https://github.com/margaretstorey/icse-MMR-TB-2025

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A Technical Briefing on Using Mixed Methods Research in Software Engineering

ICSE 2025, Ottawa

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Outline

Why mixed methods
Principles of Mixed Methods Research
MMR Design Landscape
Scenarios and Interactive Activity
Integration Strategies
Mixed Method Design Anti-Patterns (if time!)
Discussion and Wrap Up

3 | Why Mixed Methods

How it started…

How it's going…

EMSE To Appear

Guiding Principles for Mixed Methods Research in Software Engineering

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March 24, 2025

Abstract *Mixed methods research is often used in software engineering, but researchers outside of the social or human sciences often lack experience when using these designs. This paper provides guiding principles and advice on how to design mixed method research, and to encourage the intentional, rigorous, and innovative application of mixed methods in software engineering. It also presents key properties of core mixed method research designs. Through a number of fictitious but recognizable software engineering research scenarios, we showcase how to choose suitable mixed method designs and consider the inevitable trade-offs any design choice leads to. We describe several antipatterns that illustrate what to avoid in mixed method research, and when mixed method research should be considered over other approaches.*

Keywords Mixed methods · Research methods · Methodology · Guiding Principles · Guidelines

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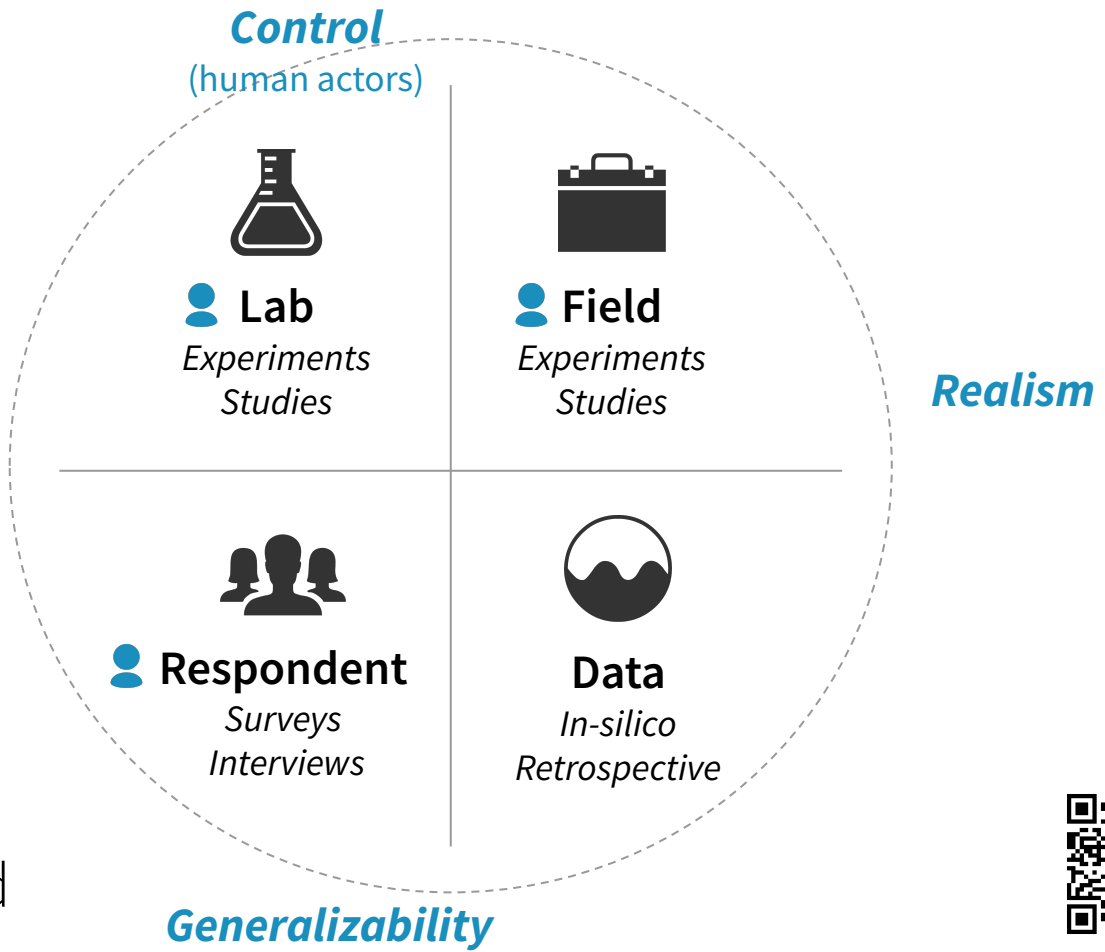
https://bit.ly/mmrse

Mixed methods research (MMR) is a research approach where multiple methods are used to collect, analyze, and integrate both qualitative and quantitative data to address a research problem and produce novel insights.

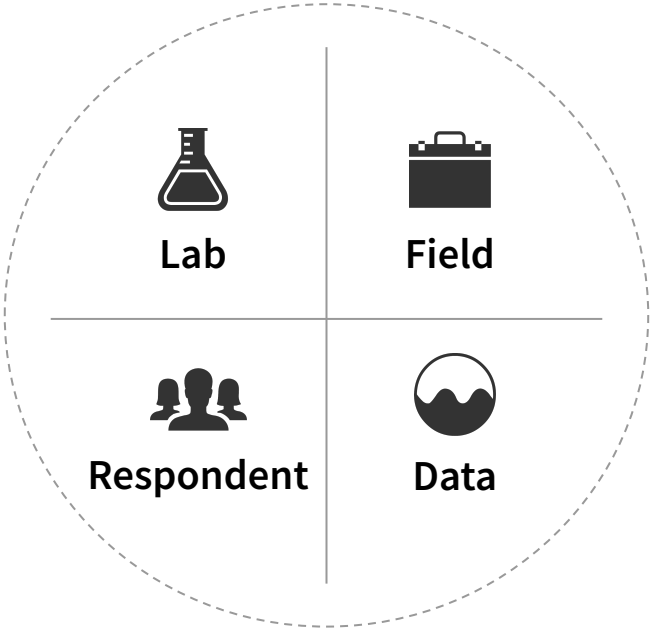
Why use Mixed Methods?



https://bit.ly/wwh-framework

- Human factors
- Hypotheticals
- Controlled

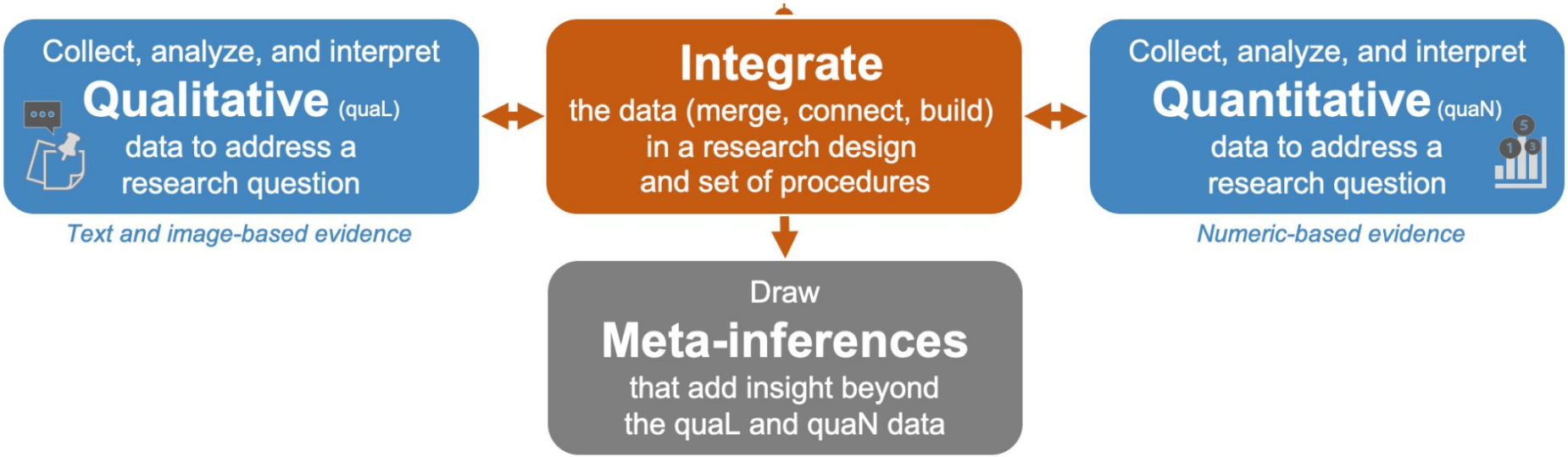
- Actionable
- Study adopters
- Non adopters



- Fast
- Quantitative
- Perceptive

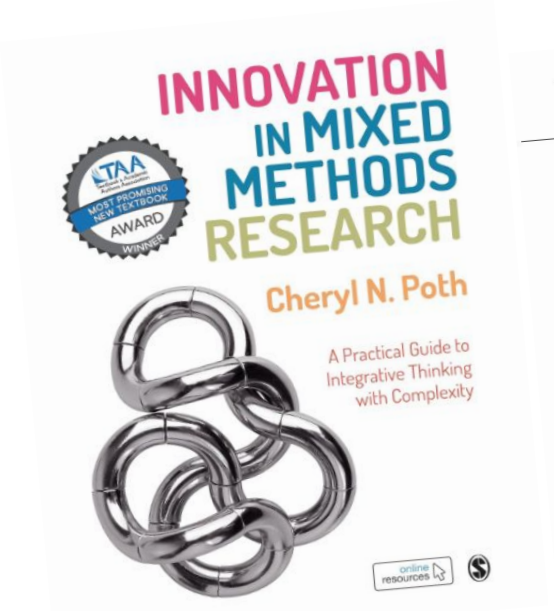
- Scalable
- Repeatable
- Unobtrusive

7 | Additional Benefits of Mixed Methods



The Importance of **Integration**

Related Research that has Inspired our Work



Bridging the Qualitative-Quantitative Divide: Guidelines for Conducting Mixed Methods Research in Information Systems

Venkatesh, V., Brown, S.A., and Bala, H. "Bridging the Qualitative-Quantitative Divide: Guidelines for Conducting Mixed Methods Research in Information Systems," MIS Quarterly (37:1), 2013, 21-54. https://doi.org/10.25300/MISQ/2013/37.1.02

67 Pages • Posted: 25 Apr 2022

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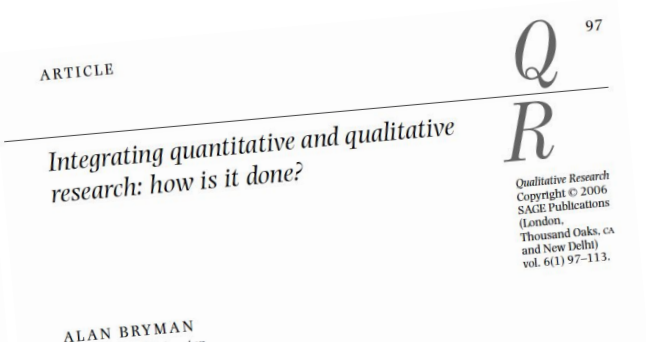
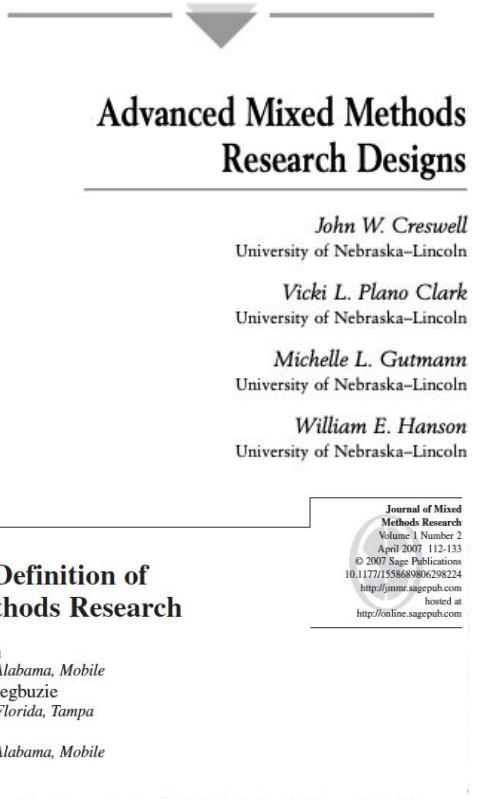
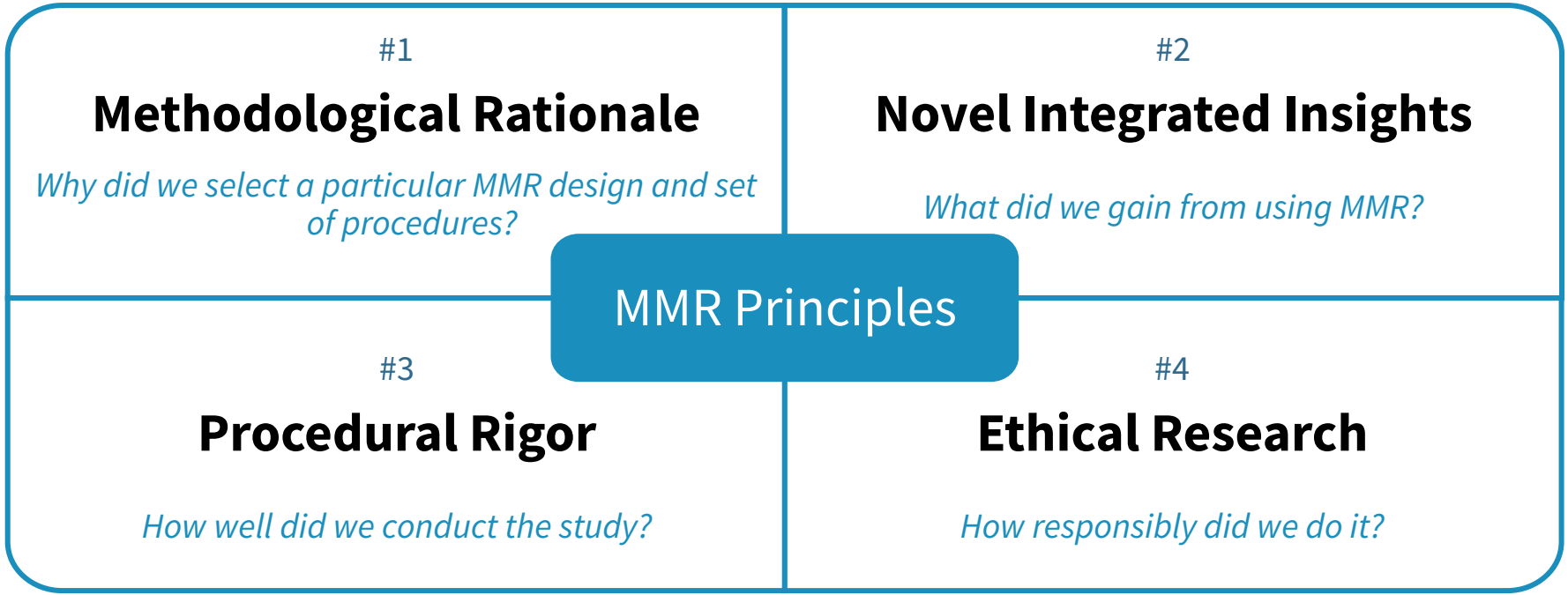
Date Written: March 17, 2013





10 | Guiding Principles of Mixed Method Research



Inspired by Poth, Ladner, Creswell and Plano Clark

#1 **Methodological Rationale** ***Why did we select a particular MMR design and set of procedures?***	#2 Novel Integrated Insights *What did we gain from using MMR?*
#3 Procedural Rigor *How well did we conduct the study?*	#4 Ethical Research *How responsibly did we do it?*

Inspired by Poth, Ladner, Creswell and Plano Clark

MMR study designs **explain** how the mixed research design and data methods are relevant for addressing a given **research problem**

"why did we select a particular MMR research design and set of strategies?"

Some key methodological rationales:

- **Complementarity:** to confirm or enhance insights of another strategy
- **Expansion:** to ask different questions not apparent up front or emerged
- **Development:** to inform or improve another strategy
- **Credibility:** to increase integrity and truth findings from a former strategy
- **Explanation:** to resolve contradictory, surprising or inconclusive findings

Principle of Methodological Rationale

#1 Methodological Rationale *Why did we select a particular MMR design and set of procedures?*	**#2** **Novel Integrated Insights** ***What did we gain from using MMR?***
#3 Procedural Rigor *How well did we conduct the study?*	#4 Ethical Research *How responsibly did we do it?*

Inspired by Poth, Ladner, Creswell and Plano Clark

MMR studies generate **new insights** through the **integration** of the strategies

"what did we gain from using MMR?"

- Improved problem understanding
- Greater depth and breadth
- Explaining unexpected results
- Complementary storytelling
- Flexible novel designs
- Interdisciplinary research findings
- Translational findings

Principle of Novel Insights

#1 Methodological Rationale *Why did we select a particular MMR design and set of procedures?*	#2 Novel Integrated Insights *What did we gain from using MMR?*
#3 **Procedural Rigor** ***How well did we conduct the study?***	#4 Ethical Research *How responsibly did we do it?*

Inspired by Poth, Ladner, Creswell and Plano Clark

MMR studies **apply** the study methods **rigorously** and **explain** them **effectively**

"how well did we conduct the study?"

- Is the use of MMR justified (methodological rationale)?
- Are the methods effectively integrated to answer the RQs?
- Are the findings from the mixed methods integrated?
- Are the different methods used rigorously conducted?

Principle of Procedural Rigor

#1 Methodological Rationale *Why did we select a particular MMR design and set of procedures?*	#2 Novel Integrated Insights *What did we gain from using MMR?*
#3 Procedural Rigor *How well did we conduct the study?*	**#4** **Ethical Research** ***How responsibly did we do it?***

Inspired by Poth, Ladner, Creswell and Plano Clark

MMR studies manifest the application of **responsible research**, with respect for **people** (e.g., participants, beneficiaries) and their **welfare** (e.g., respect for their confidentiality, privacy, time, emotions, culture, and needs) and that of the **environment** (e.g. organizations, communities of practice, society).

"how responsibly did we do it?"

- **Considering the why**: starts by carefully considering the why
- **Privacy and confidentiality:** More care if multiple sources collected from the same participant
- **Respect and cultural sensitivity:** improve awareness, customise
- **Safety and welfare:** consider the risks, get relevant training

Principle of Ethical Research

MMR Design Landscape


Landscape of MMR Design
Design Properties
Planned or Emergent
Timing (Sequential or Concurrent)

An MMR design can be either

- **Planned** - structured upfront based on the research problem or question
- **Emergent** - evolves organically throughout the study

Implementation process focusing on **when quaL** and **quaN data collection** occurs

- **Sequential** - conducting first one quaL/quaN method and then the other quaL/quaN
- **Parallel** - conducting the two quaL/quaN methods at the same time

Landscape of MMR Design

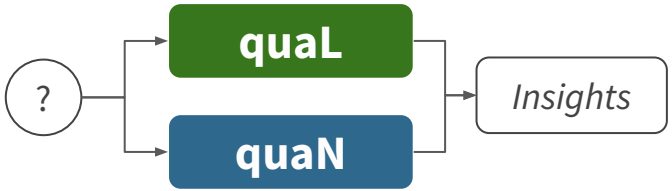
Research Designs

- ❑ Exploratory Sequential
- ❑ Explanatory Sequential
- ❑ Convergent Parallel
- ❑ Embedded

Exploratory Sequential

Explanatory Sequential

Convergent Parallel



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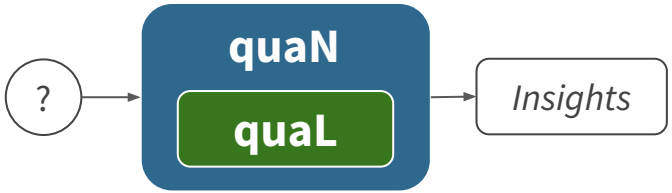
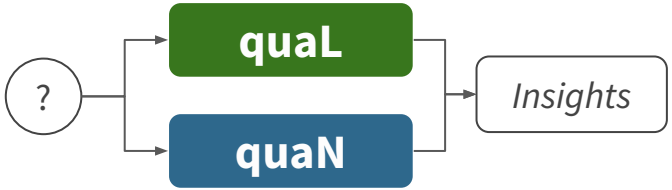


Exploratory Sequential

Explanatory Sequential

Convergent Parallel



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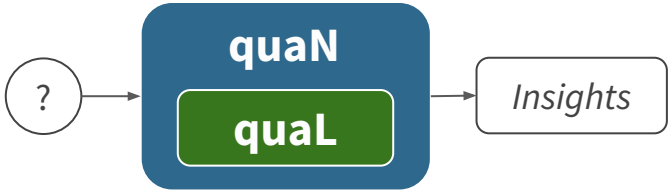


Scenarios and Sample Mixed Method Research Designs

Context: Ali (he/him), a postdoc collaborating with **industry** partner studying rollout of a **new security compliance tool** at a large software company

Problem: While the tool is designed to improve secure coding practices, it may also affect developers' ***perceived productivity*** and ***overall experience*** — in both expected and unexpected ways

Research Goal: To explore the tool's impact on developers in their real work context and determine if these experiences are shared more **broadly** across the organization

Research Question:

👉 *How does a security compliance-enforcing development tool impact developer perceived productivity and experience?*

Gap Identified: Little research exists on how developers perceive these types of tools

Design: Ali uses an **exploratory sequential mixed methods** approach:

1. **Qualitative interviews** (~20 developers) to explore impacts inductively
2. **Quantitative survey** to validate and generalize findings across the organization

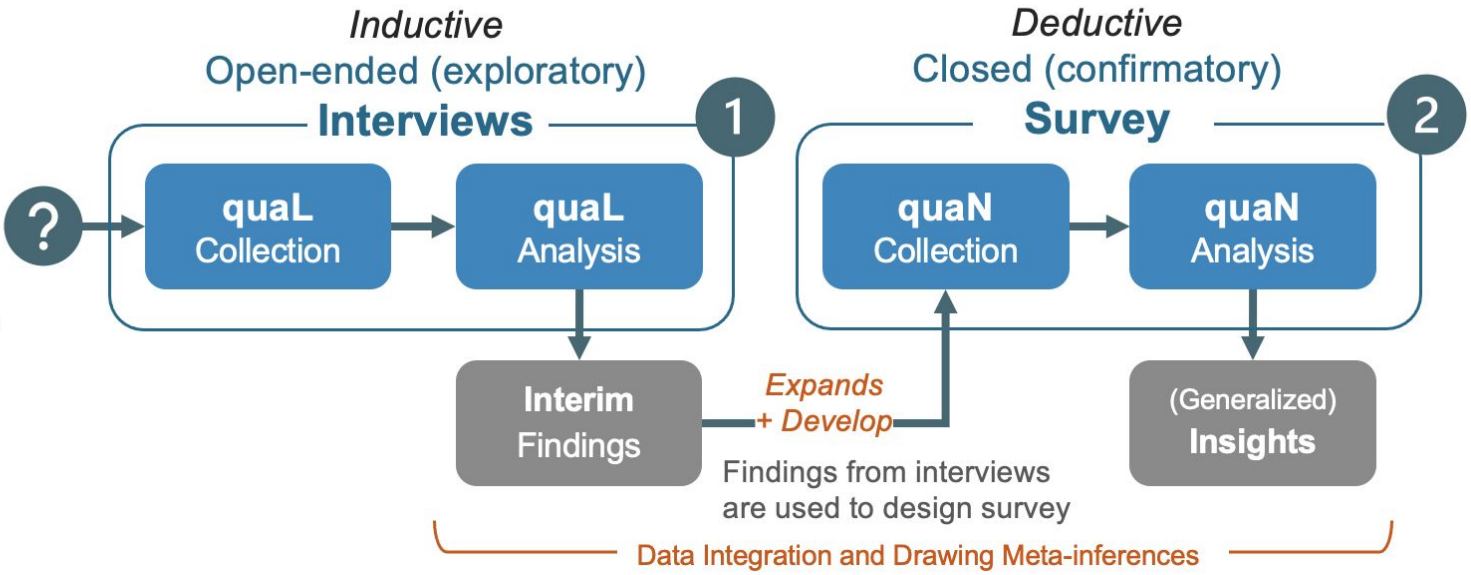
Why Mixed Methods?

- To uncover both anticipated and unanticipated effects
- To ensure insights are grounded in real developer experiences
- To scale findings across the company

Ali

Exploratory Sequential Design

Research Question:
How does using a tool to enforce compliance with security practices impact perceived developer productivity?



Activity!

Activity 1: Sam

Context: Sam (they, them) an early-stage Ph.D. student

Area: large software company

Research Goal: to study the adoption of a Generative AI tool to automate the code review process

Research Hypothesis:
👉 New GenAI tool that automates the code review process *will improve* the ***time to merge of code changes*** and improve the ***quality of the reviewed code*** (by reducing the number of bugs in the newly committed code)

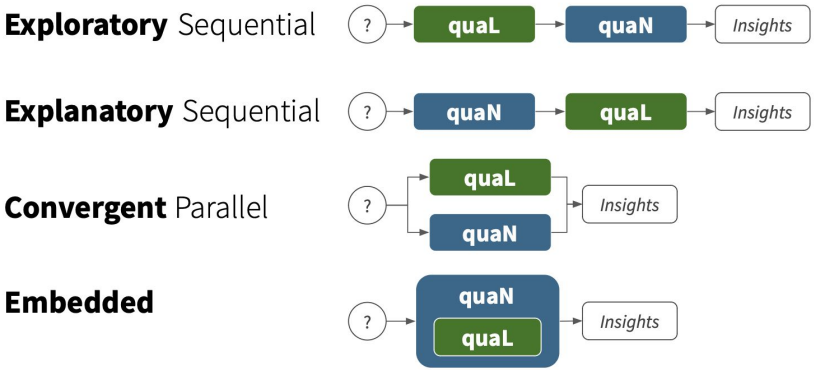
~8 mins

Activity Instructions :

- Form groups of 3-5 people and…

- Create a *mixed methods study* to address the scenario on the left
- Describe the *research strategies* for data collection and analysis you might use
- Identify the mixed methods **design** you choose

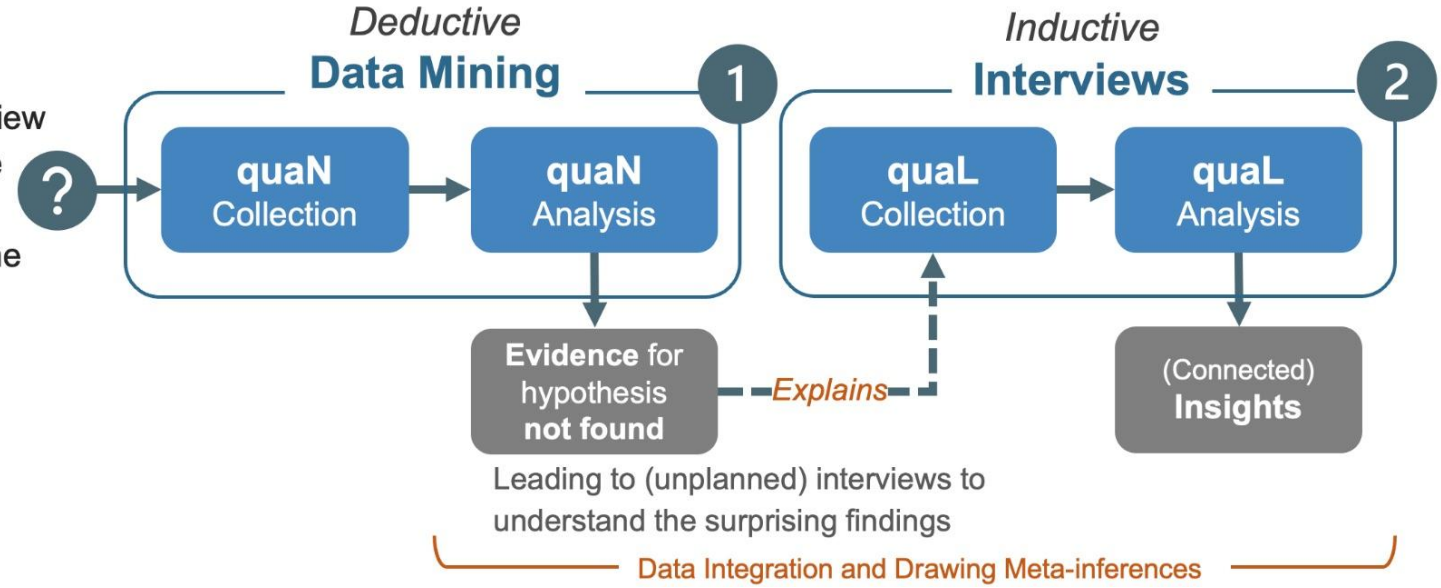
Mixed Methods Designs



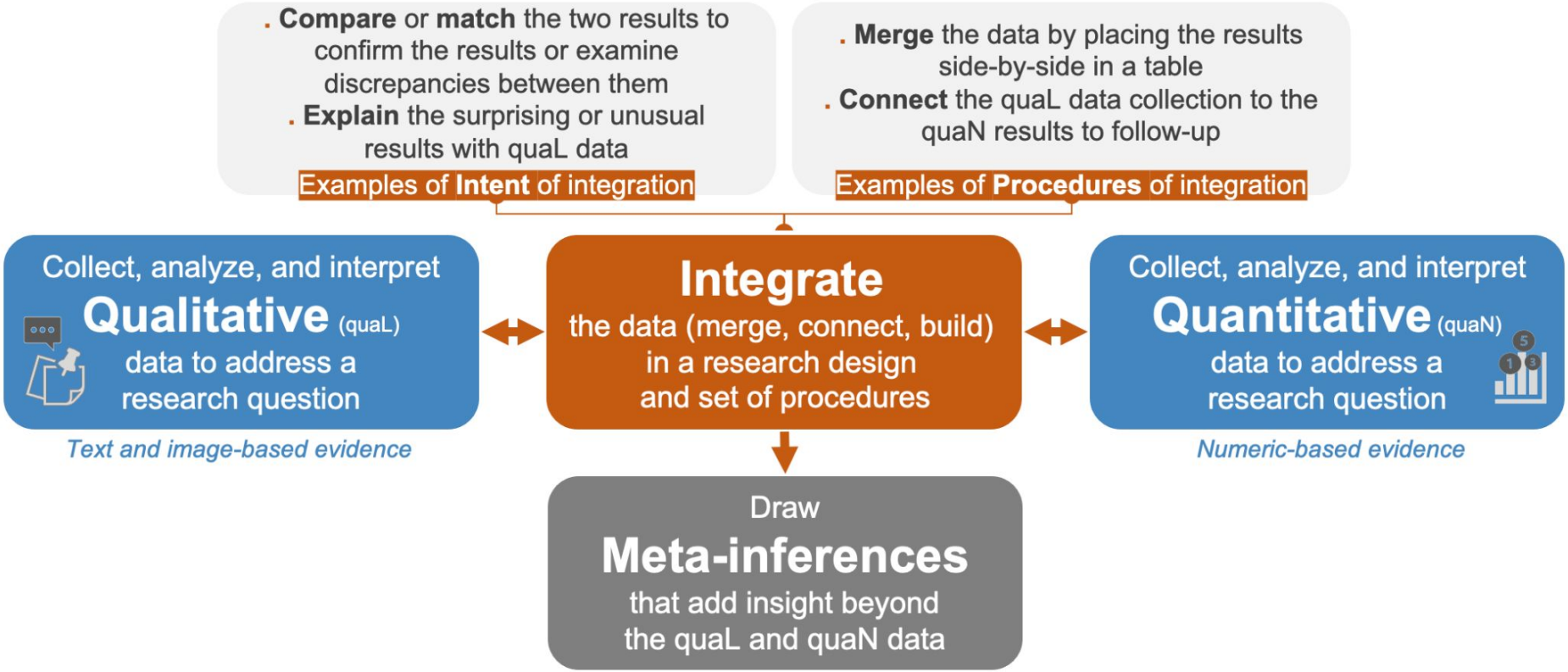
Sam

Explanatory Sequential Design

(Initial) **Hypothesis**:
New GenAI tool that automates the code review process will improve the time to merge of code changes and improve the quality of the reviewed code (by reducing the number of bugs in the newly committed code)



35 | **Integration**


. Compare or match the two results to confirm the results or examine discrepancies between them
. Explain the surprising or unusual results with quaL data
Examples of Intent of integration
. Merge the data by placing the results side-by-side in a table
. Connect the quaL data collection to the quaN results to follow-up
Examples of Procedures of integration
Collect, analyze, and interpret
Qualitative (quaL)
data to address a research question
Text and image-based evidence
Integrate
the data (merge, connect, build) in a research design and set of procedures
Collect, analyze, and interpret
Quantitative (quaN)
data to address a research question
Numeric-based evidence
Draw
Meta-inferences
that add insight beyond the quaL and quaN data

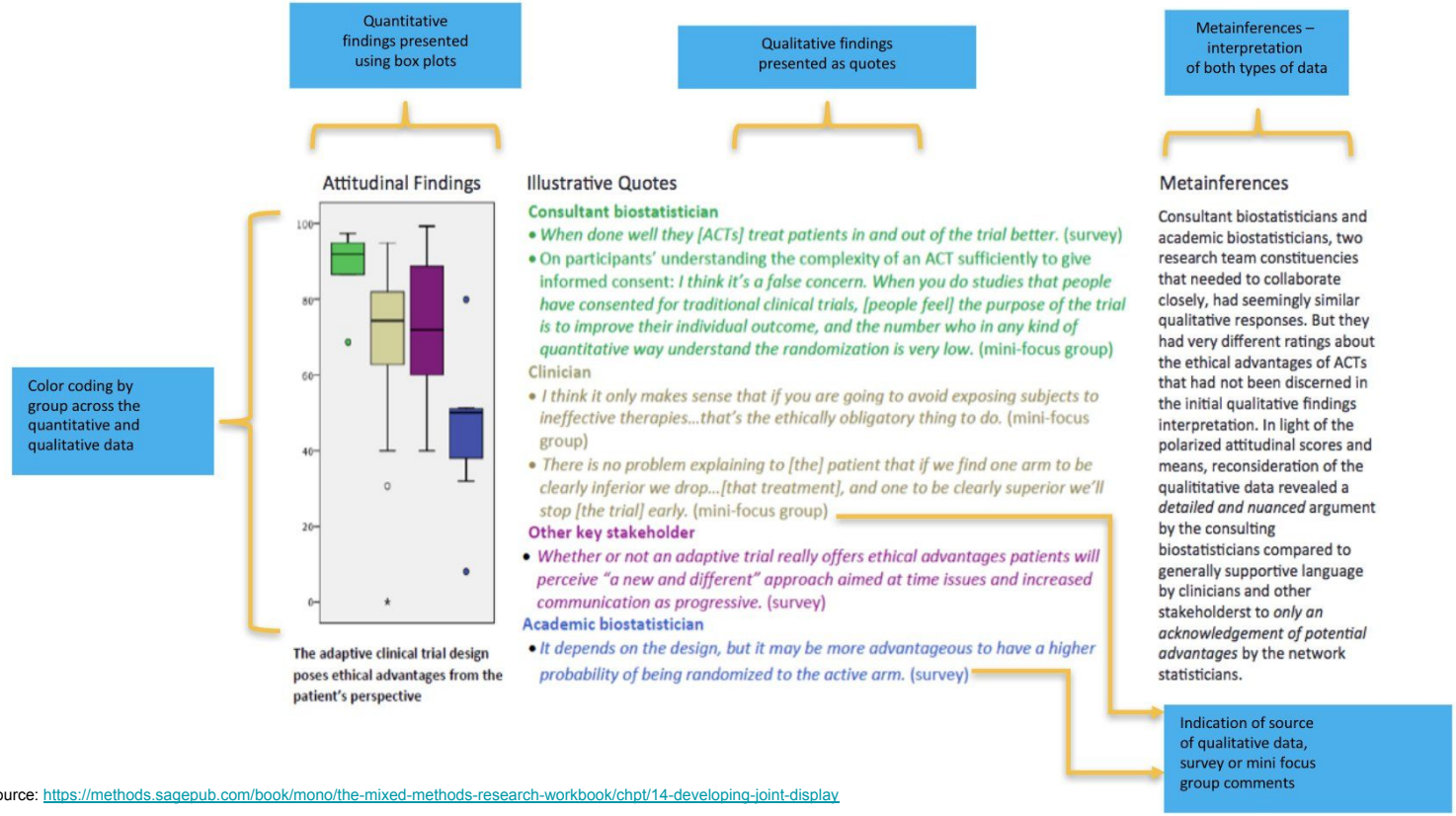
Landscape of MMR Design

Integration Strategies

- ❑ Sequential integration
- ❑ Results-based integration
- ❑ Data-based integration
- ❑ Transformation-based integration

- **Sequential Integration**
  - One method's results inform the next (e.g., quaN → quaL design decisions)
- **Data-Based Integration**
  - Simultaneous analysis of linked quaL/quaN data
  - Requires common underlying source; enables case-level connections
- **Results-Based Integration**
  - Findings combined only *after* separate analyses
  - Focused on synthesizing insights from both quaL and quaN methods
- **Transformation-Based Integration**
  - Converting data between types (quaL↔quaN)
  - Enables unified analysis within a single data paradigm

Integration Strategies - **Four Types of Integration** (Kuckartz & Rädiker)



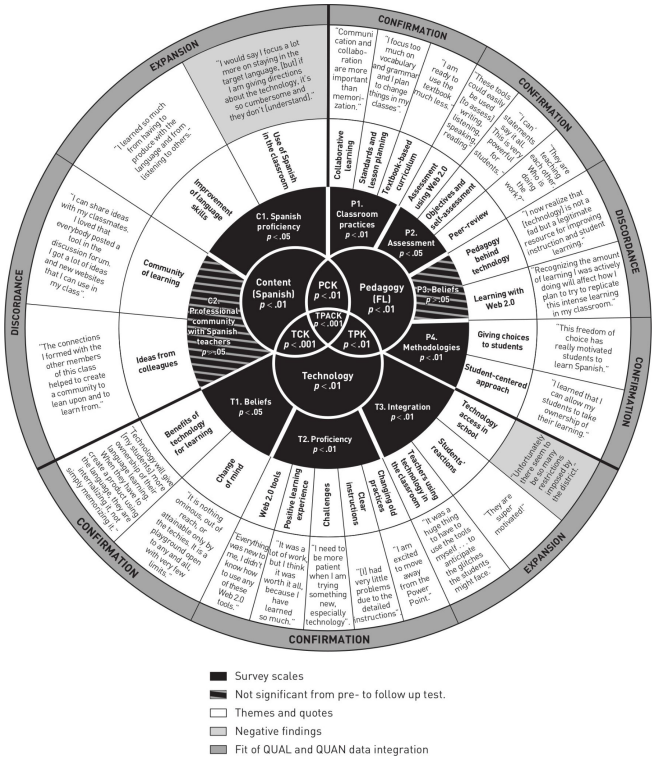
Source: https://methods.sagepub.com/book/mono/the-mixed-methods-research-workbook/chpt/14-developing-joint-display

Representing Integration through a **Joint Display**

WOS[1] Component	Qualitative Findings: Implementation Driver(s)	Qualitative Findings: Implementation Challenges/Enablers	Quantitative Findings (N = 22 Schools): Percentage of schools with low (red), medium (yellow), and high (green) implementation levels[2]
Physical Education	State policy	Time Resources Competing priorities	31.8% / 13.6% / 54.6%
Recess	District Policy	Enforcement Competing priorities Staff buy-in	18.2% / 9.1% / 72.7%
Classroom-Based Approaches	Teachers and School Leaders	Teacher buy-in Leadership support Time Resources	Brain Breaks: 54.6% / 40.9% / 4.5% Motorlabs: 95.5% / 4.5%
Before School, After School, and Active Transport	School Leaders, Teachers, Staff, Parents, Community Partnerships	Funding Partnerships Staffing/volunteers	Before School[3]: 62% / 14% / 24% After School: 27.3% / 72.7% Active Transport: 32% / 41% / 27%

1. WOS stands for Whole-of-School; 2. PE (min/week) [low <135, medium = 137.5 – offered every two weeks on an alternating schedule, high ≥135], Recess (min/week) [low <100, medium = 100-149, high ≥ 150]; 3. Missing data from one school.

Source: https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2023.1193442/full



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Representing Integration through a **Joint Display**

Mixed Method Research Anti-Patterns

Party crasher: A method makes an unexpected entrance later in the paper

Smoke and mirrors: When one approach offers a token contribution

Limitation shirker: Failure to discuss limitations from all methods used

Missing the mark: Misalignment with the research question/objective

Selling your soul: Employing an additional method to appeal to reviewer

Sample contamination: (Unintentional) same participants across methods

Lost opportunity: Failure to use initial findings for a follow-up instrument

Integration failure: Poor integration of findings from all methods used

Questionable ethics: Questionable aims or impacts on humans

Activity!

Activity 2: Vicki

~8 mins

Context: Vicki (she/her) experienced industry researcher

Area: software company

Research Goal: to understand the adoption of a new onboarding process to address the retention of new contributors to an open source project

Research Question:
👉 How does adopting a new onboarding process address the retention of new contributors to an open source project?

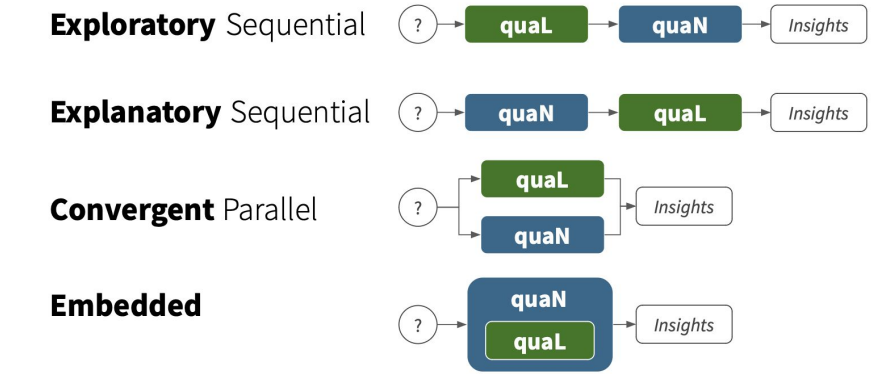
Note: The onboarding process foresees that experienced and novel developers pair on work items, asynchronously communicating over Slack.

Activity Instructions :

- Form groups of 3-5 people and…

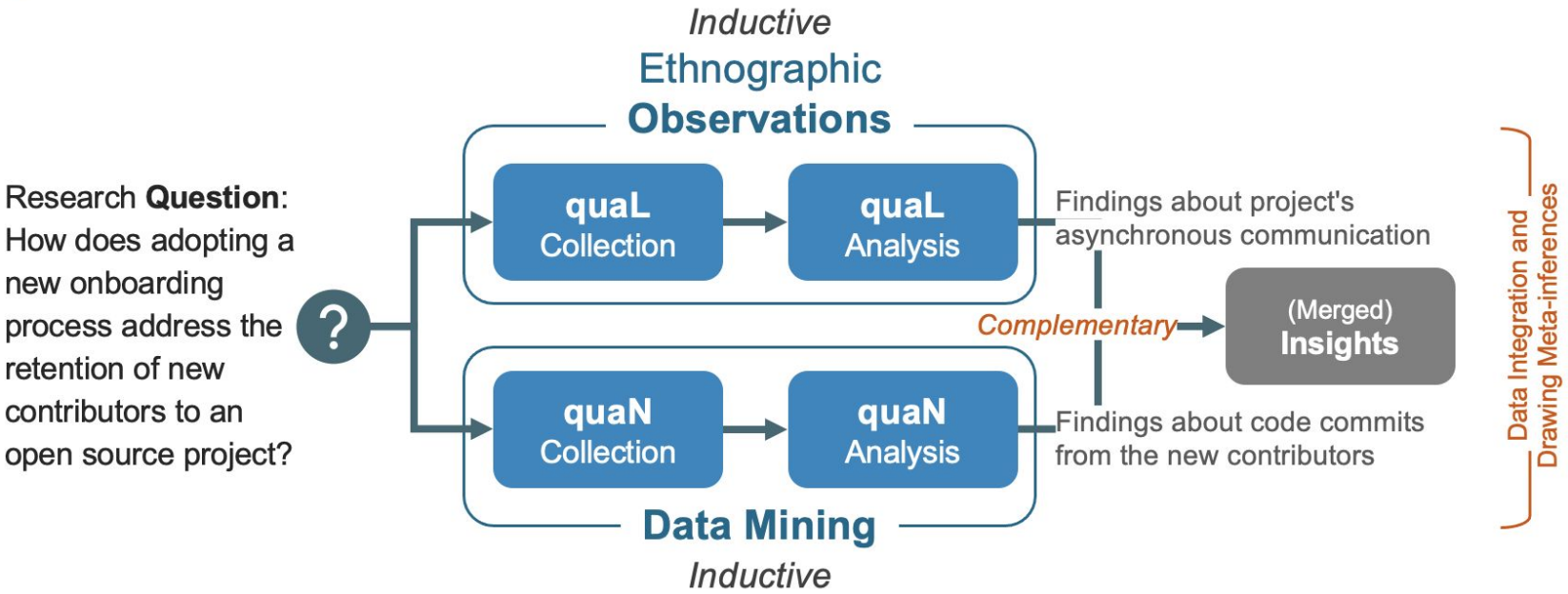
- Create a mixed methods study to address the scenario on the left
- Describe the research strategies for data collection and analysis you might use
- Identify the mixed methods **design** you choose

Mixed Methods Designs



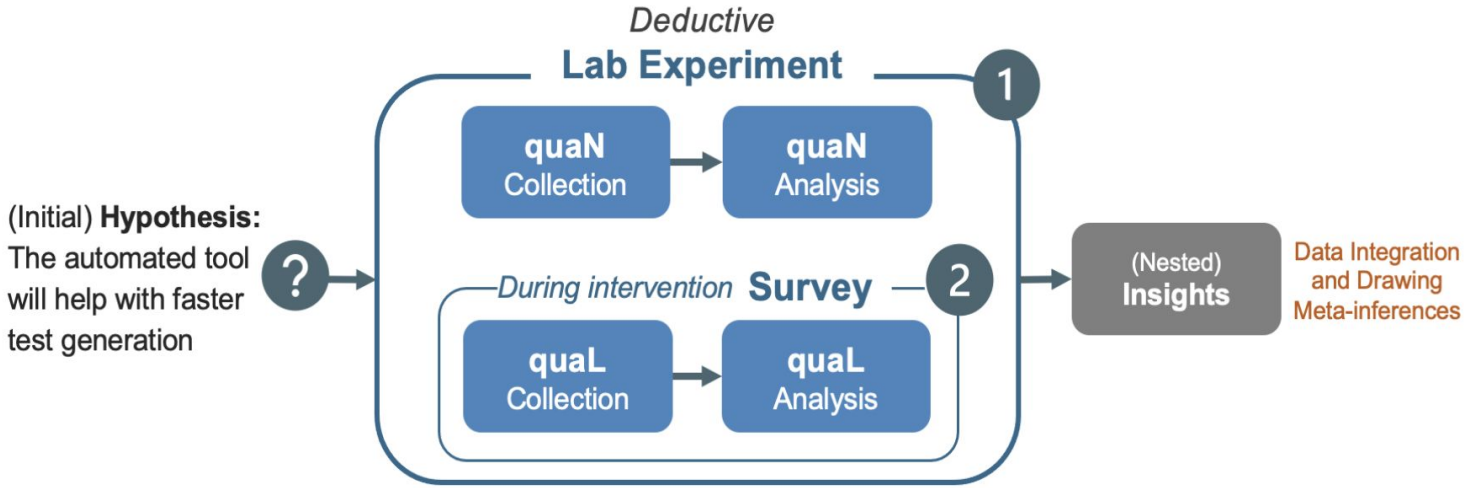
Vicki

Convergent Parallel Design



Activity 3: Zara

WHAT DESIGN HAS ZARA USED?



Context: Zara(she/her) PhD student

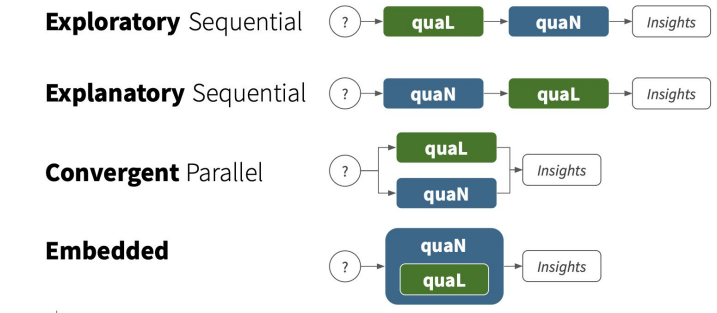
Area: automated tool for generating tests

Research Goal: to investigate how effective an automated tool she designed is for generating tests

Research Question:

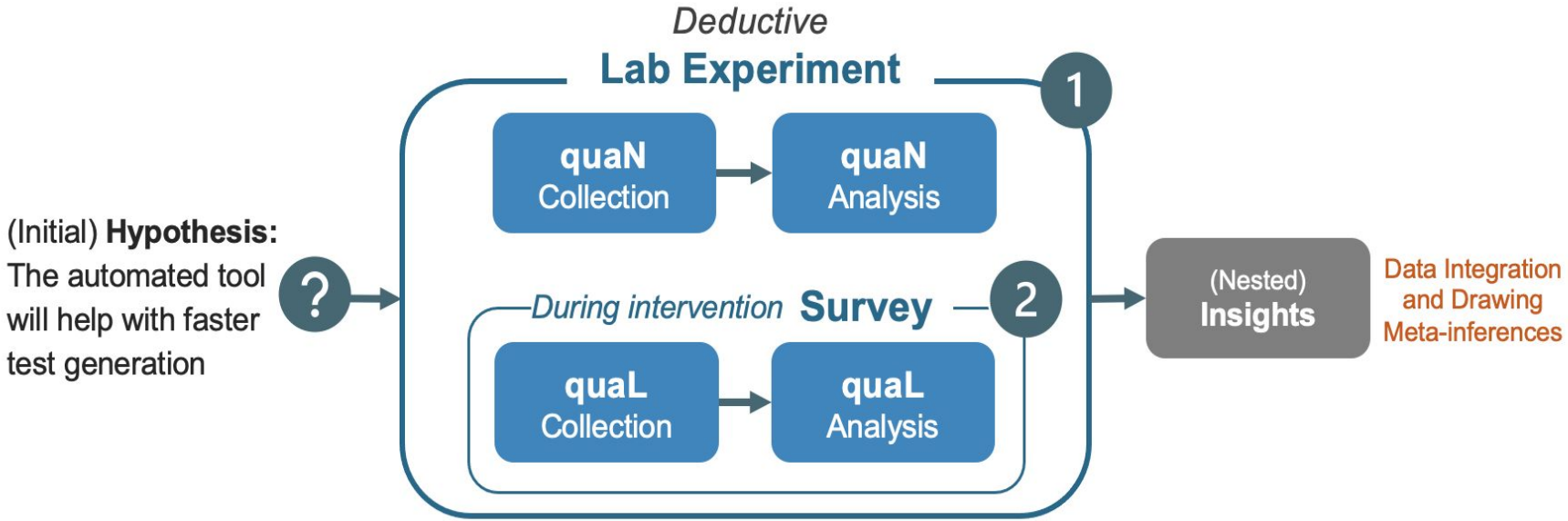
👉 *Will the software tool lead to faster test generation when used by senior computer science students?*

Mixed Methods Designs



Zara

Embedded Design



#1
Methodological Rationale
Why did we select a particular MMR design and set of procedures?

#2
Novel Integrated Insights
What did we gain from using MMR?

MMR Principles

#3
Procedural Rigor
How well did we conduct the study?

#4
Ethical Research
How responsibly did we do it?

Mixed Methods Designs

Exploratory Sequential — ? → quaL → quaN → *Insights*

Explanatory Sequential — ? → quaN → quaL → *Insights*

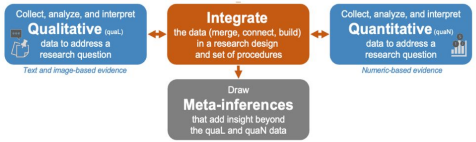
Convergent Parallel — ? → quaL, quaN → *Insights*

Embedded — ? → quaN (quaL) → *Insights*

Wrap-up and Questions

Mixed Methods Research Definition

Mixed methods research (**MMR**) is a research approach where multiple methods are used to collect, analyze, and **integrate both qualitative** and **quantitative** data to address a research problem and **produce novel insights**.



Landscape of MMR Design

Design Properties
- ❑ Research Questions
- ❑ Planned or Emergent
- ❑ Inductive or Deductive Dominance
- ❑ Timing (Sequential or Concurrent)

Integration Strategies
- ❑ Sequential integration
- ❑ Results-based integration
- ❑ Data-based integration
- ❑ Transformation-based integration

Research Designs
- ❑ Exploratory Sequential
- ❑ Explanatory Sequential
- ❑ Convergent Parallel
- ❑ Embedded

Principles to Guide MMR in SE

1 Methodological Rationale

Why did we select a particular MMR research design and set of procedures?
- ❑ Complementarity
- ❑ Expansion
- ❑ Development
- ❑ Triangulation
- ❑ Credibility
- ❑ Explanation
- ❑ Increased design flexibility

2 Novel Integrated Insights

What did we gain from using MMR?
- ❑ Improved problem understanding
- ❑ Greater depth and breadth
- ❑ Explaining unexpected results
- ❑ Complementary storytelling

3 Procedural Rigor

How well did we conduct the study?
- ❑ Is the use of mixed methods justified?
- ❑ Are the methods effectively integrated to answer the RQs?
- ❑ Are the findings from the mixed methods integrated?
- ❑ Are the different methods used rigorously conducted?

4 Ethical Research

How responsibly did we do it?
- ❑ Considering the why
- ❑ Privacy and confidentiality
- ❑ Respect and cultural sensitivity
- ❑ Safety and welfare

Antipatterns of MMR Designs

Presentation Antipatterns
- ❑ Uninvited guest or party crasher
- ❑ Smoke and mirrors
- ❑ Limitation shirker

Study Design Antipatterns
- ❑ Missing the mark
- ❑ Selling your soul
- ❑ Cargo cult research
- ❑ Sample contamination
- ❑ Lost opportunity
- ❑ Integration failure
- ❑ Questionable ethics

Paper: https://bit.ly/mmrse