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

CHECKLIST

- ☐ 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

CHECKLIST

- ☐ 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

CHECKLIST

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

SUBSTANTIAL EVIDENCE?

Yes

No

EXPERIMENT

DESCRIPTION

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

SUBSTANTIAL EVIDENCE?

Yes

No

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*'⁵ to design and conduct experiments.
- ▶ Use Briefing Form

CHECKLIST

☐

 Experiment Designed

☐

 Experiment Conducted

☐

 Experiment Evaluated

☐

 Briefing Form filled in

SUBSTANTIAL EVIDENCE?

Yes

No

EXPERIMENT

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, ...)

CHECKLIST

☐

 Validity of Hypothesis is evaluated

☐

 Research Question is answered

SUBSTANTIAL EVIDENCE?

Yes

No

EXPERIMENT

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

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 Experiment Designed

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 Experiment Conducted

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 Experiment Evaluated

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CHECKLIST

☐

 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.

CHECKLIST

- ☐ 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

CHECKLIST

- ☐ 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:** Dybbå, T., Kitchenham, B.A., Jorgensen, M.: Evidence-based software engineering for practitioners. *IEEE Software* 22(1), 58–65 (2005)