Design Science Methodology

Questions and Assignments

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Contents

Chapter 2

What is design science?

Questions

1. For each of the following design problems, identify (1) the problem context, (2) the artifact, (3) the intended interaction of the artifact with the problem context, (4) some stakeholders. Some of this information is missing from the problem statement; in those cases, supply reasonable examples of the required items.

   (a) Our organization has a handbook of software engineering methods, but it is so large that no one uses it. Which set of methods and techniques from our "methods cookbook" are relevant for realizing IT-enabled business change?

   (b) Logistics in our organization is inefficient because it is still organized manually. Select and implement a logistic financial package with an eye to future IT developments

   (c) There are several wireless communication protocols for health care devices at home. These devices monitor vital data of home-care patients and transmit them to a wireless care station located in the home, which transmits the data to care center where medical personnel has access to the data. Different care stations use different wireless communication protocols, such as Bluetooth and ZigBee. Design an application layer protocol that can run on top of Bluetooth as well as ZigBee.

   (d) Design a database system for storing annotated sensor data for use in a dike monitoring system

   (e) Improve the scalability in number of documents of lookup algorithm of web services with distributed hash tables in a P2P network.

2. Which of these problems is a design problem, and which a knowledge question? Explain your answer using the heuristics for distinguishing improvement problems from knowledge questions. If a problem is ambiguous, explain the ambiguity.

   (a) What are the goals of these users?

   (b) What would be a good procurement process for Office supplies?

   (c) What is the complexity of this algorithm?

   (d) Find an algorithm to solve this problem

   (e) How do users interact with this system?

(f) How to interact with this system?

3. What is the relationship between a problem context and the social context of an artifact?

4. Why is it important to identify the stakeholders of design research?

5. Explain why generality of knowledge comes at the cost of idealization.

6. In the three examples of question 2, give examples of each kind of knowledge that may be needed.

Assignment

Answer the following questions for the theses by

- Adolfsen (chapter 1).
- Bruintjes (chapter 1).
- De Wit (Chapters 1-3).

Read the indicated chapters only, as well as the preface, abstract, and table of contents because they may help you to answer the following questions. Since there are several choices of artifact possible, we give you the choice of artifact below. The rest of the questions is to be answered based on this choice of artifact.

1. Draw the diagram of subjects of design research (slide 5) for the thesis, using the artifact as indicated.

   (a) Artifact:
      - Adolfsen: Coverage testing methods
      - Bruintjes: A fused multiply-add floating-point and integer datapath
      - De Wit: Wireless City Networks

   (b) What is the context?

   (c) What is the interaction?

2. (a) What are the research questions as listed in the thesis?

   (b) Which of these is a design problem, and which is a knowledge question?

   (c) Locate the questions in the diagram of research problems in design science of slide 9.

3. Consider the diagram of design research context on slide 17.

   (a) Who are the stakeholders in the social context of the project?

   (b) What background knowledge is available?

   (c) What new knowledge does the thesis aim to produce?

   (d) What is the claimed scope of this knowledge (what is the class of problem contexts and artifacts to which it is claimed to be applicable)?

Chapter 3

Research goals and research questions

Questions

1. For each of the following two problems, (1) reformulate the design problem according to the template as far as possible (don't supply missing pieces of information). Next, (2) Comment on the absence of any piece of information: (2.1) Is the missing information necessary to solve this problem? (2.2) If so, how could it be obtained?

   (a) Our organization has a handbook of software engineering methods, but it is so large that no one uses it. Which set of methods and techniques from our "methods cookbook" are relevant for realizing IT-enabled business change?

   (b) Logistics in our organization is inefficient because it is still organized manually. Select and implement a logistic financial package with an eye to future IT developments.

2. Consider a database system for storing sensor data, annotated with time and data source information, for use in a dike monitoring system. The system should provide early warnings when there is a danger of dike collapse.

   (a) What is the application scenario for the database system?

   (b) Formulate the design problem for the database system (artifact) according to the design template.

   (c) Formulate the four knowledge questions of design science (effect, trade-off, sensitivity, contribution) for the database system.

3. Consider the design of an application layer protocol that should run on top of wireless communication technologies, such as Bluetooh and ZigBee, used for communication between medical devices in home care. The protocol is used by observation devices such as blood pressure monitors, temperature sensors and heartbeat sensors to a home care station, which relays this information to a medical center where nurses, physicians and medical specialists can use this to monitor the state of a patient who lives at home. The protocol should be energy-efficient because these devices are battery-powered. The system is intended to allow patients and other people needing medical attention, to live at home independently. The protocol should be usable by a variety of sensor devices. Because there is no technical personnel available to solve technical

problems, the protocol should be reliable and robust. Because medical personnel is accountable for its actions, data must be traceable to the sensor that produced it.

(a) What is the application scenario for the protocol?

(b) Formulate the design problem for the protocol (artifact) according to the design template. If any item of information is missing, identify it. Would it be needed to provide missing information before you could solve the problem?

(c) Formulate the three effect questions for the protocol.

4. Consider a distributed database running on a P2P network, to be used for storing and searching web service descriptions. The lookup algorithm uses a distributed hash table (DHT).

   (a) What is the application scenario for the lookup algorithm?

   (b) Formulate the problem of designing the lookup algorithm according to the template for design problems.

   (c) A researcher has designed a new lookup algorithm with a view to improving its scalability in the number of documents (web service descriptions) searched. Formulate the three effect questions for the lookup algorithm.

Assignment

Consider these three theses.

- Adolfsen (Preface, abstract, chapter 1).
- Bruintjes (Preface, abstract, chapter 1).
- De Wit (Preface, abstract, Chapters 1-3).

Answer the following questions for these theses. Base your answers on the indicated parts of the theses only.

1. Which application scenario(s) does the thesis mention?

2. (a) Formulate the top-level design problem according to our template (slide 11).

   (b) identify missing pieces of information. Is it necessary to supply these missing pieces in order to solve the design problem?

   Hint: some of the knowledge questions listed by the author might actually ask for this information.

3. Formulate effect, trade-off, and sensitivity questions for the treatment. Hint: These could be new questions not listed by the author; or they could be reformulations of some of the author's questions.

Chapter 4

The Design Cycle

Questions

1. In a thesis about data location compliance for cloud service providers (CSPs), the following research questions are listed.

   RQ1 What are demands regarding data location compliance of the typical customers of a CSP?

   RQ2 What technical solutions do CSPs currently have?

   RQ3 What are the current limniations for CSPs to show compliance to customer demands regarding data location?

   RQ4 How to make agreements about data location demands between customer and CSP?

   RQ5 How can CSPs enforce security policies regarding data location?

   RQ6 How can CSPs show compliance to customer demands regarding data location in public software-as-a-service cloud computing?

   (a) Each these questions is asked in some step of the engineering cycle. For each question, indicate to which step it belongs and reformulate it accordingly.

   (b) Some questions essential to the engineering cycle are missing. Add these questions.

2. Can problem solvers restrict themselves to designing an artifact rather than a treatment? Why (not)?

3. Describe the difference between design and specification as defined in this chapter, using an example.

4. Could you have a design of an artifact but not a specification? Or a specification but not a design?

5. Explain the relationship between implementation, technology transfer and goal realization by means of an example

6. Mention two important differences between the engineering cycle and an engineering process.

Assignment

Answer the following questions for the following theses. Base your answers on the indicated part of the theses only.

- Adolfsen (Preface, abstract, table of contents, chapter 1).
- Bruintjes (Preface, abstract, table of contents, chapter 1).
- De Wit (Preface, abstract, table of contents, Chapters 1-3).

1. Which parts of the engineering cycle are reported about in the thesis?
2. For those parts that are reported about, indicate in which chapter(s) it is reported about .
3. In which part of the engineering cycle does the thesis present a contribution (in the form of new knowledge and/or a new design)

Chapter 5

Stakeholders and Goals

Questions

1. Slide 5 mentions stakeholders in a problem, in a research project, in a development project, and in a software product. Explain why these are all the same stakeholder concept.

2. Consider the problem of designing a method for data compliance (slide 23).

   (a) Discuss which of the possible stakeholders listed by Clements & Bass (slide 6) is a stakeholder in this problem

   (b) For the same method for data compliance: Which of Ian Alexander's stakeholder roles (slide 7) exists for this product? Give an example of each meaningful role.

3. Define the difference between the three awareness levels of stakeholders, and illustrate them with examples.

4. (a) Define what it means for desires to be in logical conflict, in physical conflict, and in technical conflict.

   (b) For each of the examples below, indicate whether there is a conflict between goals and if so, identify the goals, and explain whether the conflict is physical, logical or technical.

   - Airports want a safe route and a fast route through the network
   - Airports want aircraft to behave in a predictable manner and respond dynamically to changing situations
   - Car owners want to equip their car with TV but have the same car battery life times
   - Car owners want to have a TV in the dashboard so that can watch during driving, and obey the law

5. For each of the stakeholders of the three examples in slides 21-24, list some desire with respect to the artifact under design, and give an example of a resource to be committed by that stakeholder to turn that desire into a goal.

6. Consider as artifact an application layer protocol used for wireless communication between medical monitoring devices in home care and a home care station. The care station relays the data to a server in central location, that relays the information to a care center. Motivate the following requirements for the protocol in terms of an external goal of a stakeholder. Describe

(i) what desired state of the environment is supported by this requirement,
(ii) which stakeholder(s)has (have) this desire, and
(iii) whether they would be willing to commit resources to achieve these desires (turning these desires into goals).

(a) The protocol must use low power
(b) The protocol must be reliable
(c) A medical device must wait for an acknowledgement from the care station before it starts transmitting data to the care station.
(d) Observations relayed to the care center must be traceable to the sensor that generated them.

Assignment

Consider the following three theses:

- Adolfsen (Preface, abstract, table of contents, chapter 1-3).
- Bruintjes (Preface, abstract, table of contents, chapter 1).
- De Wit (Preface, abstract, table of contents, Chapters 1-4).

Answer the following questions for the following theses, basing your answers on the indicated parts of the theses only.

1. What is/are the artifact(s) studied? (Use the same artifact as in the assignment of chapter 2.)
2. Who are the stakeholders in the artifact? Classify them according to the taxonomy of Clements & Bass (slide 6) and Alexander (slide 7).
3. What are their goals as assumed, explicitly or implicitly, by the thesis?
4. What is the awareness level of the stakeholders with respect to these goals?
5. What conflicts exist between goals? For any conflicts, explain whether they are logical, physical or technical.

Chapter 6

Problem Representation

Questions

1. (a) Define the concept of an architecture. Illustrate your definition with an example.
   (b) Define the concept of an architectural mechanism. Illustrate with an example.
2. (a) Describe in which way an architectural model is a theory. What claim does it make?
   (b) What is the use of architectural theories?
   (c) In which ways are they fallible?
3. (a) What is the conceptual structure of a variable-based model of a problem? Illustrate your definition with an example.
   (b) Define the concept of a variable-based mechanism. Illustrate with an example.
4. (a) Describe in which way an variable-based model is a theory. What claim does it make?
   (b) What is the use of variable-based theories?
   (c) In which ways are they fallible?
5. What is a mechanism?
6. Discuss the difference between the concept of mechanism in an architectural model and a variable-based model. Illustrate the difference by means of an example.
7. The Greenery value chain consists of farmers, transport companies, warehouses, and retailers. These components have capabilities and interact with each other. Allocate each of the variables in the causal graph of slide 27 to a component or interaction where the phenomenon indicated by the variable occurs.
8. The flex-office problem of slide 29 consists of an office with one or more office buildings, employees, their homes, a transport system (public and private) and a communication infrastructure.

(a) Draw an architecture model of this problem. There are too many interactions in this model to represent in a diagram. In your diagram, if there are interactions between A and B, only represent these by an undirected line with named with the kind(s) of interactions.

(b) Allocate the variables of slide 29 to elements (components or interactions) of this architecture. If a variable cannot be allocated, indicate what should be added to the flexoffice architecture.

(c) Discuss ways in which the architecture could have a mismatch with a concrete case: Could there by additional components in reality not represented in the architecture? Additional mechanisms in reality not represented in the model? Could the components of the architecture have different capabilities in reality than the capabilities assumed by the architecture? Could there by additional influence relations not represented in this architecture?

(d) Discuss ways in which the causal graph of slide 29 could have a mismatch with a real case: Could there be additional variables in the real case that could influence the causal relationships in the graph? Could there be additional causal relationships between the variables in the graph? Do all the variables in the graph match phenomena of the case clearly?

9. The medical laboratory of slide 31 interacts with patients, who visit the laboratory to give a blood sample or get an X-ray photo, and with hospitals, who request these tests.

   (a) Draw an architectural model of this problem.

   (b) Allocate all variables of slide 31 to elements (components or interactions) of the architecture.

   (c) Discuss ways in which in a concrete case, the architecture model and the causal model could fail to describe the case adequately.

Assignments

Consider the following three theses:

- Adolfsen (Preface, abstract, table of contents, chapter 5-6).
- De Wit (Preface, abstract, table of contents, Chapters 4).
- Van der Spoel (Summary, Preface, table of Contents, chapters 1-2).

Answer the following questions for the following theses, basing your answers on the indicated parts of the theses only.

1. Adolfsen mentions in the order of ten variables in total in chapters 5 and 6, with influence relationships. For example, test suite size influences Test suit efficiency (page 39). Identify all variables that he mentions, and draw a causal graph of influence relationships that he mentions. For each influence relation, list the page number(s) where he mentions it.

2. Figure 9 of the thesis of De Wit shows an architecture model of stakeholders. Improve this model as follows: (a) for each role, add its capabilities and (b) its goal(s). (c) Consider the influence of A on B to be the good or service provided by A to B; for each such influence, describe in a short sentence what kind of influence it is.

3. Van der Spoel lists a number of problems with the current medical treatment registration and payment claiming methodology. (a) make a causal graph of these problems. (b) what will change in this graph when the new system (DOT) is introduced? Which (if any) nodes or arrows disappear? Which (if any) nodes or arrows are added?

Chapter 7

Requirements and Indicators

Questions

1. For each of the three examples on slides 6-8:

   (a) For each assumption, indicate how the requirements should be changed if the assumption would change and the same stakeholder goal contribution should be achieved as before the change. (In some cases, no requirements may need to be changed.)

   (b) For each requirement, check if any relevant assumptions are missing. An assumption is relevant if its absence would prevent the requirement to contribute to a goal.

2. Consider as artifact an application layer protocol used for wireless communication between medical observation devices in home care and a home care station. The base station relays the data to a back-end server, which in turn communicates with medical personnel in a care center. Figure 7.1 shows an architectural model of the environment of the protocol.

   As you found out in exercise 6 of Chapter 5, each of the following requirements contributes to a stakeholder goal and makes an assumption about the environment. (a) which assumption does it make, and (b) what should change about the requirement if the assumption is dropped?

   (a) The protocol must use low power.

   (b) The protocol must be reliable.

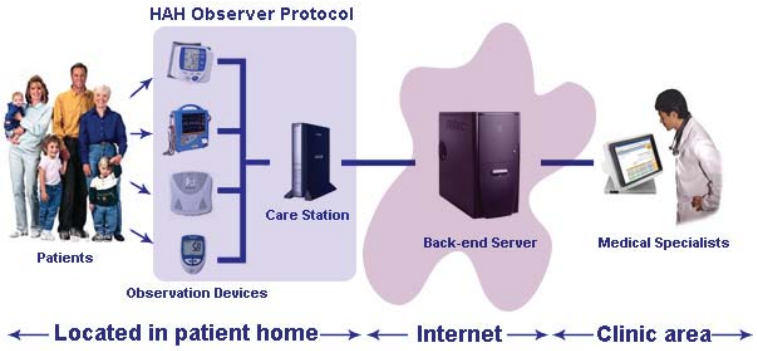

Figure 7.1: Problem architecture of Health@Home

(c) An observation device must wait for an acknowledgement from the care station before it starts transmitting data to the care station.

(d) Observations relayed to the back-end server must be traceable to the sensor that generated them.

3. What is the difference between desires, goals (defined in chapter 5), requirements and constraints (defined in this chapter)? Illustrate by means of examples.

4. Consider again the protocol mentioned in question 2 above. Classify the following requirements as (a) functional requirements, (b) quality requirements, and (c) constraints.

   (a) The protocol must use low power

   (b) The protocol must be reliable

   (c) A medical device must wait for an acknowledgement from the base station before it starts transmitting data to the base station.

   (d) Observations relayed to the care center must be traceable to the sensor that generated them.

5. Slide 22 defines mean time between failure (MTBF) as one indicator of reliability. A high MTBF is interpreted as an indication of high reliability. Does this mean that if MTBF is high, this *causes* reliability to be high? Explain your answer.

6. Slide 22 defines several indicators for most properties. Is it possible that two indicators provide contradictory information about one property? If not, explain why; if yes, give an example.

7. A glider is an aircraft without an engine. For every kilometer of altitude lost, it can travel about 60 kilometers horizontally. By using thermals, i.e. bubbles of warm air of several hundred meters in diameter, a glider pilot can spiral up to higher altitudes and so increase horizontal reach to hundreds of kilometers.

   During cross-country flights of a glider, a pilot carries a mobile computer in the cockpit, that is connected to a GPS receiver and gathers information about the flight, such as location and altitude. By connecting the computer also to a transceiver that can communicate on the short range device frequency band, the computer can send this data to other devices using the same kind of transceiver, up to 40 km away in other gliders or on the ground, and it can receive up-to-date weather data from other devices.

   Consider the design of a data communication protocol between computers connected this way in a mesh network (a network in which each node captures and disseminates data, as well as relays data that it receives from other nodes). A design document [2] lists the following requirements:

   - The protocol should disseminate data among gliders in sparse and dense networks.
   - It should cope with node mobility (nodes enter and leave the network and change their geographical position).
   - Communication overhead (operations not directly related to disseminating data) should be small.
   - Propagation delay should be small.
   - Important messages must be prioritized over unimportant ones.

- Delivery ratio should be as high as possible.

No further information is given about the exact meaning of these requirements. The design report has defined the following indicators to measure these requirements.

- *Successful packet transmission* occurs when all bytes in a packet have been sent by a transceiver.
- *Successful packet reception* occurs when a transceiver has received all bytes in a packet and had decoded the packet.
- *Number of successful packet receivers* is the number of *successful packet receptions* divided by the number of *successful packet transmissions*.
- *Latency* is the age of a packet when it is received by a node for the first time.
- *Packet loss* is the number of successfully received packets divided by the number of packets successfully sent.
- The *delivery ratio per priority* is the number of nodes that receive packets of this priority, divided by the number of nodes.

Answer the following questions about these requirements and indicators.

(a) Describe for each requirement, whether and if so, how, i.e. by what test, it can be measured using these indicators.

(b) If an indicator's definition is still ambiguous, propose an improvement.

(c) If any additional indicators are missing, please define these.

8. Usability is often defined in terms of three indicators:

   - Learnability, defined as user's effort to learn to use an artifact.
     - One indicator of this is average learning time for a group of users
     - A second indicator is the usability of the user manual
   - Understandability
     - One indicator for this is perceived understandability, as rated by the user.
   - Operability, defined as user's effort for operation and operation control
     - One indicator for this is expert-perceived operability, as rated by experts.
     - A second indicator is user-perceived operability, as rated by users after a period of use.

   The following questions are about construct validity.

   (a) Could a system be learnable, understandable and operable for a user and still not be considered usable by that user, on reasonable grounds?

   (b) Are the three indicators independent? That is, for every pair of indicators, is there an example system that satisfies the one but not the other indicator? If so, give an example for that pair.

Assignment

Consider the following three theses:

- Adolfsen (Preface, abstract, table of contents, chapter 1-3).
- Bruintjes (Preface, abstract, table of contents, chapter 1).
- De Wit (Preface, abstract, table of contents, Chapters 1-4).

Answer the following questions for the following theses, basing your answers on the indicated parts of the theses only.

1. What is/are the artifact(s) studied?
2. What are the requirements for the artifact(s)?
3. How are the requirements motivated in terms of their contribution to the stakeholder goals? (Use your answers to the assignments in Chapter 5.)
4. Classify the requirements in terms of stakeholders (slide 15 and further) and by aspect (slide 19)
5. For each requirement, does the thesis define one or more indicators for the requirement? If so, which?
6. For each indicator, are criteria defined? Why (not)?

Hint:

- Read between the lines. Not all definitions are announced by the word "definition" in a thesis.
- Acknowledge imperfection. Some definitions are incomplete and some are ambiguous. Where this is the case, acknowledge it, and do not try to improve the definition.

Chapter 8

Design Validation

Questions

1. Consider again the wireless communication protocol for gliders of exercise 7 of chapter 7. If a node A in a wireless glider network receives messages from two other gliders, B and C, it will not receive any message if the two receptions interfere. This prevents B and C to communicate with each other through A. This is called the hidden terminal problem. Together with the dynamics of glider networks, this leads to a number of requirements on a data communication protocol as listed in exercise 7 of chapter 7 (page 14).

   A design report about glider data communication protocol design lists the following design problems.

   P1 What wireless communication protocol is most suitable for the exchange of information between gliders?

   P2 How can the protocol deal with the hidden terminal problem?

   P3 How can lossless communication be provided with the protocol?

   P4 How can the protocol deal with the mobility of gliders?

   Translate these problems into one design problem and validation research questions of the four types discussed in this chapter. Use the information given in exercise 7 of chapter 7. Refer to chapter 2 for the template of design problems.

2. In exercise 3 of Chapter 3 (page 4) you formulated the design problem and validation research questions for a protocol to be designed for communication between home care medical observation devices and a home care station. In exercise 2 of Chapter 7 (page 13) you analyzed some requirements for the protocol in terms of their assumptions on the architecture of the environment. Use the added insight of that analysis to refine the validation research questions for the protocol design.

3. (a) What is the fundamental problem of validation?
   (b) How can the problem be mitigated ("made smaller")?
   (c) Can the problem be solved (eliminated)? Why (not)?

4. (a) Why is illustration not a research method?
   (b) If illustration is not a research method, why should one use it at all?

5. (a) Why is formal verification not an empirical research method?

(b) If formal verification is not a research method, why should one use it?
(c) If one is able to use formal verification, why should empirical validation then still be necessary?

6. (a) What is the purpose of validating an artifact by expert opinion?
   (b) What are the limitation of validation by expert opinion?
   (c) How can you mitigate these limitations?

7. (a) Describe the six steps of mechanism Simulation, using an example.
   (b) List the different ways in which an artifact can be built or acquired.
   (c) List the different ways in which the context can be built or acquired
   (d) There are three possible goals of mechanism simulation. Describe these goals giving examples.
   (e) What are the limitations of mechanism simulation. How can these limitations be mitigated?

8. What is the similarity and what is the difference between technical action research and mechanism simulation? Give an example to explain the similarity and the difference.

   (a) Describe the six steps of a statistical difference-making experiment, using an example.
   (b) What are the roles of statistics in data analysis?

9. Scaling up to practice takes place along two dimensions.

   (a) Describe these dimensions.
   (b) What role do mechanism simulation experiments and statistical difference-making experiments play in scaling up research?

10. Position expert opinion research, mechanism simulation experiments, technical action research and statistical difference-making experiments in the diagram of slide 61.

11. Validation is risk assessment.

    (a) Who are the risk-takers, and what risks do they take?
    (b) What does validation research do to mitigate these risks?

12. Validating a design is validating a theory

    (a) What theory is validated in validation research?
    (b) In which two ways can this theory be validated?

Assignments

Answer the following questions about the thesis by Adolfsen.

1. What is/are the artifact(s) studied?

2. Check the validation research questions that you formulated in the assignment of chapter 3 against the requirements that you analyzed in chapter 7, and update the validation research questions if necessary.

3. The student used mechanism simulation to answer his validation questions. Describe how each of the tasks on slide 32 were performed, giving references to page numbers of the thesis where these descriptions are found.

Chapter 9

Scientific Theories

Questions

1. (a) What are the two characteristics of scientific theories?
   (b) How are these characteristics maintained in practice?
   (c) Do these characteristics give empirically validated scientific theories the certainty of mathematical theories?

2. (a) What are the two components of scientific theories?
   (b) Are both components mandatory or could we have a scientific theory with one of them missing? If so, what could such a theory be used for?

3. (a) In exercise 2 of chapter 3 you formulated knowledge questions about a sensor database system.
      i. What conceptual framework(s) are used to state these questions? Give a few examples of concepts in these frameworks.
      ii. The answers to these effect questions are theories. Give an example of such a theory.

4. (a) In exercise 3 of chapter 3 you formulated three effect questions for an application layer protocol wireless home care devices.
      i. What conceptual framework(s) are used to state these questions? Give a few examples of concepts in these frameworks.
      ii. The answers to these effect questions are theories. Give an example of such a theory.

5. (a) A conceptual framework cannot be true or false. Explain this.
   (b) Explain which questions we can ask to test a conceptual framework's usability, and which questions we can ask to test its usefulness.

6. (a) Constructs are used to define samples and to interpret measurements. Describe these two uses of constructs.
   (b) What is the problem of construct validity in both of these cases?

7. (a) Describe five threats to construct validity.
   (b) There are two ways to check the mutual consistency of operationalizations. Describe these.
   (c) Managing construct validity requires the researcher to be explicit in several different ways. About what should the researcher be explicit?

8. (a) What is the difference between a population and a scope? Give an example.

9. (a) Describe the paradox of idealization and give an example of it.
   (b) How is the paradox resolved in laboratory science?
   (c) How is it resolved in engineering science?

10. (a) What are the uses of theory in problem investigation and implementation evaluation?
    (b) What are the uses of theory in treatment design?
    (c) What are the uses of theory in design validation?
    (d)

11. (a) Can a theory be prescriptive? Why (not)?
    (b) What conditions should a theory satisfy when used to support a decision?

12. (a) "Every validated design specification is supported by a theory." Why?

Assignments

Answer the following questions about the thesis by Adolfsen.

1. Section 6.1 of this thesis presents summaries of three sets of measurements done in case 1, plus explanations.
   (a) Which sets of measurements have been done?
   (b) Are any of the measurement data included in the thesis?
   (c) What theory (or theories) are proposed to explain these observations?
   (d) Relate these theories to the causal graph you made in assignment 1 of chapter 6.
   (e) What is the scope and population of these theories?
   (f) Give any alternative explanations that you can think of.

Chapter 10

Research Design

Questions

1. Scaling up proceeds by two dimensions, each with two extreme values, giving a total of four combinations of extremes of these dimensions. Define these dimensions and give examples of research designs in the four extreme corners of this classification.

2. (a) Define the concept of a model and give an example.
   (b) What is the difference between a modelling study and a case study?

3. For each of the following research designs, (i) indicate what the object(s) of study is (are), (ii) what the population is, and (iii) whether each OoS is a model or a case.
   (a) The research design for survey of expert opinion of section 8.2.3 (slide 30).
   (b) The research design for mechanism simulation of section 8.2.4 (slide 39)
   (c) The research design for technical action research of section 8.2.5 (slide 47)
   (d) The research design for statistical difference making of section 8.2.6 (slide 52).

4. (a) For each of the research designs of exercise 3, discuss the suitability of the OoS to answer the research questions.

5. (a) Explain the difference between an independent variable and a treatment.

6. (a) For each of the research designs in exercise 3, indicate (i) what the independent variable(s) is/are, (ii) what the dependent variable(s) is/are and (iii) whether there is a treatment and if so, what is the treatment.

7. (a) Explain the difference between a quantitative, qualitative and interpretative scale. Give examples of each.

8. (a) For each of the research designs in exercise 3, indicate (i) what measurements are made, (ii) what instruments are used to make the measurements (if no instruments are mentioned, indicate which instrument(s) you would use), and (iii) the validity and suitability of the measurement specification.

9. (a) What is the difference between deductive and ampliative inference?

(b) Describe in which sense descriptive inference, abductive inference and inductive inference are all ampliative.

10. (a) What are the two steps of case-based inference?
    (b) Define what internal and external validity mean for case-based inference, in terms of these steps.
    (c) Discuss one threat each for internal and external validity in case-based inference.

11. (a) For the three examples on slide 49, identify the abduction step and the generalization step. For each example, explain what justifies the generalization.

12. (a) Describe the two steps of sample-based inference.
    (b) Define the meaning of conclusion validity, internal and external validity in sample-based inference.
    (c) Describe one threat against conclusion validity in sample-based inference.

13. (a) Identify the two steps of sample-based inference in the two experimental statistical studies mentioned on slide 65.
    (b) Check which threats against conclusion validity listed on slide 66 could materialize in each of the experiments.
    (c) Check which threats to internal validity (slide 52) could materialize in each of the experiments.
    (d) Check which threats to external validity (slide 56) could materialize in each experiment.

Assignments

Answer the following questions about the reesearch design described in chapter 5 of the thesis by Adolfsen.

1. Adolfsen describes a number of OoS's of the form (Artifact X Context). Which are they?

2. Are these OoS's models or cases?

3. At several points in chapter 5, Adolfsen gives elements of a similarity argument for these OoS's. Summarize all these parts of the argument and discuss validity of the choice of OoS.

4. What is treatment validity in this research design? How is treatment validity ensured?

5. What is measurement validity in this research design? How is measurement validity ensured?

6. What is internal validity in this research design? How is internal validity ensured?

Chapter 11

The Empirical Cycle

Questions

1. The empirical cycle and engineering cycle are both instances of a rational problem-solving cycle. Describe the rational problem-solving cycle and show how the empirical and engineering cycles are instances of it.

2. List the three principles of research ethics and show how these principles occur in the different parts of validating a research design.

3. Make a list of knowledge goals in the engineering cycle, and give examples of them.

4. The validity of research design decisions consists of four kinds of criteria (slide 31). Relate these criteria to the standard validity questions of the engineering cycle (effect, requirements, trade-off, sensitivity).

5. (a) "Validation of measurements and inferences cannot be done during research design but can only be done during analysis of results." Why is this statement false?

   (b) "Validation of measurements and inferences must not only be done during design but also during analysis." Why is this statement true?

   (c) The suitability of the research design (OoS, treatment, measurements) and the validity of research design (measurements, inferences) all receive attention in the checklist questions for results Analysis. Indicate where these issues receive attention.

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