

```
graph TD; Start(( )) --> FQ[FORMULATE QUESTION]; FQ --> FH[FORMULATE HYPOTHESIS]; FH --> SE[SEARCH FOR EXISTING EVIDENCE]; SE -.-> End(( )); SE --> FQ
```

FORMULATE QUESTION

DESCRIPTION

- Contains **technology** in a **context** showing an **effect**.

GUIDELINES

- ▶ Create question using a structured approach such as **PICOT**¹.
- ▶ Validate question with **FINER**¹.

ACCEPTANCE CRITERIA

- ☐ Question systematically constructed
- ☐ Formulation of question validated

FORMULATE HYPOTHESIS

DESCRIPTION

- A testable prediction based on the question.

GUIDELINES

- ▶ Contains: two or more variables, context, relationship between the variables
- ▶ 'If I [do X], then [Y] will happen.'²

ACCEPTANCE CRITERIA

- ☐ Hypothesis is formulated as prediction
- ☐ Prediction is testable

SEARCH FOR EXISTING EVIDENCE

DESCRIPTION

- Search for evidence related to the research question.
- Enlarge your Personal Evidence Pool.
- Deepen your understanding of the research domain.
- If necessary, incrementally refine the research question.

GUIDELINES

- ▶ Try to find as much relevant evidence as possible
- ▶ Use 'Cited by' function of search engines
- ▶ Read through found work's bibliography
- ▶ Refer to Systematic Literature Reviews for a wide comparison of related work
- ▶ Find similar work using classification systems such as CCS³
- ▶ Use EBSE Checklist⁴ for critical appraisal of related work
- ▶ Note search strings for more structured search approach
- ▶ Too few search results? Make Research Question more general
- ▶ Too many/general search results? Narrow down Research Question

ACCEPTANCE CRITERIA

- ☐ Rough understanding/overview of research domain
- ☐ Deep understanding of research domain
- ☐ Critical appraisal of relevant related work

SUBSTANTIAL EVIDENCE?

Yes

No

DESCRIPTION

Check if Personal Evidence Pool contains enough substantial evidence to answer the Research Question.

EXPERIMENT

DESCRIPTION

- Design, Conduct and Evaluate Experiment
- If the Research Question can not be answered in one experiment: Split up the question. Recursively start a new process instance in FORMULATE QUESTION using a sub-question.

GUIDELINES

- ▶ Use guidelines from literature like, *Experimenting in Software Engineering*¹⁵ to design and conduct experiments.
- ▶ Use Briefing Form

ACCEPTANCE CRITERIA

☐

 Experiment Designed

☐

 Experiment Conducted

☐

 Experiment Evaluated

☐

 Briefing Form filled in

ANSWER QUESTION

DESCRIPTION

- Accept or reject Hypothesis based on evidence.
- Answer the Research Question accordingly.

GUIDELINES

- ▶ Make sure evidence is substantial enough to answer the Research Question.
- ▶ Try to avoid bias. (Confirmation Bias, Information Expectancy Bias, ...)

ACCEPTANCE CRITERIA

☐

 Validity of Hypothesis is evaluated

☐

 Research Question is answered



DISCUSSION

DESCRIPTION

- Discuss the whole study, suggest future approaches and limits.

GUIDELINES

- ▶ Critically assess study using EBSE Checklist⁴
- ▶ Put study in relation to larger context.

ACCEPTANCE CRITERIA

- ☐ Content of study critically assessed
- ☐ Study put in larger context

EVALUATE PROCESS

DESCRIPTION

- Reflect on your work in the previous steps and seek ways to improve your future performance.

GUIDELINES

- ▶ Use After Action Review and Postmortem Analysis⁴

ACCEPTANCE CRITERIA

- ☐ AAR done
- ☐ PMA done
- ☐ Conclusions drawn for future processes

REFERENCES

- [1] Farrugia, P., Petrisor, B.A., Farrokhyar, F., Bhandari, M.: Practical tips for surgical research: Research questions, hypotheses and objectives. *Canadian journal of surgery. Journal canadien de chirurgie* 53(4), 278–281 (2009)
- [2] Buddies, S.: A Strong Hypothesis (2010), <http://www.sciencebuddies.org/blog/2010/02/a-strong-hypothesis.php>
- [3] <http://dl.acm.org/ccs/ccs.cfm>
- [4] Dybå, T., Kitchenham, B.A., Jorgensen, M.: Evidence-based software engineering for practitioners. *IEEE Software* 22(1), 58–65 (2005)
- [5] Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B., & Wesslén, A. (2012). *Experimentation in software engineering*. Springer Science & Business Media.

P opulation	What specific population are you interested in?	F easible	<ul style="list-style-type: none"> ▶ Adequate number of subjects ▶ Adequate technical expertise ▶ Affordable in time and money ▶ Manageable in scope
I ntervention (Technology)	What is the investigational technology / intervention?	I nteresting	<ul style="list-style-type: none"> ▶ Getting the answer intrigues investigator, peers and community
C omparison Group	What is the main alternative / baseline to compare with the intervention	N ovel	<ul style="list-style-type: none"> ▶ Confirms, refutes or extends previous findings
O utcome	What do you intend to accomplish, measure, improve or affect?	E thical	<ul style="list-style-type: none"> ▶ Amendable to a study that institutional review board will approve
T ime	What is the appropriate follow-up time to assess outcome?	R elevant	<ul style="list-style-type: none"> ▶ To scientific knowledge ▶ To clinical and health policy ▶ To future research

Study Appraisal Checklist

1. Is there any vested interest?
 - ▶ Who sponsored the study?
 - ▶ Do the researchers have any vested interest in the results?
2. Is the evidence valid?
 - ▶ Was the study's design appropriate to answer the question?
 - ▶ How were the tasks, subjects, and setting selected?
 - ▶ What data was collected, and what were the methods for collecting the data?
 - ▶ Which methods of data analysis were used, and were they appropriate?
3. Is the evidence important?
 - ▶ What were the study's results?
 - ▶ Are the results credible, and, if so, how accurate are they?
 - ▶ What conclusions were drawn, and are they justified by the results?
 - ▶ Are the results of practical and statistical significance?
4. Can the evidence be used in practice?
 - ▶ Are the study's findings transferable to other industrial settings?
 - ▶ Did the study evaluate all the important outcome measures?
 - ▶ Does the study provide guidelines for practice based on the results?
 - ▶ Are the guidelines well described and easy to use?
 - ▶ Will the benefits of using the guidelines outweigh the costs?
5. Is the evidence in this study consistent with the evidence in other available studies?
 - ▶ Are there good reasons for any apparent inconsistencies?
 - ▶ Have the reasons for any disagreements been investigated?

After Action Review (AAR)

- ▶ What was supposed to happen?
- ▶ What actually happened?
- ▶ Why were there differences?
- ▶ What did we learn?

Postmortem Analysis (PA)

- ▶ What went so well that we want to repeat it?
- ▶ What was useful but could have gone better?
- ▶ What were the mistakes that we want to avoid for the future?
- ▶ What were the reasons for the success or mistakes?

REFERENCES

- FINER, PICOT:** Farrugia, P., Petrisor, B.A., Farrokhyar, F., Bhandari, M.: Practical tips for surgical research: Research questions, hypotheses and objectives. Canadian journal of surgery. Journal canadien de chirurgie 53(4), 278–281 (2009)
- Checklist, AAR, PA:** Dybå, T., Kitchenham, B.A., Jorgensen, M.: Evidence-based software engineering for practitioners. IEEE Software 22(1), 58–65 (2005)