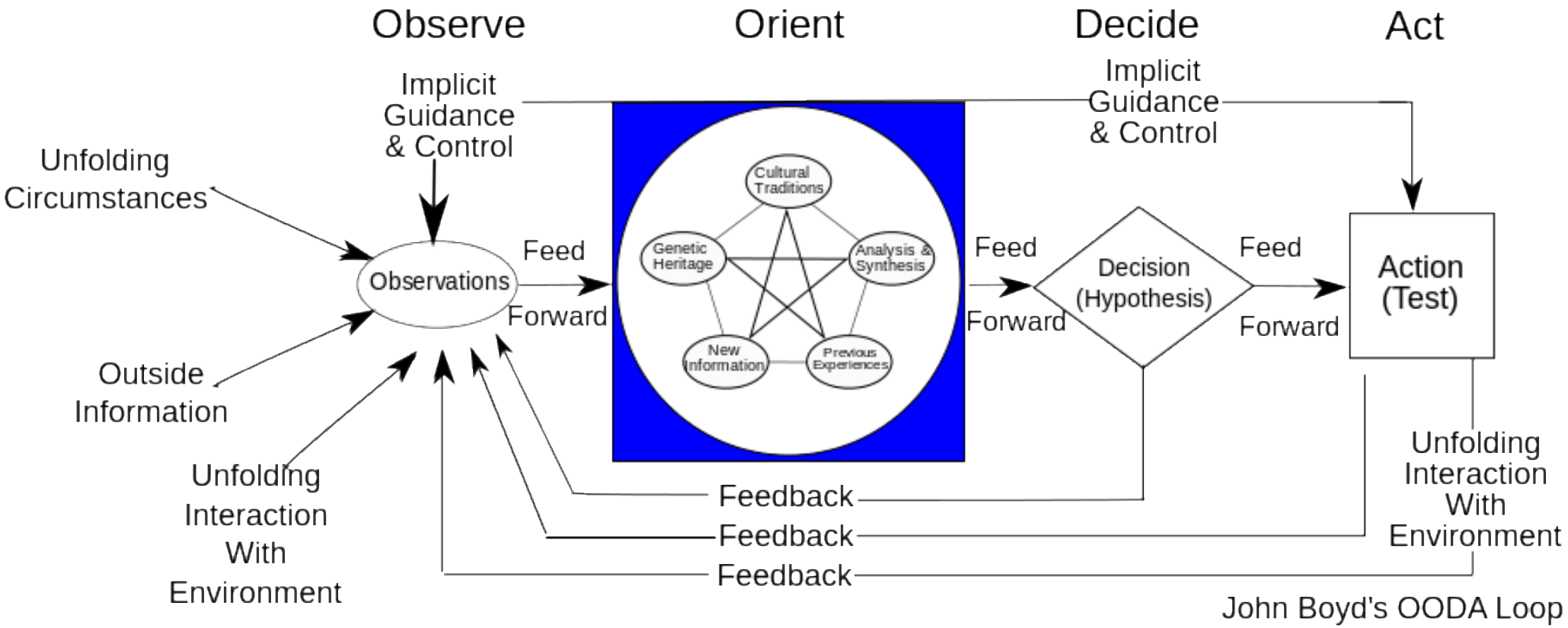


The Swiss cheese model



Modified from Reason, 1999, by R.I. Crook

OODA Loop

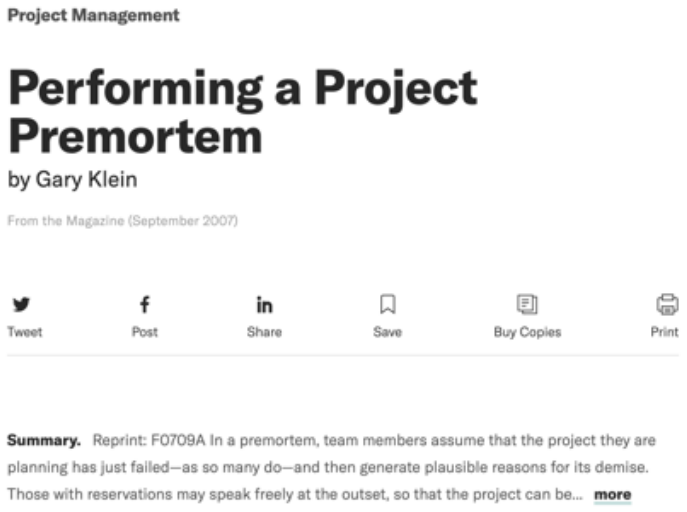


No matter what you do

- Some idiots won’t follow your rules ☺

Pre-mortems

- "unlike a typical critiquing session, in which project team members are asked what *might* go wrong, the premortem operates on the assumption that the 'patient' has died, and so asks what *did* go wrong."



Project Management

Performing a Project Premortem

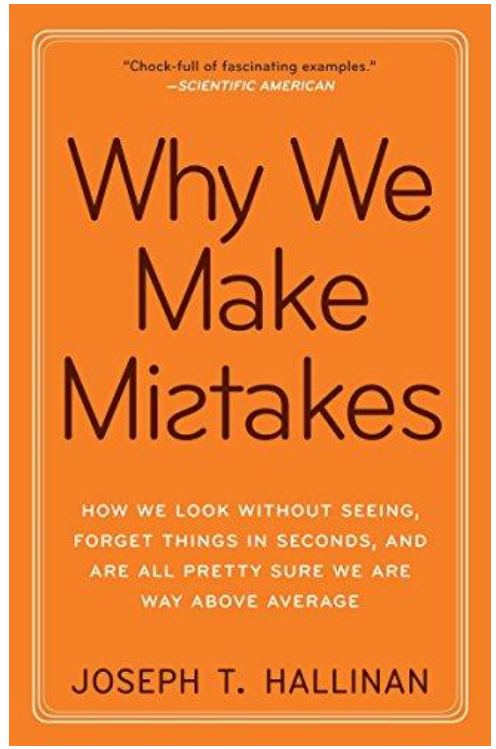
by Gary Klein

From the Magazine (September 2007)

Tweet Post Share Save Buy Copies Print

Summary. Reprint: F0709A In a premortem, team members assume that the project they are planning has just failed—as so many do—and then generate plausible reasons for its demise. Those with reservations may speak freely at the outset, so that the project can be... **more**

Why do we make misakes?



Generalization

- …in the words of psychologist Tom Stafford, we can't find our typos because we're engaging in a high-level task in writing. **Our brains generalize simple, component parts to focus on complex tasks**, so essentially we can't catch the small details because we're focused on a large task.

https://medium.com/swlh/why-we-miss-our-own-typos-96ab2f06afb7

Boredom can give rise to errors, adverse patient events, and decreased productivity—costly and unnecessary outcomes for consumers, employees, and organizations alike. As a function of boredom, individuals may feel over-worked or under-employed, and become distracted, stressed, or disillusioned. Staff who are bored also are less likely to engage with or focus on their work.

Original Articles

Boredom in the Workplace: Reasons, Impact, and Solutions

Michelle Cleary , PhD, RN, Jan Sayers , PhD, RN, Violeta Lopez , PhD, RN & Catherine Hungerford , PhD, RN

Pages 83-89 | Received 24 Jun 2015, Accepted 13 Aug 2015, Published online: 10 Feb 2016

Download citation https://doi.org/10.3109/01612840.2015.1084554 Check for updates

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Abstract

Boredom in the workplace is not uncommon, and has been discussed widely in the academic literature in relation to the associated costs to individuals and organizations. Boredom can give rise to errors, adverse patient events, and decreased productivity—costly and unnecessary outcomes for consumers, employees, and organizations alike. As a function of boredom, individuals may

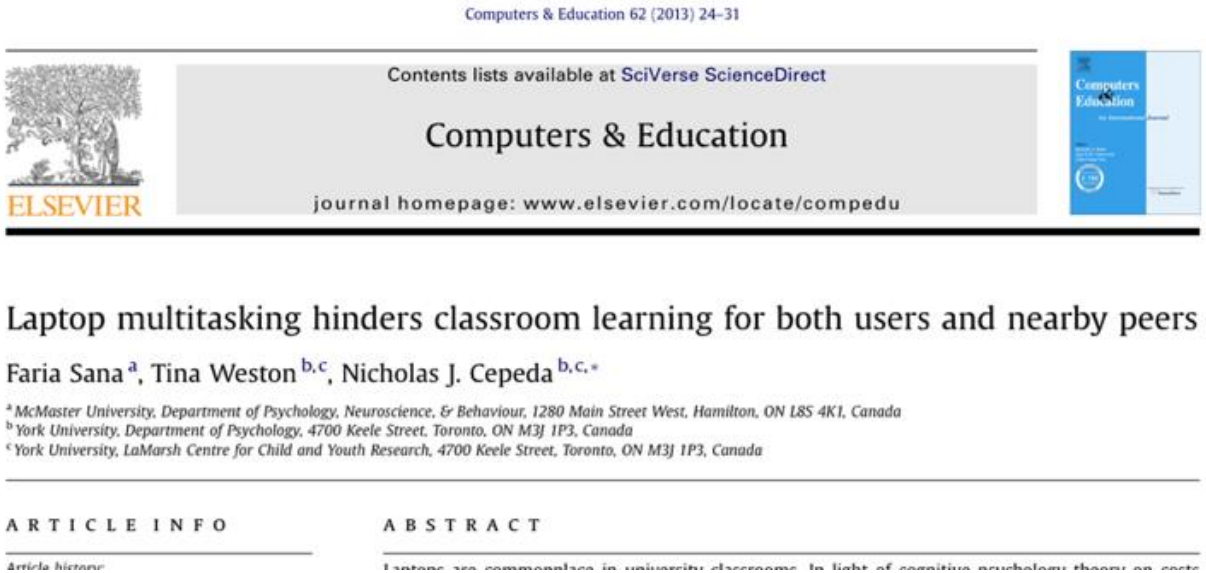
Related rese

People also read

Boredom at work spillover model work motivation boredom

Cognitive Load

- ...” students who switch back and forth between attending to a classroom lecture and checking e-mail, Facebook, and IMing with friends”



Computers & Education 62 (2013) 24–31

Contents lists available at SciVerse ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Laptop multitasking hinders classroom learning for both users and nearby peers

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[b] York University, Department of Psychology, 4700 Keele Street, Toronto, ON M3J 1P3, Canada
[c] York University, LaMarsh Centre for Child and Youth Research, 4700 Keele Street, Toronto, ON M3J 1P3, Canada

ARTICLE INFO

ABSTRACT

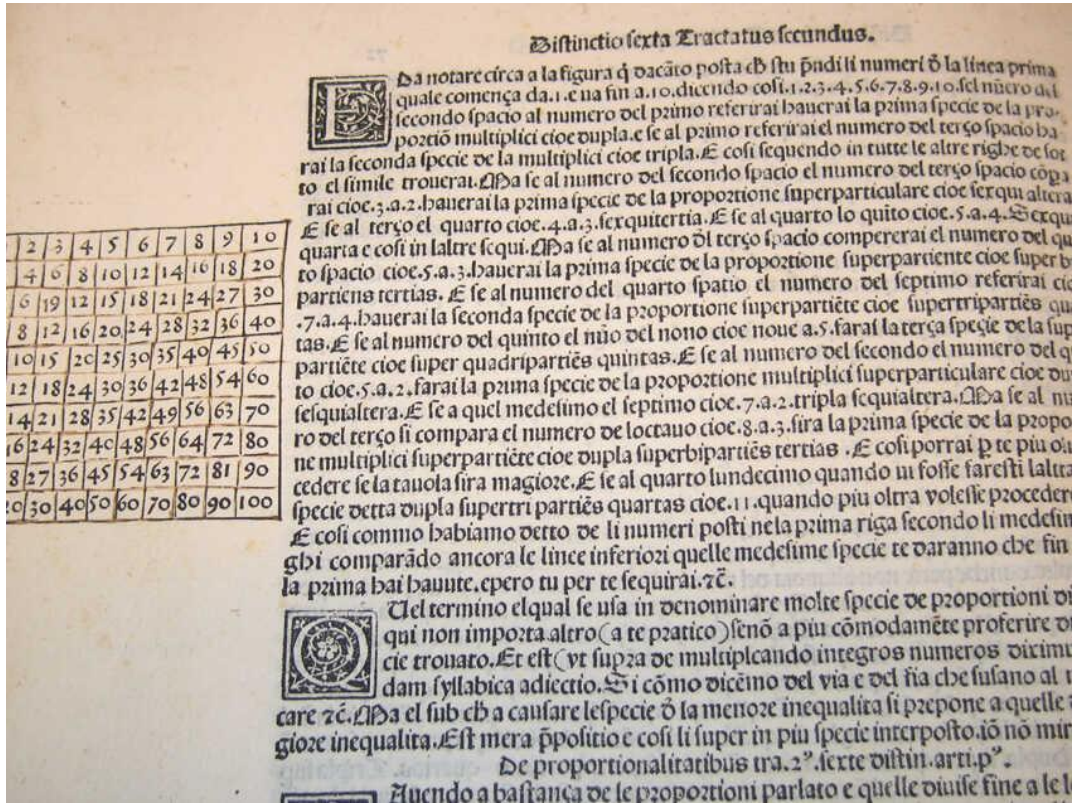
Can we remove human error?

catch

Can we ~~remove~~ human error?

Can we catch human error before we ship our code?

Can we automate tasks to prevent problems?



Distinctio sexta Tractatus secundus.

Da notare circa a la figura q̃ dacãto posta ch̃ stu p̃di li numeri ō la linea prima quale comença da.1.e na fin a.10.dicendo cosi.1.2.3.4.5.6.7.8.9.10.sel nūero del secondo spacio al numero del primo referirai haverai la prima specie de la proportiõ multiplici cioe dupla.e se al primo referirai el numero del terço spacio harai la seconda specie de la multiplici cioe tripla.Et cosi sequendo in tutte le altre righe de sotto el simile troverai.Da se al numero del secondo spacio el numero del terço spacio cõparai cioe.3.a.2.haverai la prima specie de la proportione superparticulare cioe sexqui altera.Et se al terço el quarto cioe.4.a.3.sexquitertia.Et se al quarto lo quito cioe.5.a.4.Sexquiquarta e cosi in laltre sequi.Da se al numero dl terço spacio compererai el numero del quarto spacio cioe.5.a.3.haverai la prima specie de la proportione superpartiente cioe superpartiens tertias.Et se al numero del quarto spatio el numero del septimo referirai cioe.7.a.4.haverai la seconda specie de la proportione superpartiẽte cioe supertripartiẽs quartas.Et se al numero del quinto el nũo del nono cioe noue a.5.farai la terça specie de la superpartiẽte cioe super quadripartiẽs quintas.Et se al numero del secondo el numero del quinto cioe.5.a.2.farai la prima specie de la proportione multiplici superparticulare cioe dupla sesquialtera.Et se a quel medesimo el septimo cioe.7.a.2.tripla sequialtera.Da se al numero del terço si compara el numero de loctauo cioe.8.a.3.sira la prima specie de la proportione multiplici superpartiẽte cioe dupla superbipartiẽs tertias .Et cosi porrai p te piu oltra procedere se la tauola sira magiore.Et se al quarto undecimo quando ui fosse faresti laltra specie detta dupla supertri partiẽs quartas cioe.11.quando piu oltra volesse procedere.Et cosi commo habiamo detto de li numeri posti ne la prima riga secondo li medesimi ghi comparãdo ancora le linee inferiori quelle medesime specie te daranno che fin la prima hai hauute.epero tu per te sequirai.tẽ.

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	6	9	12	15	18	21	24	27	30
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	10	15	20	25	30	35	40	45	50
	12	18	24	30	36	42	48	54	60
	14	21	28	35	42	49	56	63	70
	16	24	32	40	48	56	64	72	80
	8	27	36	45	54	63	72	81	90
	20	30	40	50	60	70	80	90	100

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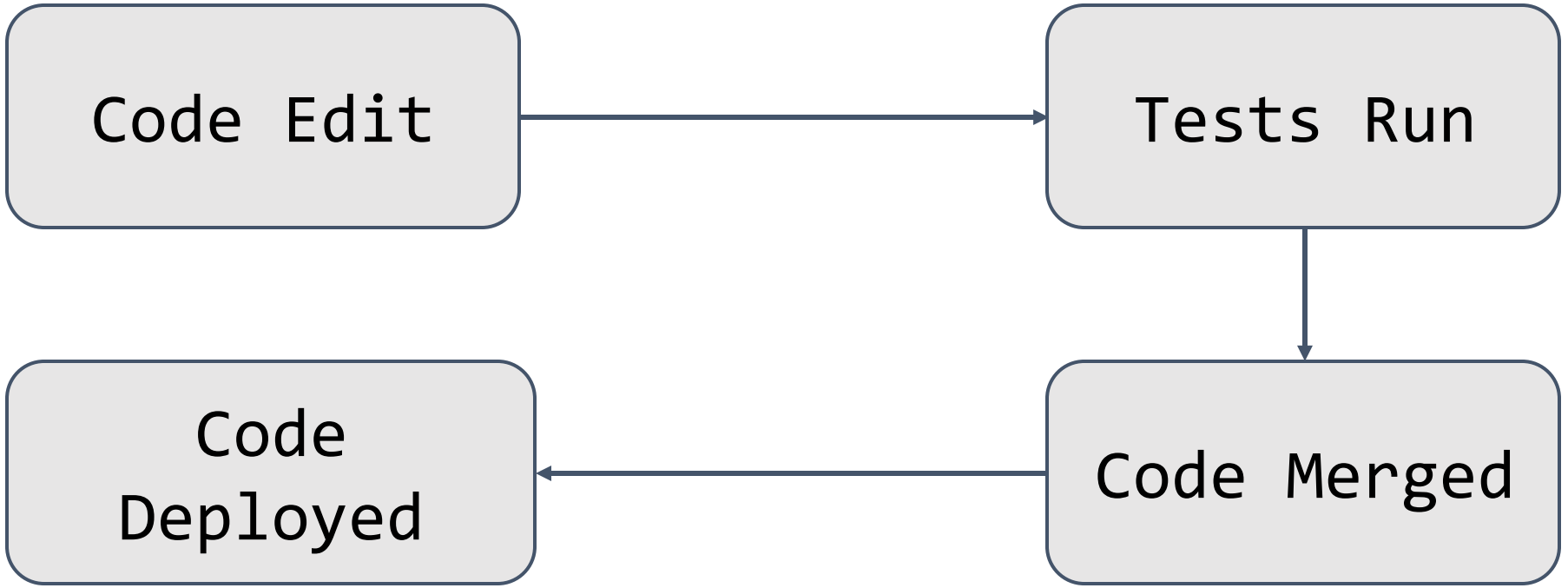
Approach:
Automate what we can
Review what we cannot

CI/CD Pipeline overview



Continuous Integration:

Catch mistakes before you push your code!

History of CI

(1999) Extreme Programming (XP) rule: “Integrate Often”

(2000) Martin Fowler posts “Continuous Integration” blog

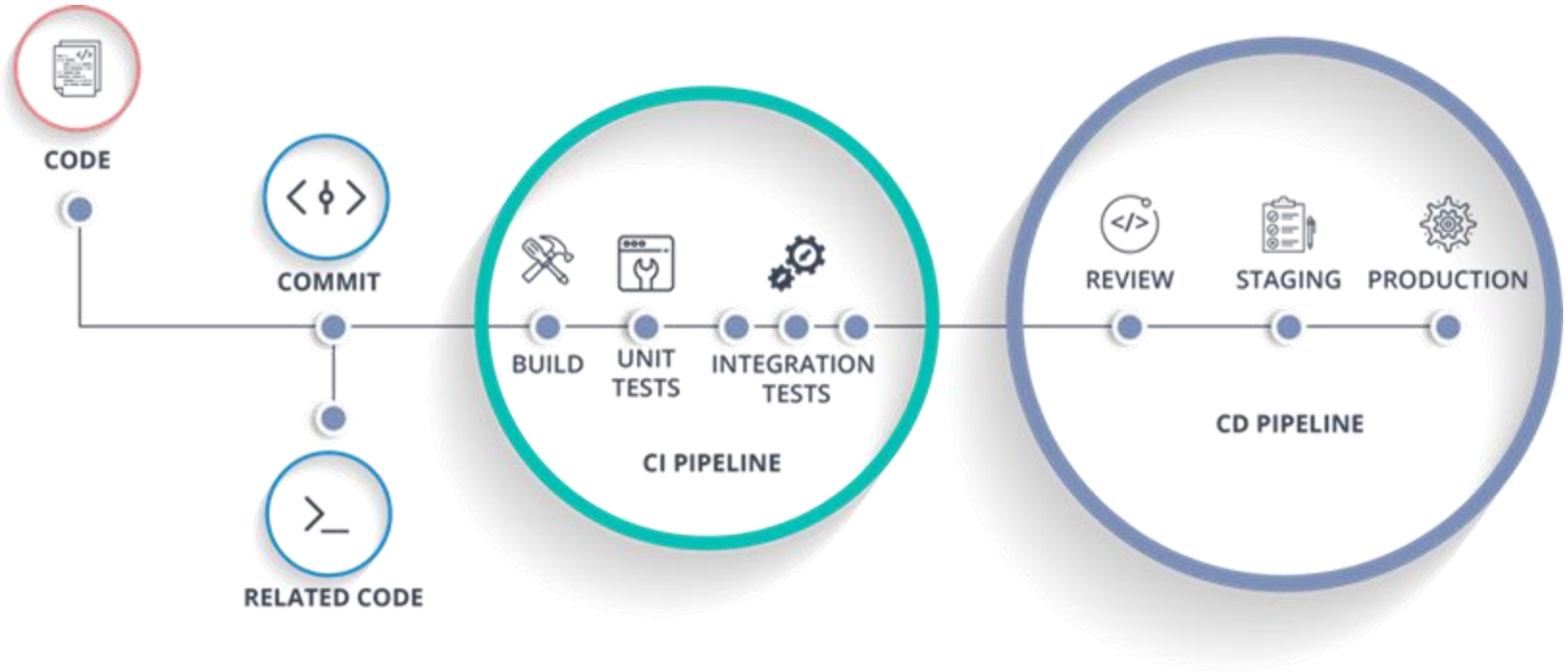
(2001) First CI tool

(2005) Hudson/Jenkins

(2011) Travis CI

(2019) GitHub Actions

Example CI/CD Pipeline



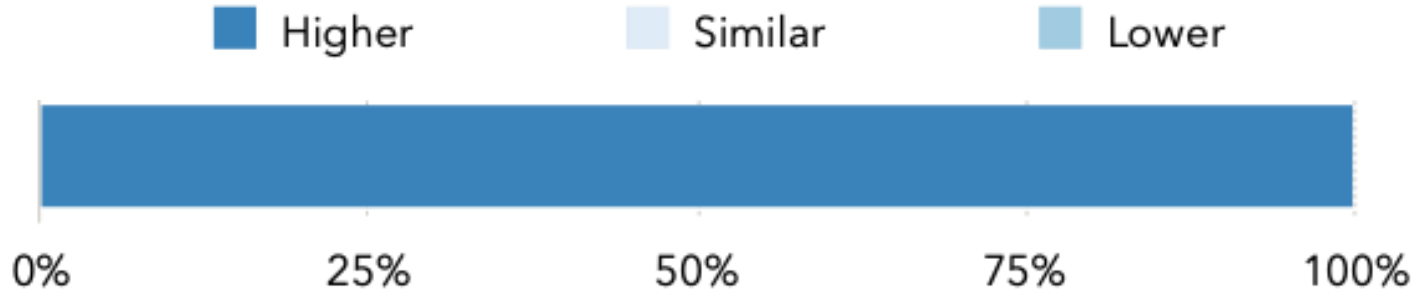
Developers say:

CI helps us catch bugs earlier
CI makes us less worried about breaking our builds
CI lets us spend less time debugging

“[CI] does have a pretty big impact on [catching bugs]. It allows us to find issues even before they get into our main repo, … rather than letting bugs go unnoticed, for months, and letting users catch them.”

Developers report:

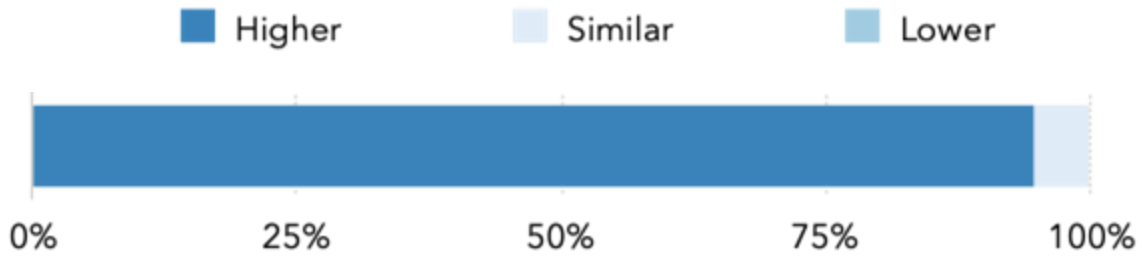
Do developers on projects with CI give (more/similar/less) value to automated tests?



Developers report:

Do developers on projects with CI give (more/similar/less) value to automated tests?

Do projects with CI have (higher/similar/lower) test quality?



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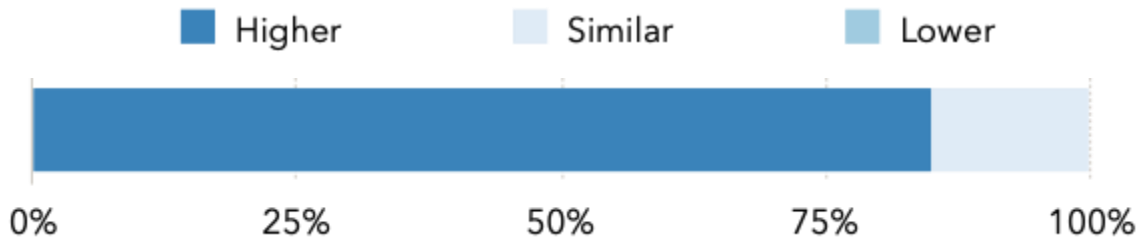
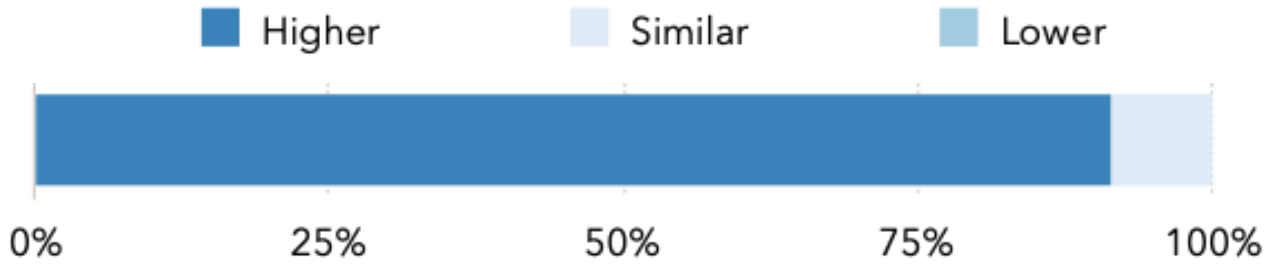


Developers report:

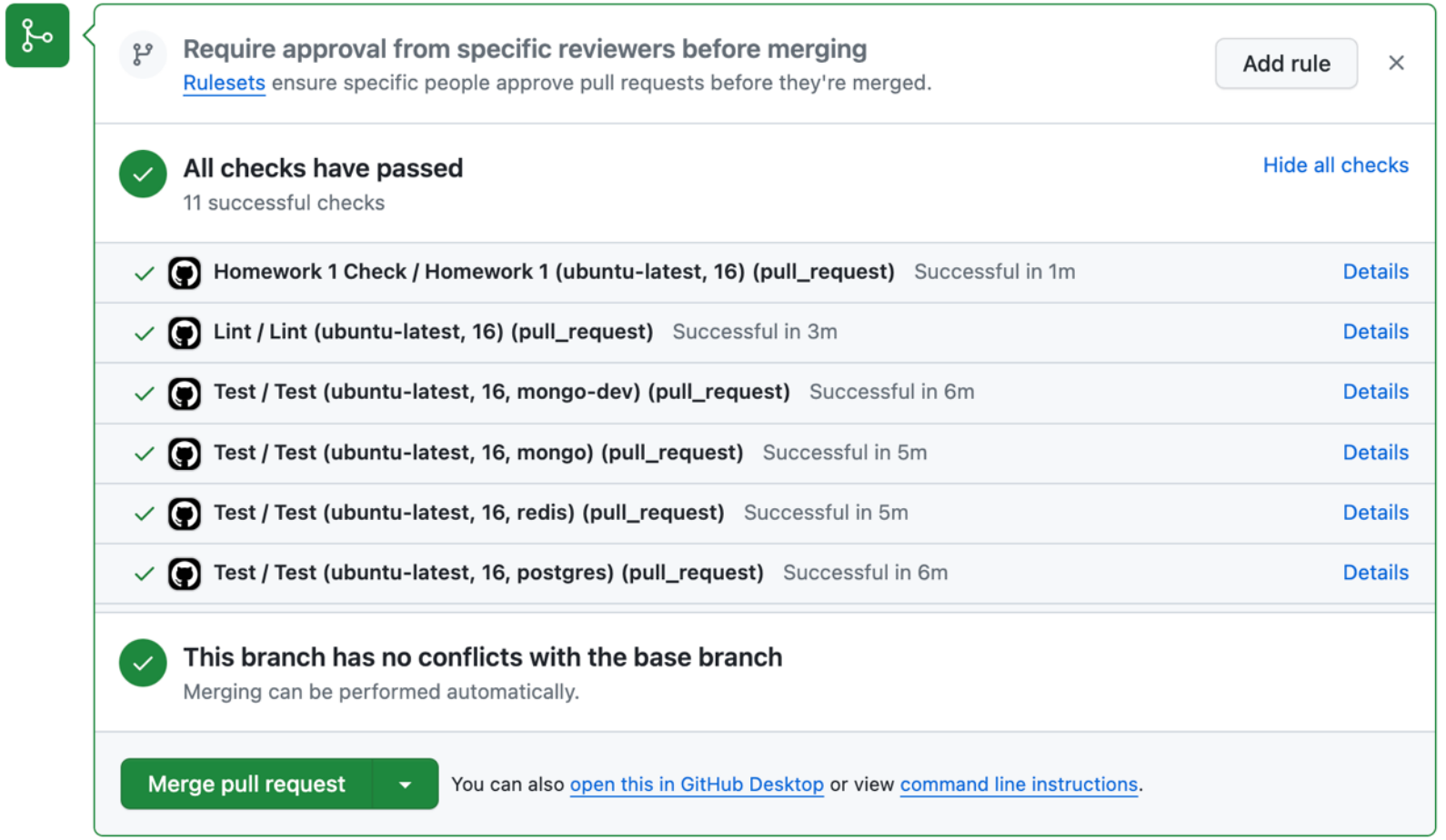
Do developers on projects with CI give (more/similar/less) value to automated tests?
Do projects with CI have (higher/similar/lower) test quality?
Do projects with CI have (higher/similar/lower) code quality?
Are developers on projects with CI (more/similar/less) productive?



Observation

CI helps us catch errors before others see them

CI can run static and dynamic analysis



Static Validation

- Style guides
- Compiler warnings and errors
- Static analysis
  - FindBugs
  - clang-tidy
  - Pylons Webtest
- Code review

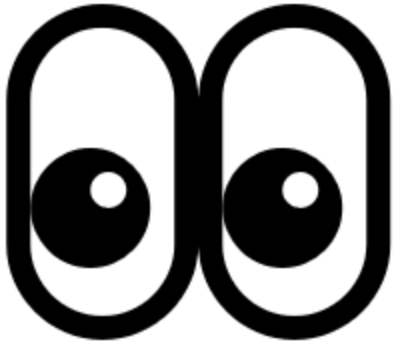
Style Guide

- List of environment-specific preferred practices
- Could include:
  - Libraries / idioms to use
  - Formatting

Style Guide Examples

- https://www.python.org/dev/peps/pep-0008/
- https://github.com/airbnb/javascript
- https://subversion.apache.org/docs/community-guide/conventions.html
- https://google.github.io/styleguide/cppguide.html
- https://google.github.io/styleguide/pyguide.html
- Linux kernel style guide

Who writes these style guides?



Who writes these style guides?

(*ad hoc* 🍑🤫) Self-proclaimed code protectors

(*wisdom*) Team veteran developers

(*copy-paste)* Google search for blog posts by experts

(*empirical study*) Evidence-based analysis of code styles that correlate with bugs

For problems we can’t easily automate, we can perform code review

Boeing Model 299 test on October 30, 1935.

- Plane crashed because of locked elevator control surface (opposite effect of MCAS)
- 4 engines were deemed “too complex”
- Test pilots developed checklists to help them fly

Checklists help manage complex processes

The Checklist: https://www.newyorker.com/magazine/2007/12/10/the-checklist

Dr. Peter Pronovost

- Inspired by B-17 Story
- After checklist, ten-day line-infection rate went from eleven per cent to zero
- In 15 months, only two line infections occurred
- For one hospital, the checklist had prevented forty-three infections and eight deaths, and saved $2M

The Pronovost Checklist

Central venous catheters, or lines, are used for medications, blood, fluids or nutrition and can stay in for days or weeks. But bacteria can grow in the line and spread a type of infection to the bloodstream, which causes death in one out five patients who contract it. This five-step checklist for doctors and nurses to use before inserting a line can prevent infections and death.

1. **Wash hands** with soap and water or an alcohol cleanser
2. **Wear sterile clothing**—a mask, gloves, and hair covering—and cover patient with a sterile drape, except for a very small hole where the line goes in
3. **Clean patient's skin** with chlorhexidine (a type of soap) when the line is put in
4. **Avoid veins in arm and leg,** which are more likely to get infected than veins in chest
5. **Check the line for infection** each day and remove when no longer needed

Source: Dr. Peter Pronovost

https://www.wsj.com/articles/SB10001424052748704364004576131963185893084

Difference between Pilot and Doctor error?

Which is Developer error more like?

How to create a checklist?

- Start with problems we have seen before
  - “Safety regulations are written in blood”
- Justify why this is not automatable
- Not all checklist items need to be very specific
  - An item could be “does this team know we are proposing this change”

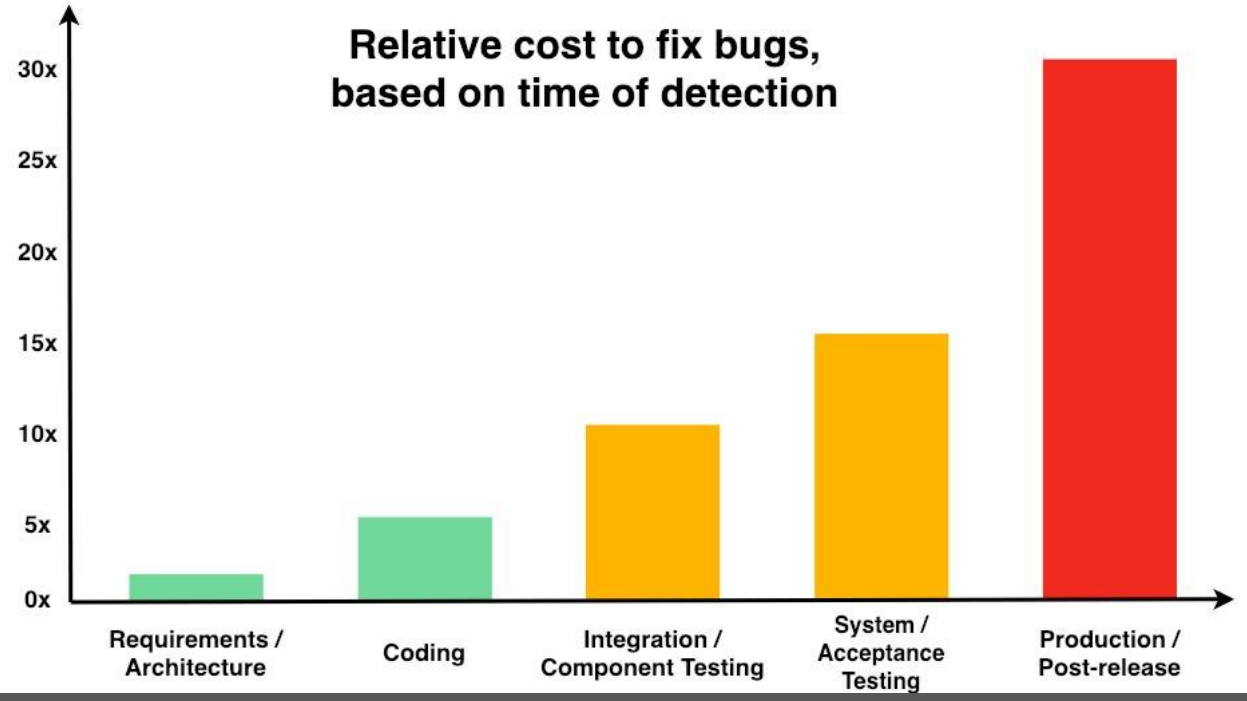
Activity: Create a checklist

- In pairs, think about dumb mistakes your “friend” made the last time they were coding.
  - Write your names on a piece of paper.
  - Write down two checklist items that would have caught those errors.
- Divide into teams: left and right sides of the classroom.
- Which team had the most unique/good entries in their list?

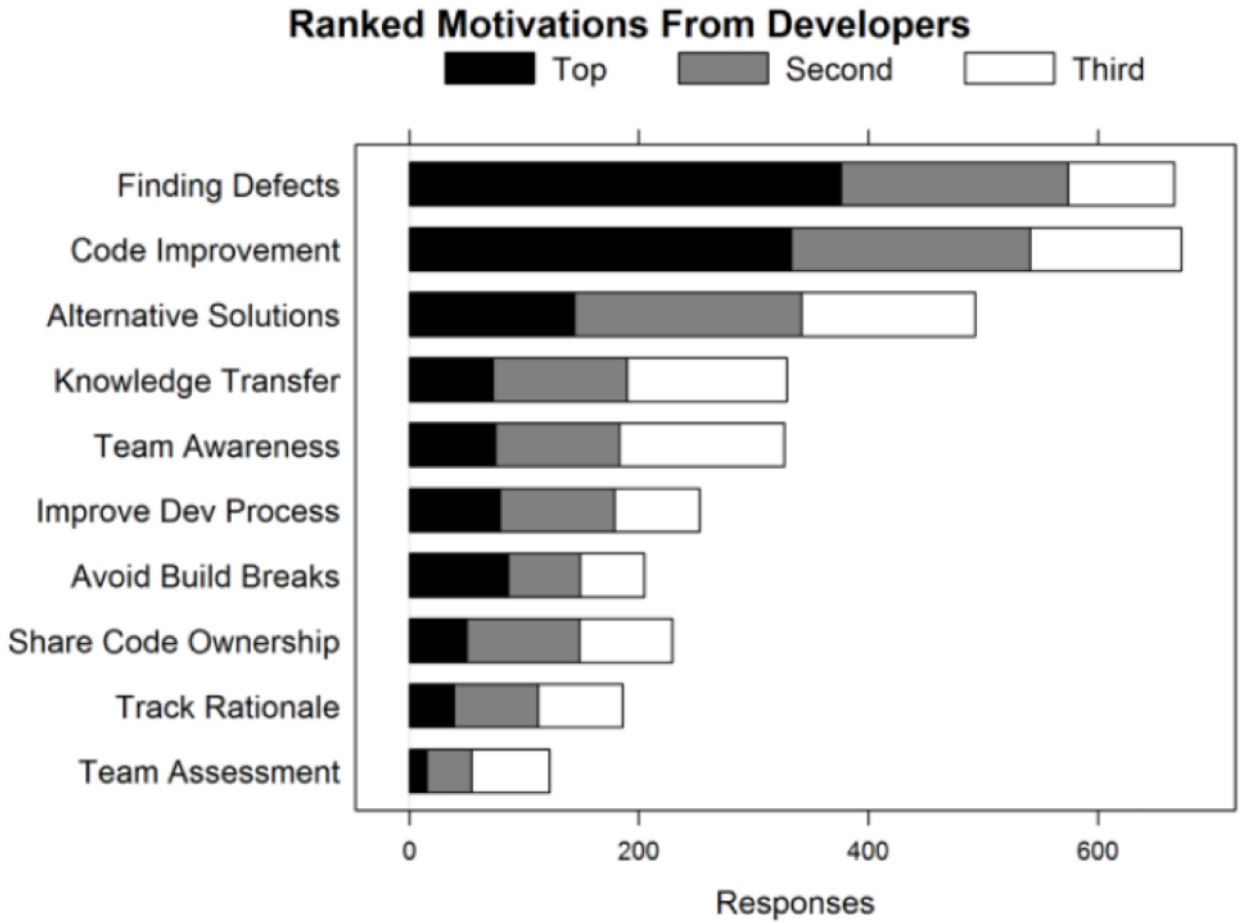
Expectations and Outcomes for code review

Motivation

- Linus's Law: "Given enough eyeballs, all bugs are shallow."
  - - The Cathedral and the Bazaar, Eric Raymond

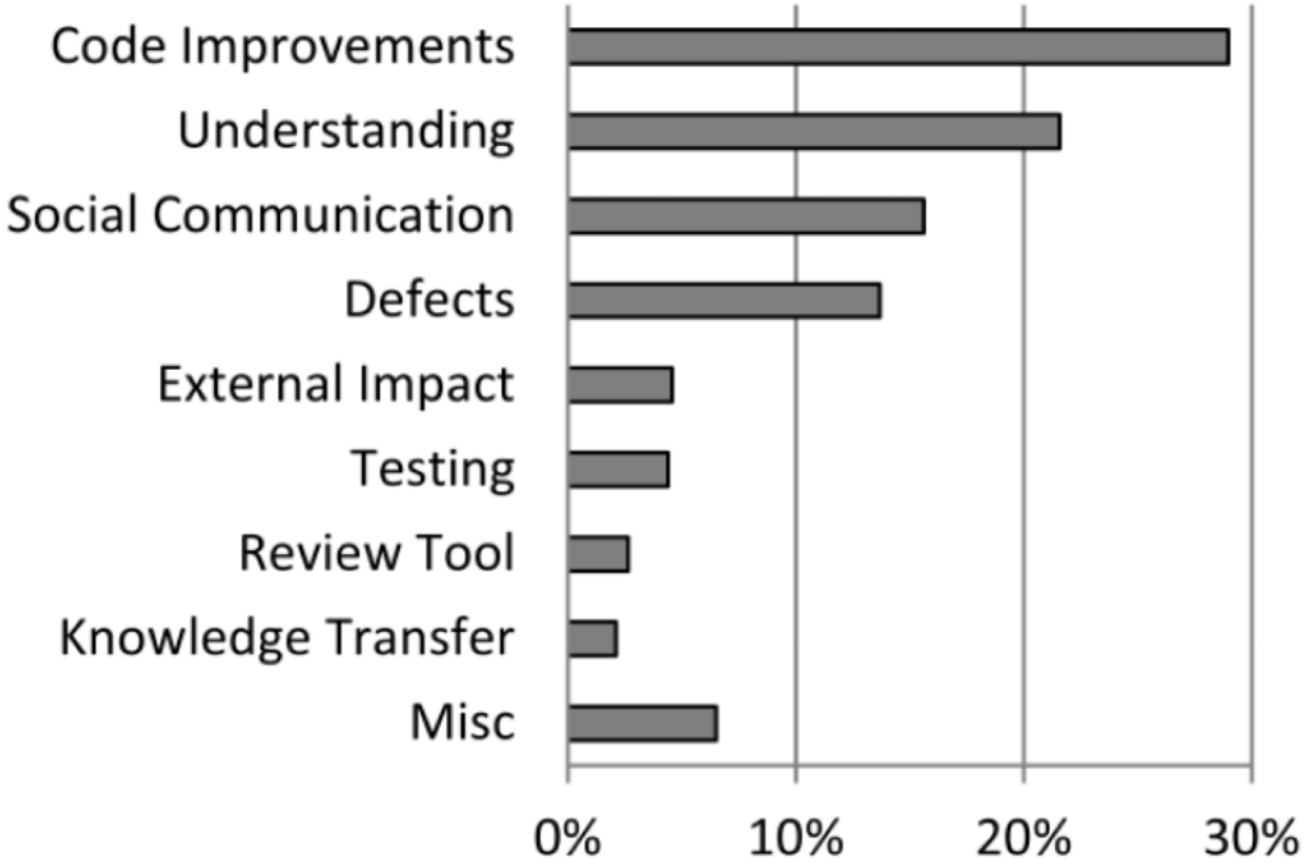


Code Review at Microsoft



Bacchelli, Alberto and Christian Bird. "Expectations, outcomes, and challenges of modern code review." Proceedings of the 2013 International Conference on Software Engineering. IEEE Press, 2013.

Outcomes (Analyzing Reviews)



Mismatch of Expectations and Outcomes

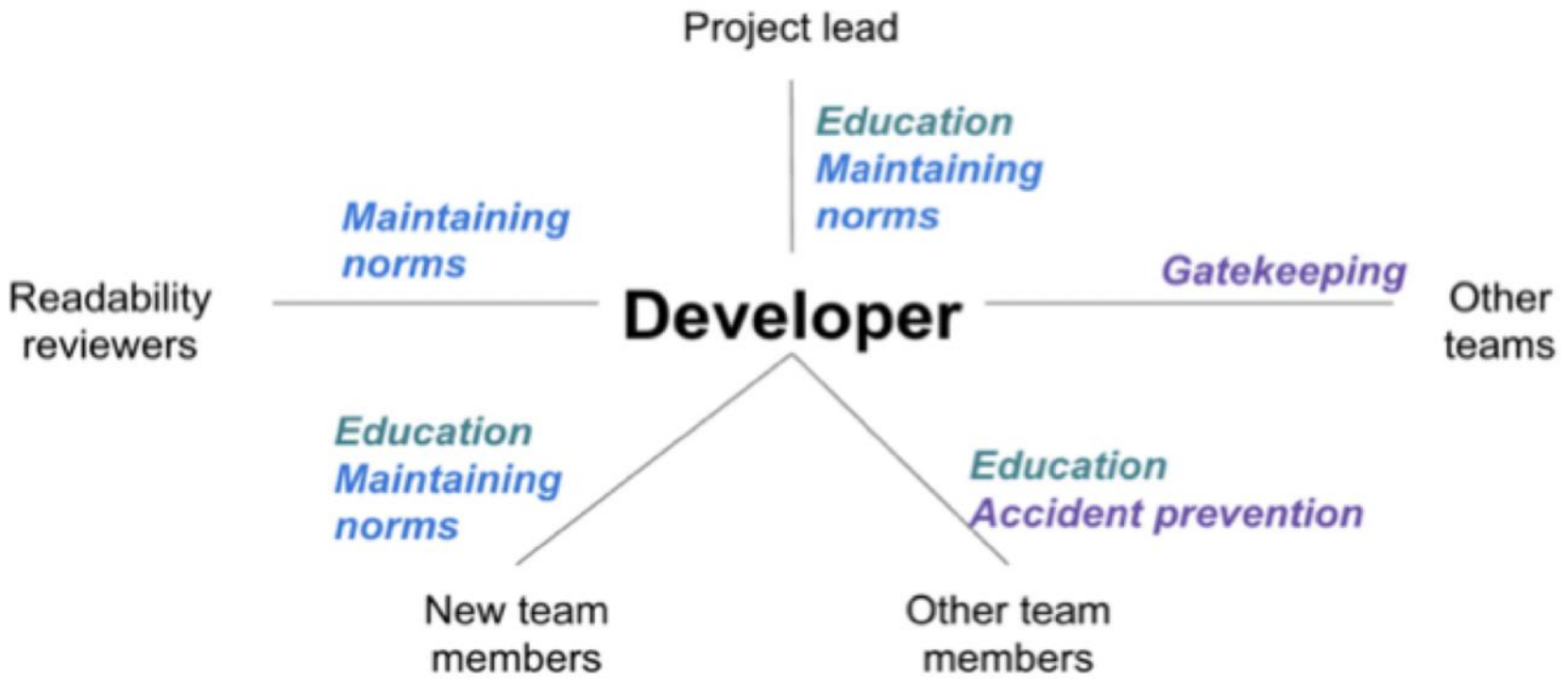
- Low quality of code reviews
  - Reviewers look for easy errors, as formatting issues
  - Miss serious errors
- Understanding is the main challenge
  - Understanding the reason for a change
  - Understanding the code and its context
  - Feedback channels to ask questions often needed
- No quality assurance on the outcome

Code Review at Google

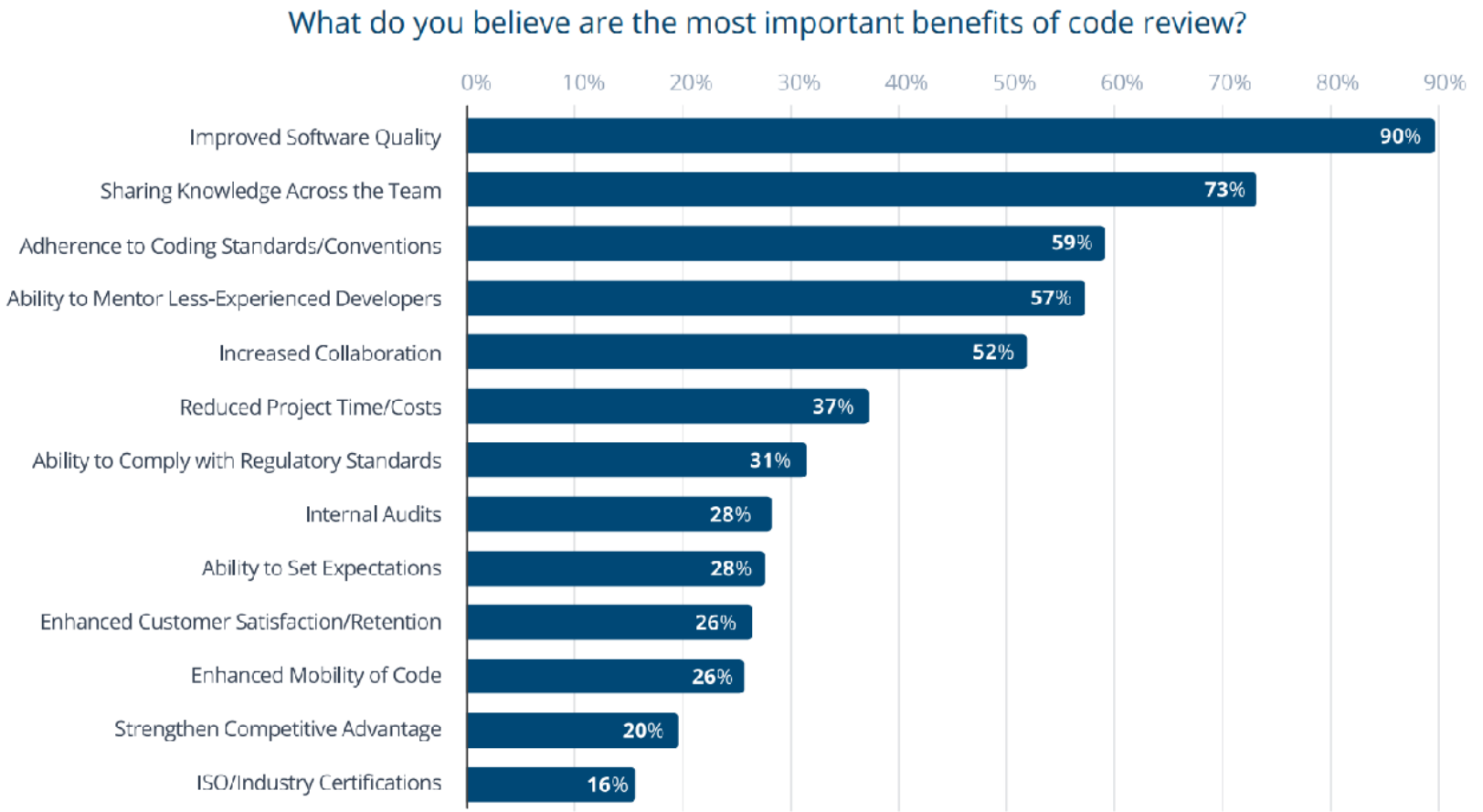
- Introduced to “force developers to write code that other developers could understand”
- Three benefits:
  - checking the consistency of style and design
  - ensuring adequate tests
  - improving security by making sure no single developer could commit arbitrary code without oversight

Caitlin Sadowski, Emma Söderberg, Luke Church, Michal Sipko, and Alberto Bacchelli. 2018. Modern Code Review: A Case Study at Google. International Conference on Software Engineering

Reviewing Relationships



The State of Code Review survey



n = 1129

Code Review

- Start with the “big ideas”
- Automate the little things
- Focus on understanding
- Remember a person wrote the code
- Don’t overwhelm the person with feedback

Don’t forget that coders are people with feelings

- A coder’s self-worth is in their artifacts
- CI can avoid embarrassment
- Identify defects, not alternatives; do not criticize coder
  - “*you* didn’t initialize variable a” -> “I don’t see where variable a is initialized”
- Avoid defending code; avoid discussions of solutions/alternatives
- Reviewers should not “show off” that they are better/smarter
- Avoid style discussions if there are no guidelines
- The coder gets to decide how to resolve fault

Risk Analysis:

- Probability a human makes a mistake: Very Likely
- Severity: ranges, but could be extensive

Solution:

Use CI to catch your mistakes, make you look better, and mitigate your risks!

Use Code review to teach and learn