

Research Methods in Informatics and its Applications: Design-Oriented Research

Matthias Baumgart¹ M. Yaser Houri² Thomas Rückstieß³
Frank Sehnke⁴

¹Efficient Algorithms, TU Munich, baumgart@in.tum.de

²System Architecture Group, University of Karlsruhe, houri@ibds.uka.de

³Robotics and Embedded Systems, TU Munich, ruecksti@in.tum.de

⁴Robotics and Embedded Systems, TU Munich, sehnke@in.tum.de

April 27, 2007

Content

- 1 Introduction
- 2 Relationship
- 3 Methodology
- 4 Pros and Cons
- 5 Examples in Our Research

Research

Research is an **activity** that contributes to the **understanding** of a **phenomenon**.

A phenomenon is

- a set of behaviours of some entity(ies) that is found interesting by the researcher

Understanding is

- knowledge that allows prediction of the behavior of some aspects

Design

Design can denote many things:

design as **profession**, as an **activity**, or as an **artifact**

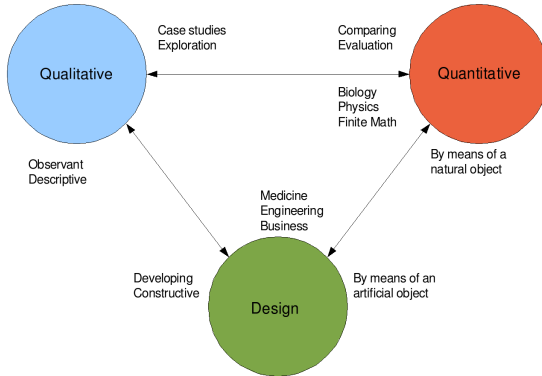
In our context, design

- is an activity
- means “to invent and bring into being”
- creates something new that usually serves human purposes

Design-Oriented Research

Design-Oriented Research **produces new knowledge** as its main objective. The **creation of an artifact** during this process plays an important role but is not the main goal.

Relationship



Parkinson:

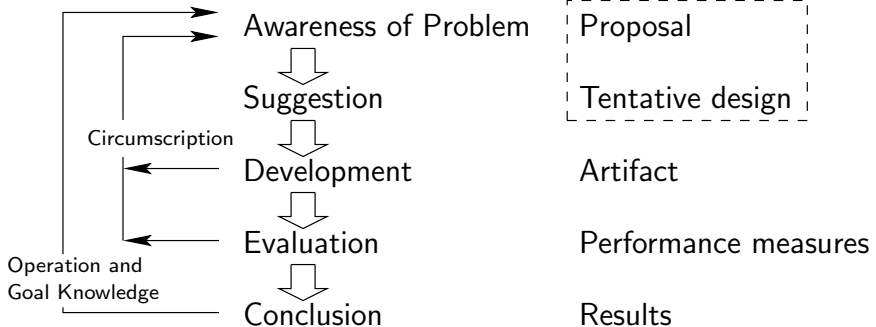
- Medicine described different patients with loss of motor control... (Qualitative)
- Parkinson compared these case studies and discovered one disease pattern (Quantitative)
- Specific medicaments that simulate Parkinson disease ... (Design)

General Methodology of Design Research

Knowledge
Flows

Process
Steps

Outputs



Awareness of Problem

- Comes from multiple sources:
 - New developments in industry
 - Allied discipline
- Output is a Proposal.

Airplane

Problem: How to fly?

Awareness of Problem

- Comes from multiple sources:
 - New developments in industry
 - Allied discipline
- Output is a Proposal.

Airplane

Problem: How to fly?

Awareness of Problem

- Comes from multiple sources:
 - New developments in industry
 - Allied discipline
- Output is a Proposal.

Network Protocol

Problem: Developing network protocol for wireless LANs.

Suggestion

- Creative step towards problem solution drawn from the existing knowledge/theory base.
- Output is a Tentative Design.

Airplane

Suggestions: Drawn shapes and Calculations

Suggestion

- Creative step towards problem solution drawn from the existing knowledge/theory base.
- Output is a Tentative Design.

Airplane

Suggestions: Drawn shapes and Calculations

Suggestion

- Creative step towards problem solution drawn from the existing knowledge/theory base.
- Output is a Tentative Design.

Network Protocol

Drawn figures and specifications of how this protocol should work

Development

- Implementation of the Tentative Design.
- Output is an Artifact.

Airplane

Wright brothers built the first powered heavier-than air flight in 17th December 1903.

Development

- Implementation of the Tentative Design.
- Output is an Artifact.

Airplane

Wright brothers built the first powered heavier-than air flight in 17th December 1903.

Development

- Implementation of the Tentative Design.
- Output is an Artifact.

Network Protocol

Writing a program that implements the behavior of the protocol.

Evaluation

- Evaluating the artifact according to a implicit or explicit criteria made in the Proposal.
- Deviations from expectations must be tentatively explained.
- Output is a Feedback to another round of Suggestion.

Airplane

They had control problems, which are solved later by using ailerons.

Evaluation

- Evaluating the artifact according to a implicit or explicit criteria made in the Proposal.
- Deviations from expectations must be tentatively explained.
- Output is a Feedback to another round of Suggestion.

Airplane

They had control problems, which are solved later by using ailerons.

Evaluation

- Evaluating the artifact according to a implicit or explicit criteria made in the Proposal.
- Deviations from expectations must be tentatively explained.
- Output is a Feedback to another round of Suggestion.

Network Protocol

Simulating the behavior of the protocol using a network simulator.

Conclusion

- Expose final results.
- Anomalous behavior of the artifact is the subject of further research.

Airplane

With airplanes further research in aerodynamics was possible.

Conclusion

- Expose final results.
- Anomalous behavior of the artifact is the subject of further research.

Airplane

With airplanes further research in aerodynamics was possible.

Conclusion

- Expose final results.
- Anomalous behavior of the artifact is the subject of further research.

Network Protocol

This protocol has better performance than other protocols.

Advantages of Design Research

- Some knowledge might not be accessible without a designed artifact.

Example

To do research on subatomic particles (quarks), researchers have to build a particle accelerator first, since they are not visible with the naked eye.

Advantages of Design Research

- Design Research involves building something artificial, hence the time and conditions of the research can be determined by the researcher, rather than the research object.

Example

Earthquake researchers have to wait for an earthquake to happen, while someone who designs a mathematical model of an earthquake can do his research whenever he chooses.

Advantages of Design Research

- The designed artifact might have additional or unexpected value, in addition to being a tool for conducting research.

Example

Atomic Force Microscopes were originally developed to view single atoms on a surface. It turned out, that with the fine tip of the microscope it was for the first time possible to manipulate and push single atoms as well. Teflon was originally invented to conduct research on ultra-low friction for industrial purposes. Now it can be found in every household pan.

Disadvantages of Design Research

- Since the research objects are of artificial nature, they are imperfect or inaccurate. Mistakes and misleading conclusions might be drawn by using the artifact.

Example

Software to process recorded data might be buggy and makes errors in its calculations. The hubble telescope software had some bugs before and only very blurry pictures could be received.

Disadvantages of Design Research

- The necessity to build artifacts might be costly, dangerous, or disadvantageous in some other sense. It might require a lot of resources, just to create the artifact, before research can be done.

Example

Meteorological satellites not only are expensive but there is always the risk of destroying them in the process of shooting them in the atmosphere with a rocket.

Disadvantages of Design Research

- By trying to answer a research question by means of an artifact, one might (consciously or subconsciously) be tempted to develop the artifact biased towards an answer one would expect or like to find out. Design research imposes a danger of subjectiveness towards the research.

Example

to be discussed now...

Examples in Our Research

Design Research in Computer Science:

- Model-building and Simulations
- Benchmarks
- Software Engineering (not in general)

Examples in Our Research

Matthias: Tool to count Spanning Trees.

Yaser: Network Protocoll.

Thomas: Hand Simulator to test and compare algorithms.

Frank: FlexCube.

Thank you for your attention.

Any questions?

References



S. T. March and G. F. Smith.

Design and natural science research on information technology.

Decision Support Systems, 15:251–266, 1995.



H. Simon.

The Sciences of the Artificial.

Cambridge, MA, MIT Press, 1996.



V. Vaishnavi and W. Kuechler.

Design Research in Information Systems.

www.isworld.org/Researchdesign/drisISworld.htm