

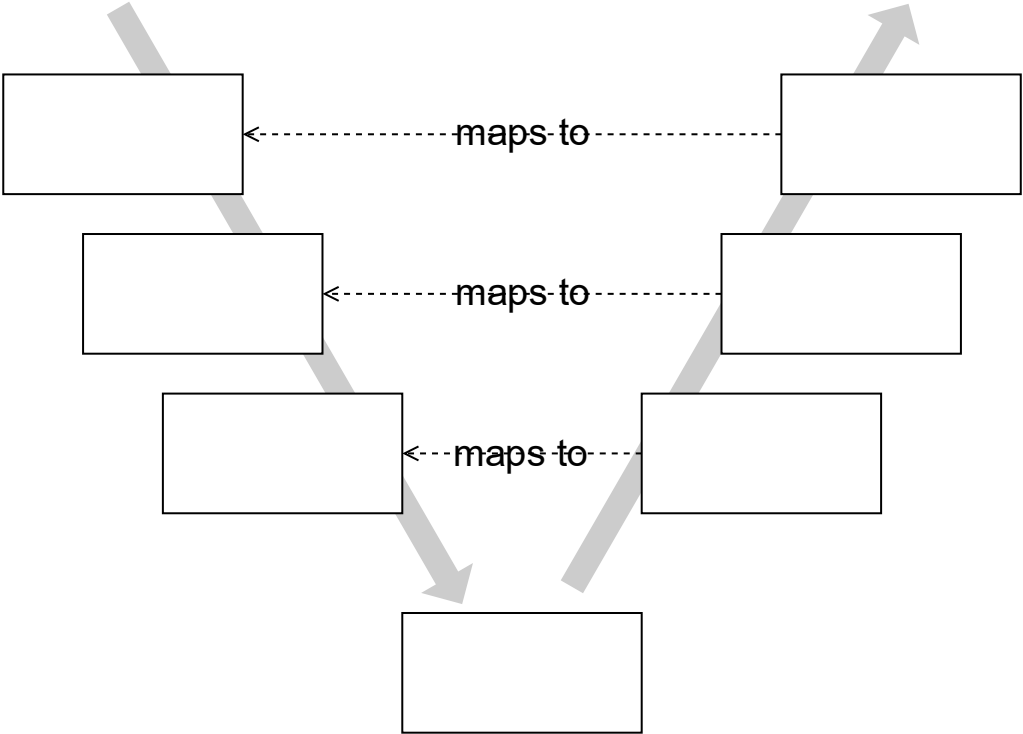
Companion material of the chapter “Experiences in Using the V-Model as a Framework for Applied Doctoral Research”
from the book “Handbook on Teaching Empirical Software Engineering”

The V-Model as a framework for applied research in ESE

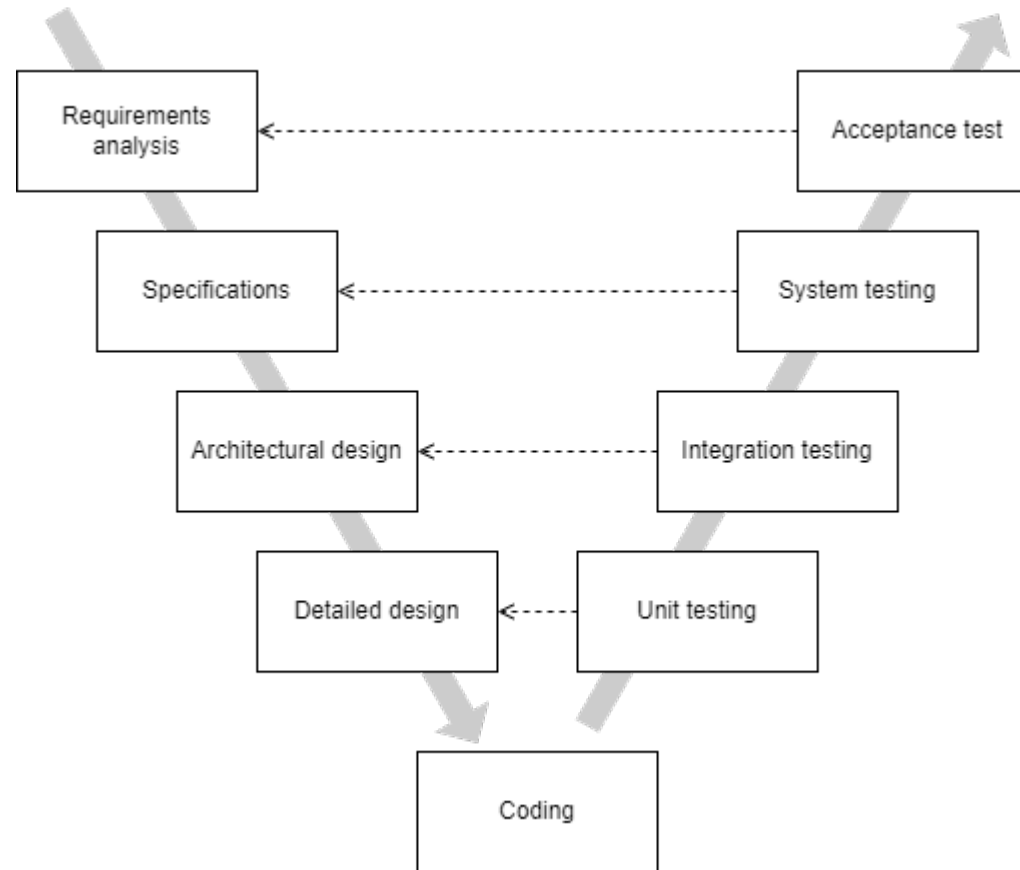
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Prof. Dr. Dr. h.c. Dieter Rombach (Professor Emeritus RPTU Kaiserslautern)

The V-Model is a conceptual model that organize elements in a “V-shape”

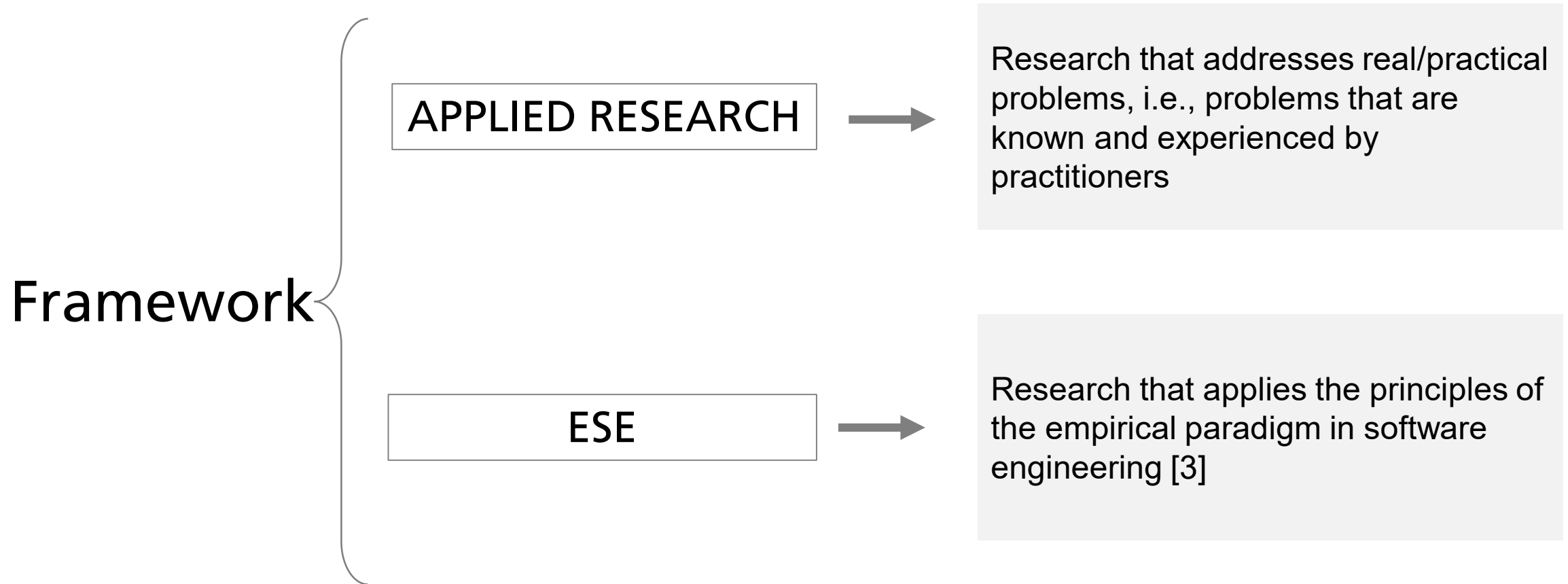


Historically, the V-Model was introduced as a “process model” [1]

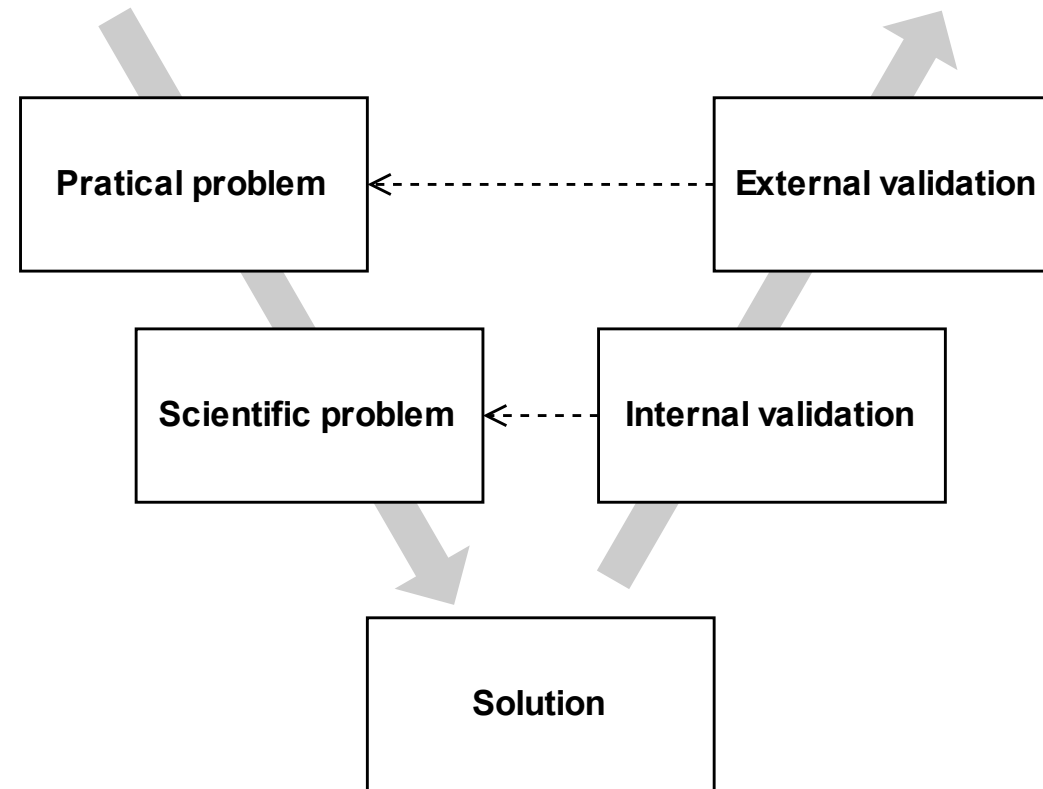


A variant of the original V-Model being used to frame a traditional software development lifecycle. Source: adapted from [2].

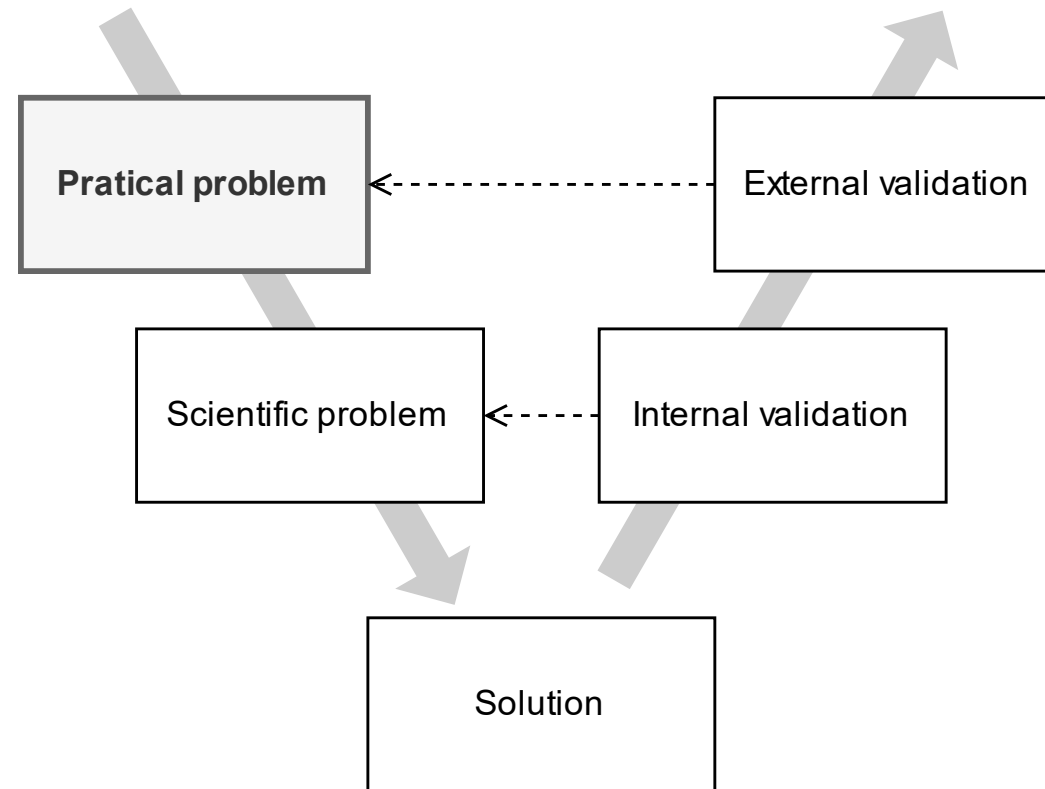
The *empirical* V-Model is a framework for applied research in ESE



Most of the time, the empirical V-Model is pictured with five stages



The first stage is “practical problem”



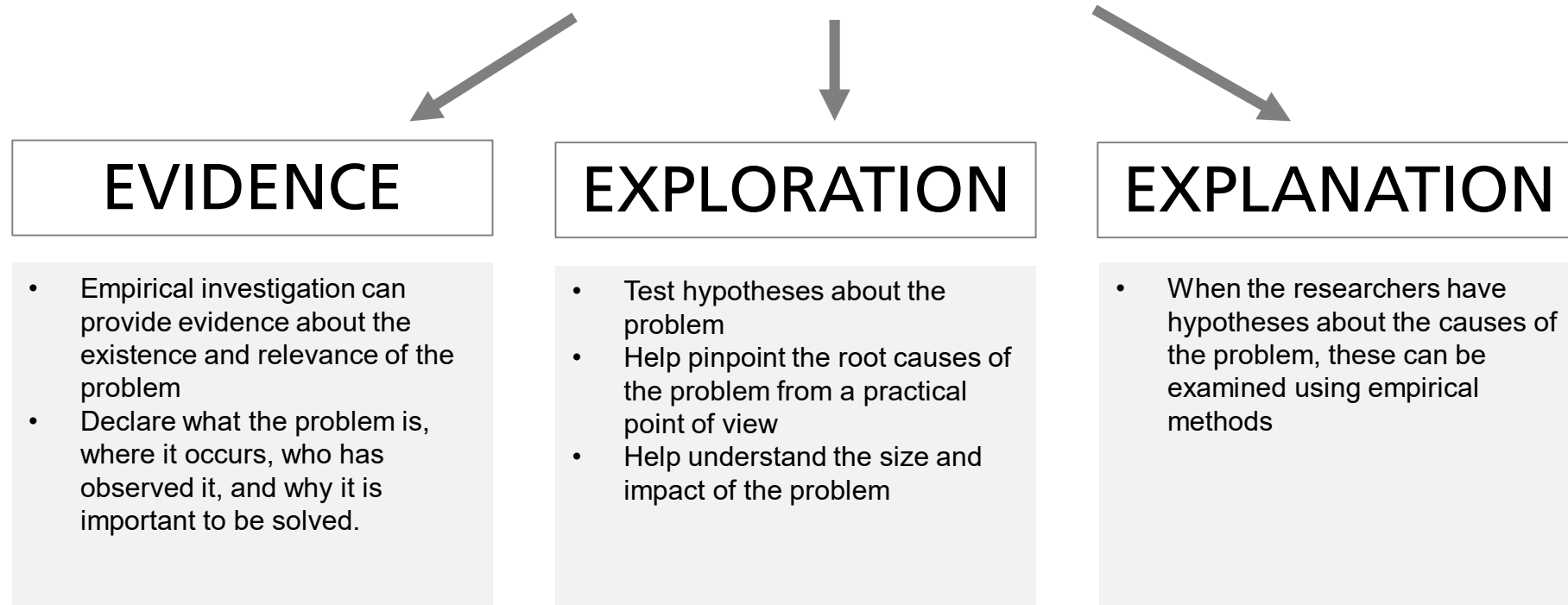
Also known as “industry problem”/“state of the practice”

What is the practical problem faced by practitioners?

Guiding question to “practical problem”

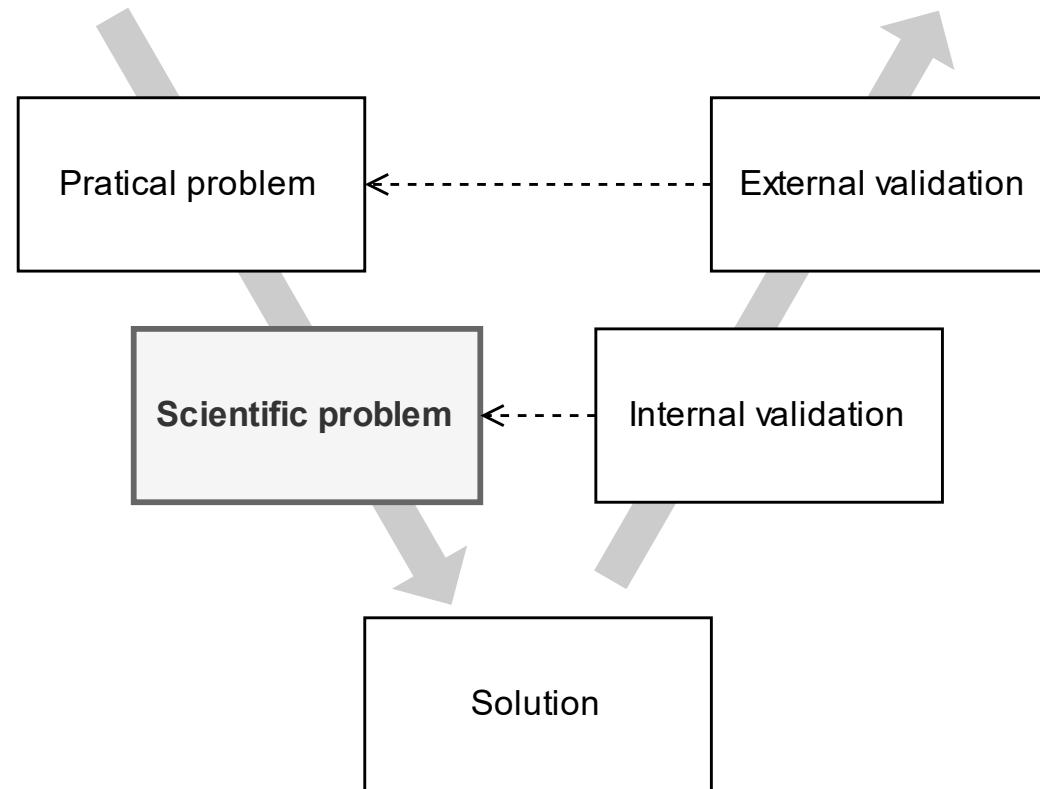
The investigation of the practical problem may serve different purposes

Practical problem investigation



Typical empirical strategies for investigating practical problems: surveys with practitioners, case studies

The second stage is “scientific problem”

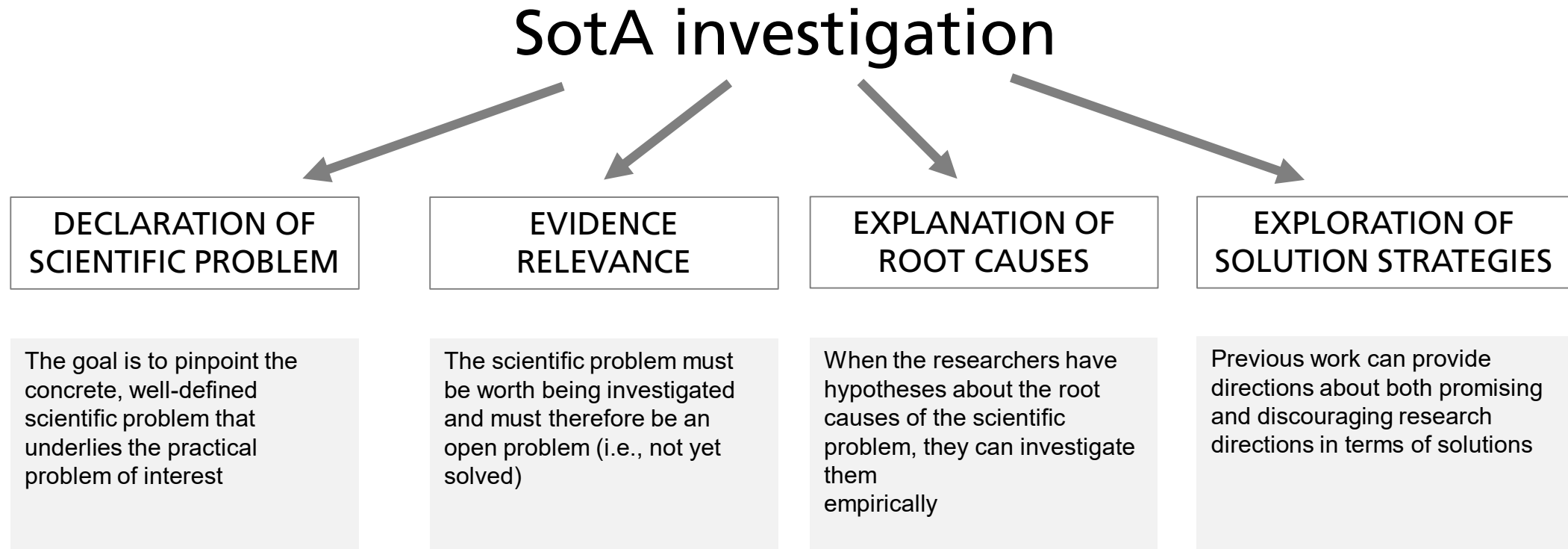


Also known as “research problem”/“research challenge”

How does the state of the art (SotA) address the problem?

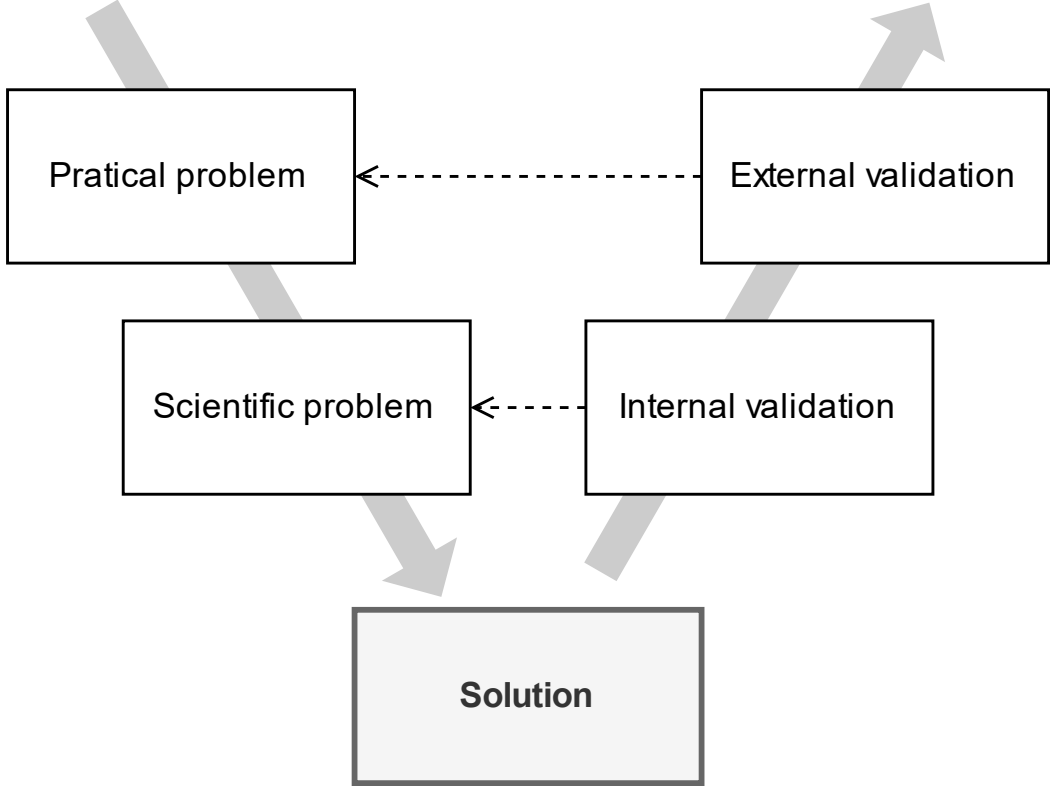
Guiding question to “scientific problem”

The investigation of the SotA may serve diverse purposes



Typical empirical strategy for investigating scientific problems: systematic literature reviews

The third stage is “solution”

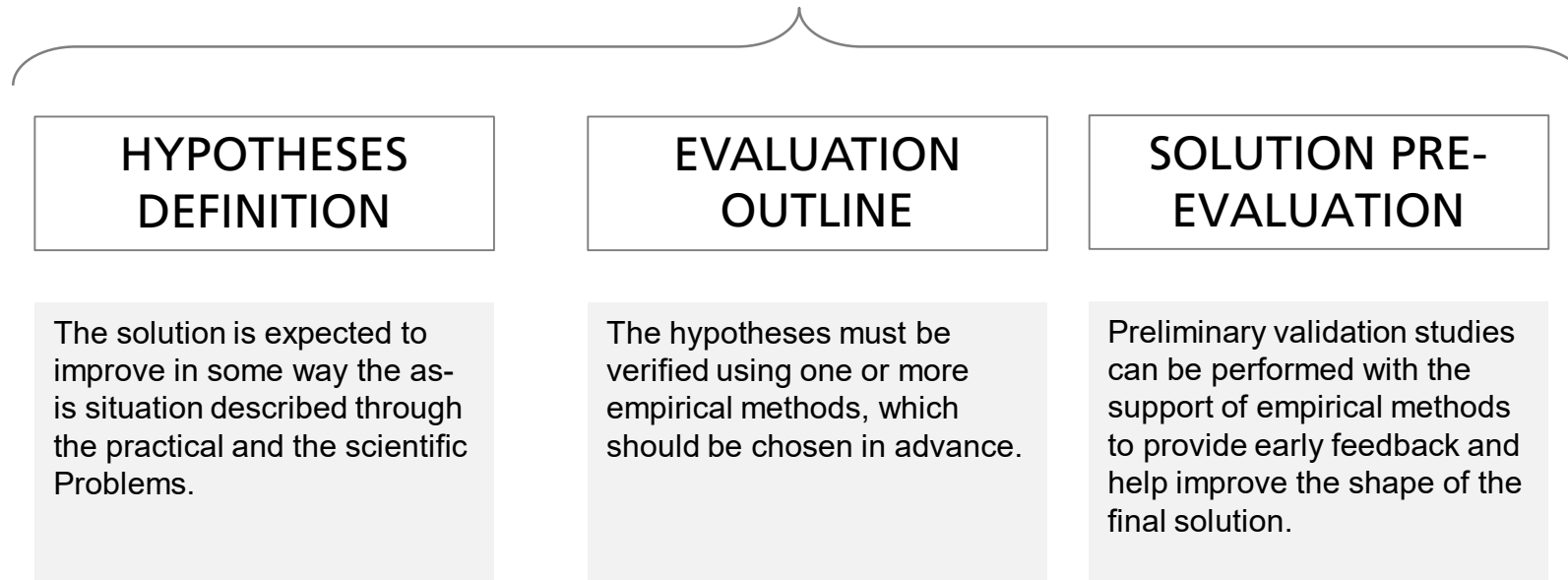


What is the research goal and what solution strategy can be used?

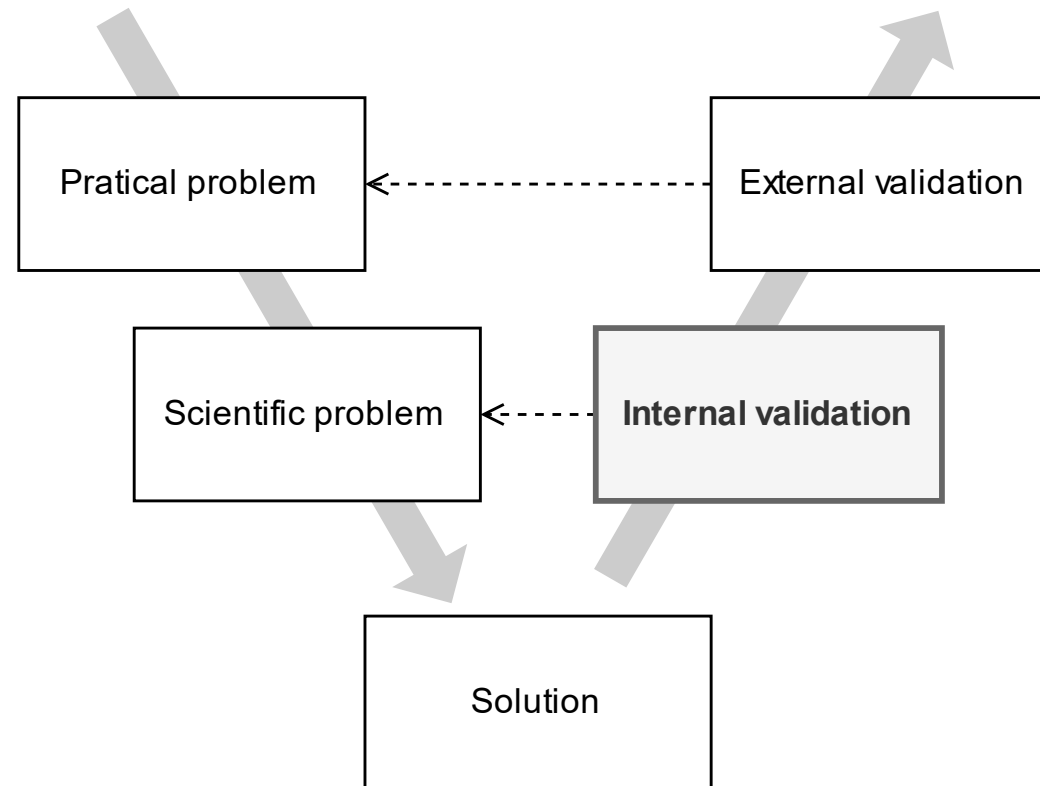
Guiding questions to “solution”

In the solution stage, empirical methods aren't applied (but empirical work happens)

Empirical work @ solution stage



The fourth stage is “internal validation”



Also known as “academic validation”/“scientific benefit”

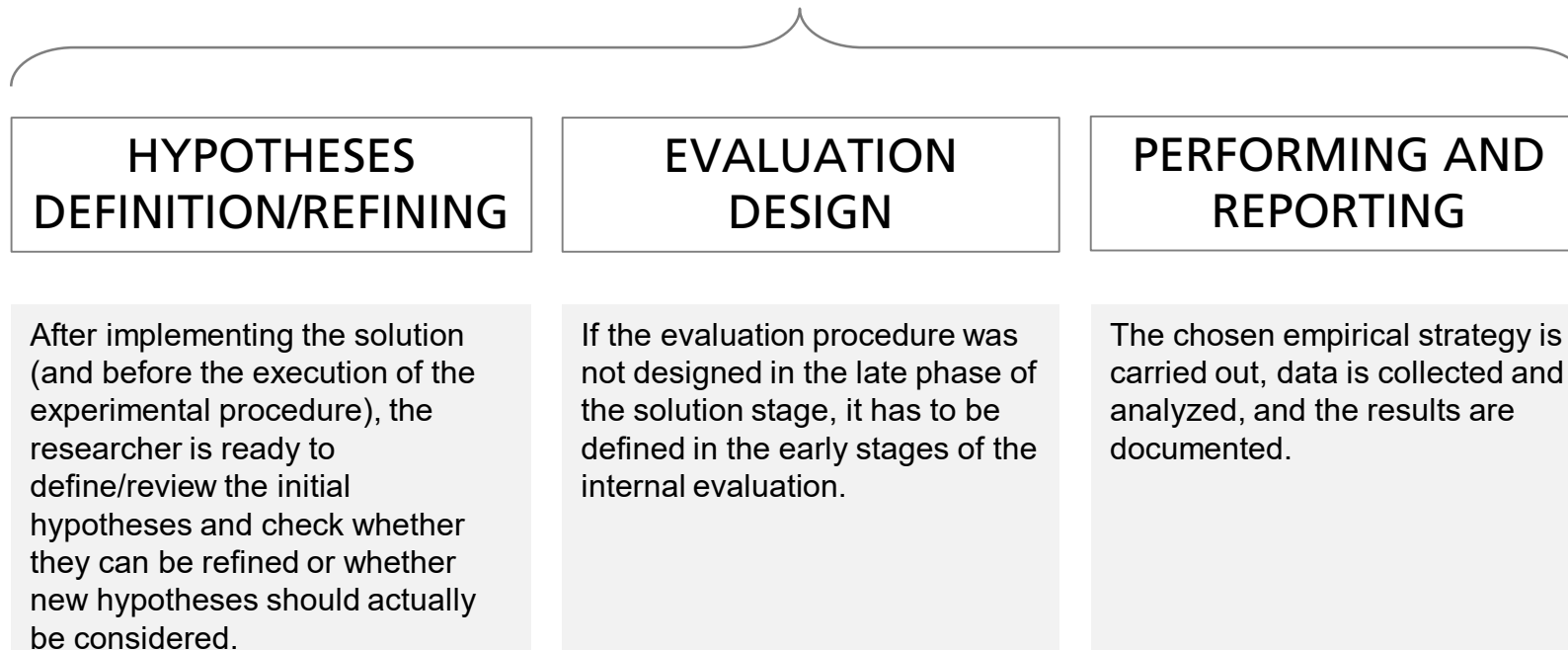
What benefits does the solution offer in terms of addressing the scientific problem?

Guiding question to “internal validation”

Internal validation is about applying one or more empirical methods to test the hypotheses of the implemented solution to address the scientific problem.

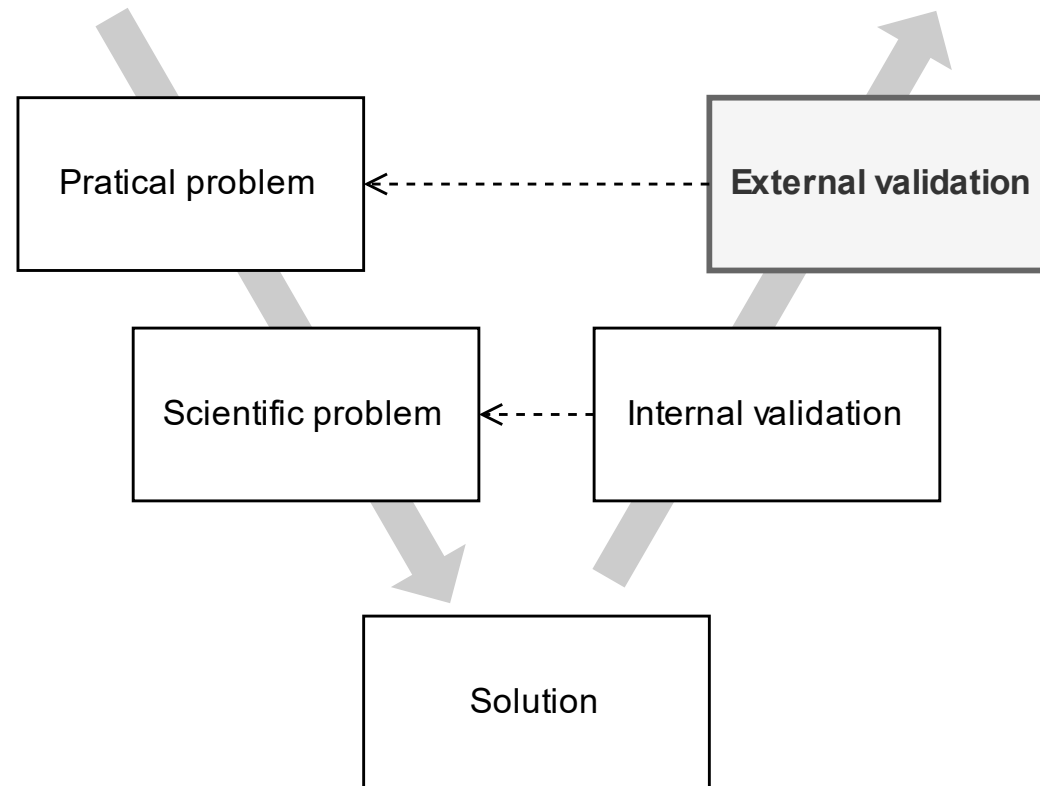
Empiricism at the internal validation stage include several activities

Empiricism @ internal validation



Typical empirical strategy during internal validation: controlled experiments

The fifth stage is “external validation”



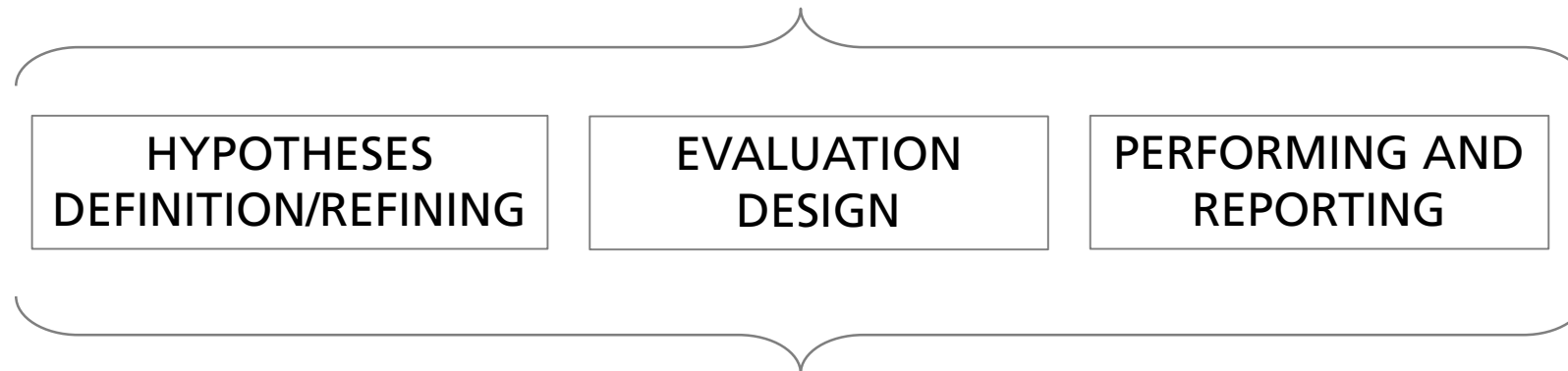
Also known as “industry validation”/“practical benefit”

To what extent is the solution beneficial in practice?

Guiding questions to “external validation”

Empiricism in the external validation includes the same activities of internal validation

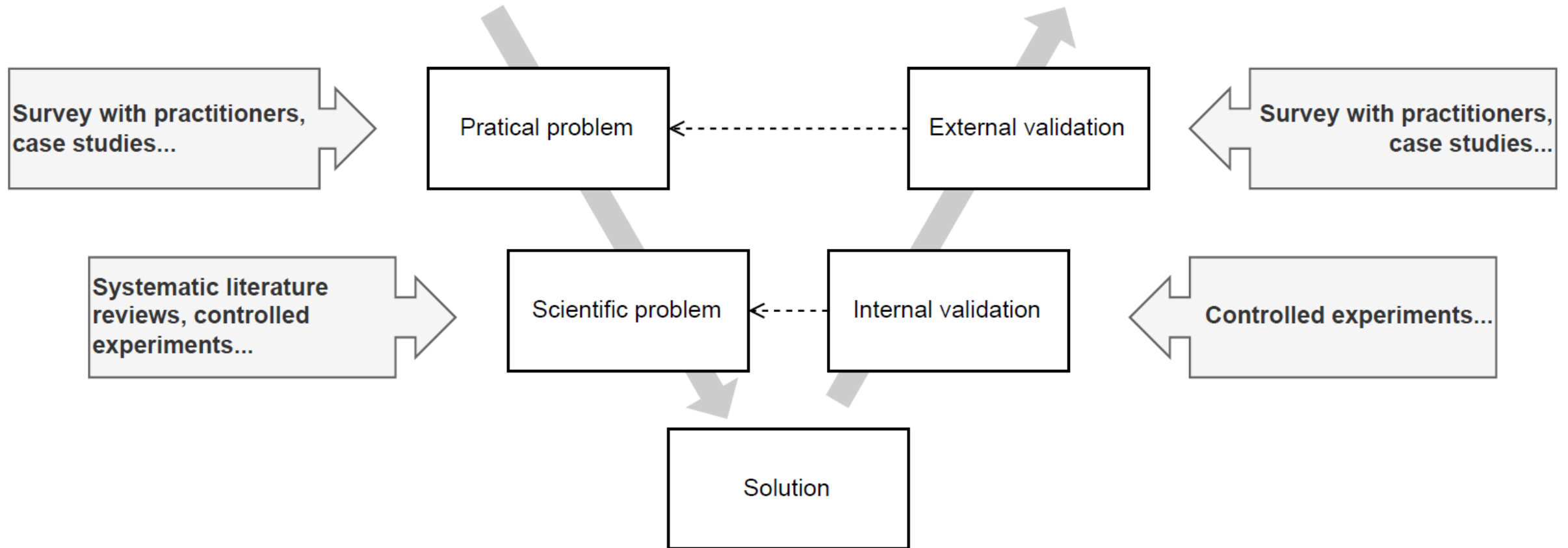
Empiricism @ internal validation



Empiricism @ external validation

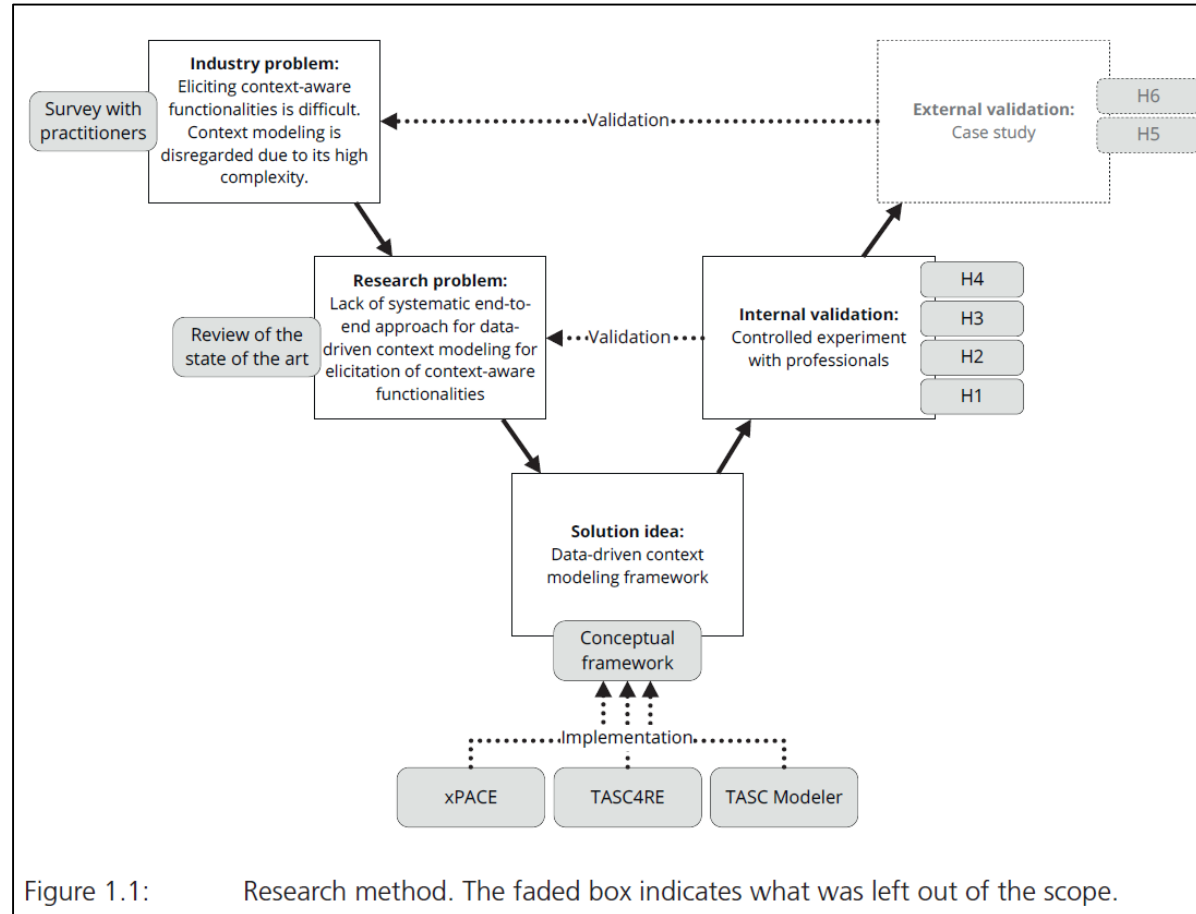
Typical empirical strategies during external validation: case studies, surveys with practitioners

There are typical empirical strategies used in each stage of the framework



Please note that these are *typical* strategies, not the only strategies.

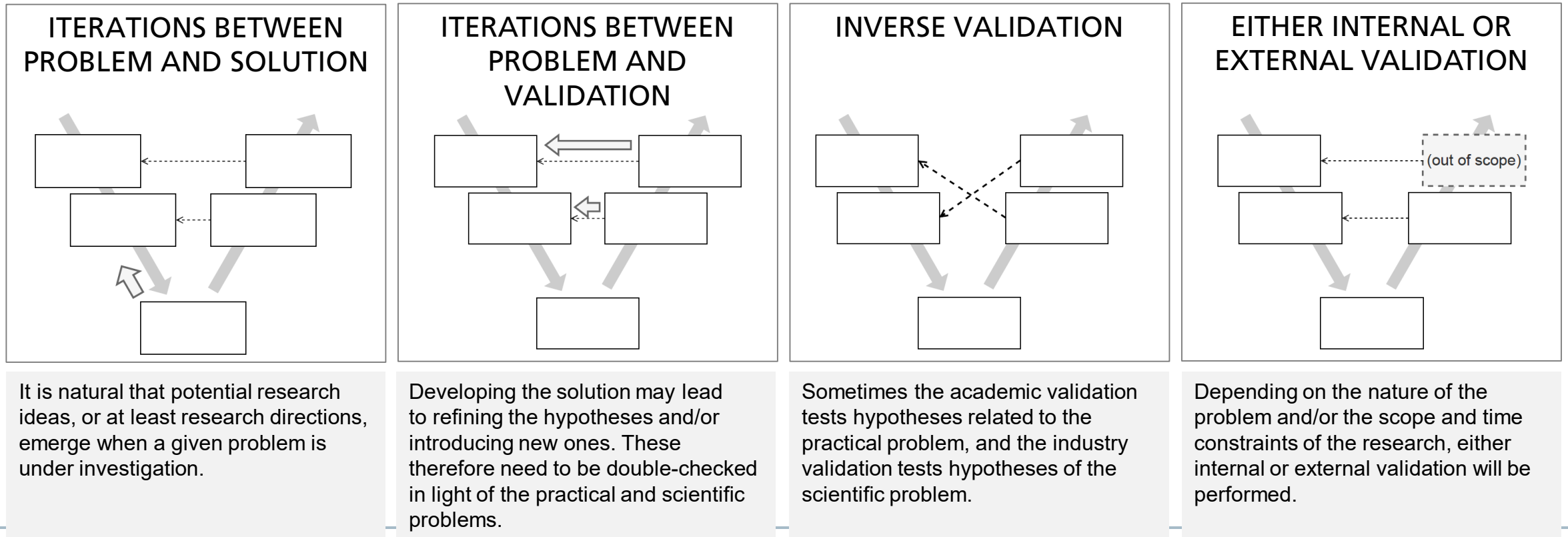
Example from a PhD thesis



Example of the empirical V-Model being used to describe the research method in a PhD thesis. Source: [4]

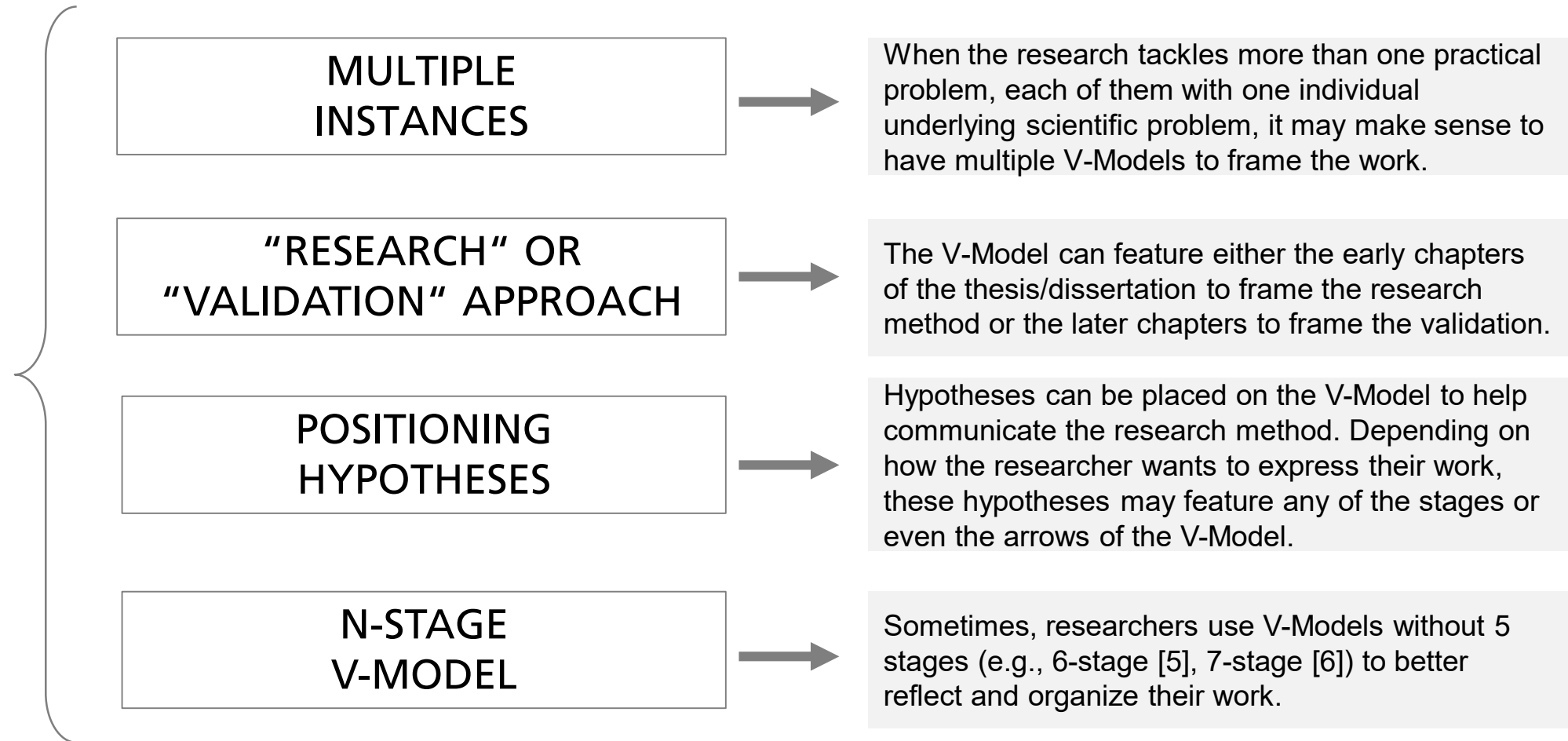
The V-Model may be followed sequentially, but variations exist

Variations



There are alternative usage patterns beyond the 5-stage empirical V-Model

Alternative usage patterns



References

- [1] P. Rook. Controlling software projects. *Software engineering journal*, 1(1):7–16, 1986.
- [2] S. Mathur and S. Malik. Advancements in the v-model. *International Journal of Computer Applications*, 1(12):29–34, 2010.
- [3] V. Basili. The experimental paradigm in software engineering. In *Experimental Software Engineering Issues: Critical Assessment and Future Directions*, pages 1–12. Springer, 1993
- [4] R. Falcão. *Data-driven context modeling for the elicitation of context-aware functionalities*. Fraunhofer Verlag, 2023.
- [5] M. Anastasopoulos. *Evolution Control for Software Product Lines: An Automation Layer over Configuration Management*. Fraunhofer IRB Verlag, 2014.
- [6] O. Armbrust. *The SCOPE approach for scoping software processes*. Fraunhofer Verlag, 2010.