Preparing a Ph.D. Thesis Proposal in Informatics

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Abstract

This document discusses the nature and purpose of a Ph.D. thesis proposal in informatics. The thesis proposal is an important milestone, as it structures the essential conceptual foundation of the study, showing intent, drive, and capacity for knowledge generation. The informatics domain covers computer science, software engineering, information systems, human-computer interaction, and other fields related to software and information.

Keywords: Research Design, Thesis Proposal, Ph.D. in Informatics.

1 Introduction

A thesis proposal (TP) is a written document expressing and structuring the essential elements of a study. It serves to communicate the nature and purpose of the study and how it is intended to be accomplished. Developing a TP is challenging because of the diverse research elements involved and the various ways these elements can be combined. Decisions regarding what elements to consider and how to organize them must be wary of several quality dimensions, including the quality of the proposition (novelty, relevance, and affinity with the domain), the quality of the process (rigor and systematicity), and the quality of the communication (clarity and consistency).

The communication dimension is often neglected when preparing the TP as you immerse in and gain familiarity with the research domain and focus on a problem. On the other hand, examiners can be highly sensitive to communication issues, amplifying perceived inconsistencies. This cognitive conflict can frustrate both parties. It happens so often that you present an interesting idea but fail to demonstrate mastery of the research process (e.g., by neglecting methodological issues) or fail to articulate the various elements of the research compellingly (e.g., unclear constructs).

The primary purpose of this document is to help you understand that good communication is an essential and inseparable part of Ph.D. research and that it should be accomplished from the very beginning. We assume that the TP takes one semester to one year to complete, and its acceptance by examiners is a condition for continuation with the Ph.D.

2 Research Design: An Overview

A TP is intended to provide a view into the future. Research design is the process of putting together the elements necessary to explain and justify a study's nature, purpose, and process. Research design is also the output of this design process: research designs are intended to answer some fundamental questions about the study. In general, a research design should explain:

- Problem statement (showing potential relevance to research and practice);
- Background (contextualizing the study in the research landscape);
- Related work (positioning the study against the state of the art);
- Research questions (guiding the search for knowledge);
- Mains constructs (specifying what knowledge will be researched);
- Research approach (indicating how the constructs will be operationalized and validated);
- Research contributions (showing uniqueness and novelty);
- Importance (indicating potential impact on research and practice);
- Methodology (demonstrating rigor and systematicity);
- Planned activities (exhibiting viability).

Figure 1 shows an artifact named TP canvas, which summarizes the abovementioned elements. This artifact offers two advantages: 1) it overviews the fundamental questions that the examiners can ask about the study, and 2) it helps contemplate the research design as a coherent whole, where all elements must be articulated and harmonized.

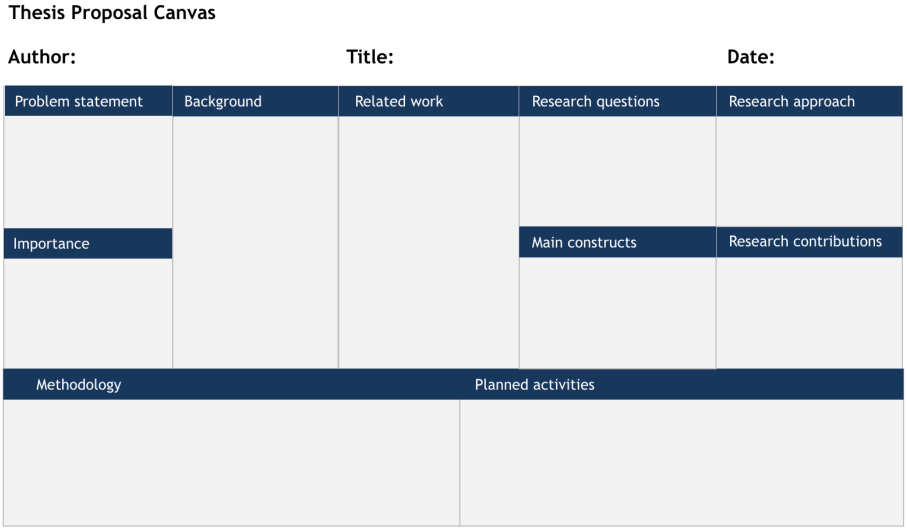

Figure 1. Thesis proposal canvas (template)

The canvas shown in Figure 1 is a template. It can be adapted to emphasize specific aspects of the research. For instance, Gregor (2017) defines a template that emphasizes the theoretical background of a study. Informatics is a diverse domain; therefore, different research practices may require fine-tuning the elements of research.

A theoretical discussion about canvases can be found in Antunes and Tate (2022). It shows that the canvas can systematize a TP at both the surface and deep levels, where the former deals with finding the knowledge elements you need to address in the study (domain knowledge), and the latter concerns finding a balance between the elements of the research (problem, approach, contributions, etc.).

3 Research Design: The Details

The elements discussed above provide an entry point for research design. The actual demonstration that the research design is fit for purpose requires going into further details. For instance, in relation to the problem statement, the TP should indicate if the study is addressing a problem (stemming from research and/or practice), a gap in the literature (new concept or conceptualization), a challenge (e.g., improving performance), an opportunity (e.g., transferring knowledge to a different domain), or a set of requirements (common in informatics).

Figure 2 shows the TP canvas with a more detailed set of research elements that may be necessary to detail the study. This helps explain the nature, purpose, and process of research, understand the relationships between the various elements of the research, and check for quality.

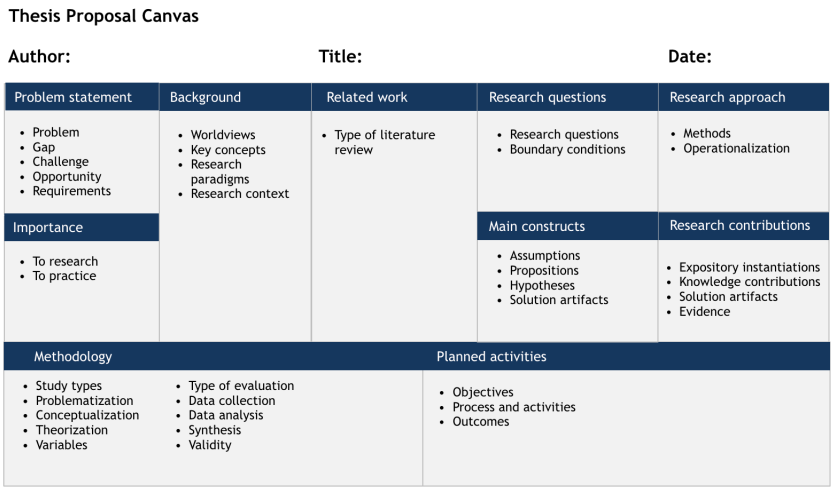

Figure 2. Thesis proposal canvas with detailed elements

The TP canvas does not have to be explicitly presented in a TP. It can be used in the background to help you accomplish the research design. Nevertheless, you should assume that examiners will have an implicit canvas in their minds, given that it highlights fundamental questions about the study.

4 Research Design: The Narrative

The TP must effectively communicate the research design. Sheppard and Suddaby (2017) suggest that good research communication requires telling a good story. The authors elaborate on the following narrative structure (Figure 3):

- **Narrative setting**: The time and place where the story starts. This refers to the study context. In informatics, the context is often technical, concerning a technology, system, or application. In some cases, the context is socio-technical, concerning the relationships between technology and people (e.g., user experience). Given the diversity of the domain, a variety of research contexts can be considered.
- **Narrative conflict**: The tension that drives the story and makes it interesting and relatable. Any good story requires a good conflict. This refers to the research problem (or research gap, challenge, opportunity, and set of requirements). The conflict must be compelling, exhibiting a certain level of drama and urgency in problem-solving. The conflict can be a research problem, gap, challenge, opportunity, or set of requirements.
- **Main characters**: The focal point of the story, around which events occur. This refers to core constructs that capture what will make the study move. Core constructs conceptualize how the conflict can be resolved. As part of this conceptualization, we can include research questions, assumptions, boundary conditions, statements, hypotheses, and solution artifacts. Solution artifacts are common in informatics, representing empirical characterizations of software and information.
- **Narrative arc**: Where the story goes. In other words, having stated the problem, you must explain which research activities will be done to tackle it.

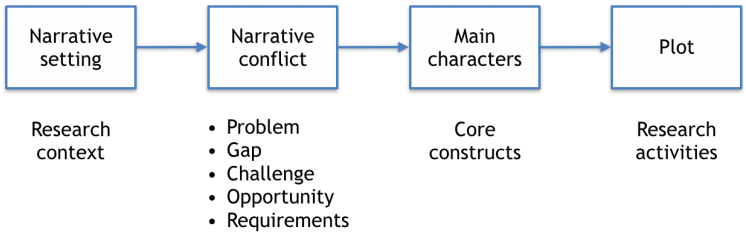

Figure 3. The narrative

This kind of narrative complements the research design; it does not prevent careful consideration of the detailed elements (Figure 2). Strictly organizing the TP in accordance with this narrative structure will lead to many holes in your TP. You can, for instance, structure the introductory part of the TP according to this narrative, as it will start by telling a compelling story about your study, but then you also need to identify and structure the other elements of the research. Next, we further discuss some of those elements.

5 Worldview

Scientific research is framed by competing worldviews (e.g., quantitative versus qualitative research, positivism versus pragmatism, systems design versus use, technical versus socio-technical systems) and research communities built around these worldviews. Therefore, you must carefully position your study within a research community. You should understand the main philosophical stances, theoretical views, and research practices adopted by the target research community. These can be found in foundational publications by key researchers which you should necessarily refer to in the TP.

The *worldview* concept differs from the *domain* concept. On the one hand, the domain situates the research problem. For instance, the problem may relate to systems architectures, programming languages, information processing, user experience, etc. On the other hand, the worldview identifies the unique set of values, paradigms, theories, methods, and experiments adopted by a research community that permits a specific set of solutions (Kuhn, 1970). For instance, the sensemaking construct has been researched from two very different worldviews: organizational, which emphasizes how organizations make sense of situations (Weick *et al.*, 2005), and individual, which centers on how individuals make sense of situations (Klein *et al.*, 2006).

Communities fiercely compete for relevance and status in the pursuit of knowledge. However, understanding the different forces in play can be overwhelming. This is an area where the supervisors' expertise is critical to position the TP. Carefully consider the mix-up of different foundations and the use of equivocal arguments pertaining to different communities. The adopted worldview should be identified early on to avoid misconstruing the TP. A careful selection of foundational references helps readers determine how well the TP aligns with the adopted worldview. Provide examples of relevant studies stemming from the adopted worldview and discuss the affinities and similarities to your study. The TP should seek affinity with and recognition from the selected research community.

6 Methodology

Methodology concerns the philosophical debate about how research is done, considering, for example, principles, frameworks of understanding, and research methods (Stol and Fitzgerald, 2018). Methodology scaffolds the decision-

making process, leading the study toward a particular research design. As quoted by Stol and Fitzgerald (2018), "The proper place to study elephants is the jungle, not the zoo. The proper place to study bacteria is the laboratory, not the jungle." Before explaining the main design elements of a study, the TP should explain how those decisions were shaped by methodology.

Methodology is a difficult topic for novice researchers. Anecdotal evidence from many TPs suggests the topic is frequently misunderstood. This happens for two main reasons. One reason is the diversity of the domain, often leading to discussions about individual methods and approaches instead of principles. Another reason is the pragmatist philosophical standpoint about knowledge production in informatics (Biesta, 2010), justified by the multiplicity of problems found in the domain, thus leading to a preference for problem-solving approaches (De Souza, 2018).

Anecdotal evidence also suggests that, in many cases, what is presented as methodology is just a series of steps with no solid justification. The methodology, if any, is unstated, assuming that the examiners can easily map the proposed steps to existing methodologies. This lack of clarity can be misleading and should be avoided. The TP should discuss existing methodologies, justify the adopted methodology, and include citations to relevant foundational method papers guiding the study.

Note that your study is expected to deliver novelty. However, the novelty is in the research constructs, not the methodology. Following well-regarded methodologies reinforces the study's rigor and is no indication of a lack of novelty. Proposing a new methodology is not usually within the scope of a Ph.D. study, as methodologies are developed over time by the research community.

An important decision to make is what study type to adopt. The following list highlights some common types found in informatics:

- **Experimental research** (Stol and Fitzgerald, 2018): Focuses on evaluating something (e.g., algorithms, systems, tools) under controlled conditions. Usually, there is an emphasis on quantitative evaluation and comparative analysis (e.g., before-and-after, this-versus-that).
- **Exploratory research** (Stol and Fitzgerald, 2018): Focuses on exploring possibilities brought by new ideas, technologies, and applications. Exploration is often done in poorly controlled conditions or artificial environments. Usually, it seeks to understand the challenges of a particular setting and gather qualitative findings about "what was going on."
- **Descriptive research** (Creswell, 2009**)**: It is highly theoretical. A set of variables is defined, and their relationships are studied, which helps describe and ideally explain a phenomenon of interest (e.g., database optimization, protocol efficiency). This type of research is highly sought after in the information systems field, but it is less common in the broader informatics landscape.
- **Developmental research** (Richey and Klein, 2005): It is pragmatic and practice-oriented. The main focus is developing a first-of-a-kind artifact (e.g., new language, algorithm, interaction device, software framework). It involves careful articulation between the problem, requirements, design, development, and evaluation. The primary evaluation focus is on successful use.
- **Design science research** (Hevner *et al.*, 2004): It is focused on creating novel and innovative artifacts (e.g., methods, constructs, algorithms, architectures, systems, and processes) that resolve identified organizational problems (e.g., security, privacy, performance). Design involves iterative build-evaluate cycles anchored on relevant needs and a rigorous understanding of the existing knowledge base (e.g., models, methods, designs). The primary evaluation focus is on utility. Design science research is very common in informatics. For instance, decision-support systems are often researched using design science (Arnott, 2006).
- **Action research** (Baskerville, 1999): It is grounded in immediate and practical action to solve an immediate problem based on useful knowledge. It involves an intervention from the researcher in a real-world organization, such as introducing a new technology or software development practice in a company. The evaluation focus is on observing and analyzing the impacts of the intervention.
- **Case study research** (Ketokivi and Choi, 2014): Focuses on a detailed understanding (thick descriptions) rather than a generalized understanding of a phenomenon. It considers a particular case or a set of cases and their empirical contexts, which are then analyzed and compared in detail (e.g., introducing a privacy-preserving mechanism in a hospital's system).
- **Applied research** (Niiniluoto, 1993): Focuses on the practical application of existing knowledge (including technological solutions) into a new domain. The outcomes are usually focused on effectiveness towards the intended uses. Applied research is widespread in informatics, as ideas are constantly tested in different domains. However, care is necessary to provide substantive knowledge contributions from new applications.
- **Simulation research** (Stol and Fitzgerald, 2018): It models a particular system or phenomenon. It provides a detailed understanding of the model construction, explains the targeted system or phenomenon, and contributes measurements.

The TP should clarify and justify the adopted study type. The selection of study type influences the selection of methods and determines the research design. You should also provide a set of foundational method papers that substantiate the decision.

7 Literature Review

The literature review is an essential component of the research design. Unfortunately, a common approach to literature reviews in informatics is to build a "laundry list," where items of interest (studies, methods, algorithms, software components) are listed with no particular structure. Another approach that should be avoided is the "historical overview," where items of interest are discussed chronologically. Concerning the TP, historical overviews are not very interesting because they usually reveal more about your learning process than exactly where a research field stands today.

Systematic reviews are trendy nowadays (Paré *et al.*, 2015). They require the definition of a specific set of search criteria and systematic search in databases such as Scopus, Web of Science, and Google Scholar. The search is followed by screening, where well-defined inclusion and exclusion criteria are consistently applied. Systematic reviews are highly recommended. When doing systematic reviews, the search strings and inclusion/exclusion criteria should be reported.

A good literature review should not just account for prior research. It should also clarify and structure the current state of the art. Two excellent ways to do this are (Kuorikoski and Ylikoski, 2015):

- **Build a conceptual framework**: Define a set of concepts and relationships (using boxes and arrows) that position the research problem, highlight different concerns, issues, and sub-problems, and emphasize the missing knowledge. A conceptual framework summarizes your viewpoint about the state of the art.
- **Build a model**: Characterize the state of the art using a known modeling approach. The model highlights typical relationships, such as cause-effect, input-process-output, parent-child, and before-after.

Antunes et al. (2022) explain the significant properties of these types of artifacts. An example can be found in Antunes and Tate (2024).

8 Problematization

Problematization concerns the process of identifying and characterizing a research problem (Alvesson and Sandberg, 2011). It derives from a critical analysis of the literature review. There are several well-known approaches to problematization:

- **Critical research**: Identify a phenomenon of interest, characterize the existing explanations, and then challenge those explanations.
- **Problem-solving**: Identify a current problem (with theoretical and practical implications) and propose an innovative, one-of-a-kind solution.
- **Gap spotting**: Characterize an existing body of knowledge and then discuss what specific knowledge is missing.
- **Requirements definition**: Characterize a future artifact and its operating environment and show that developing the artifact requires meaningful research.

Problem-solving and requirements definition are common problematization approaches in informatics, an applied research domain.

9 Research Questions

There must be more than an interesting problem to pursue a Ph.D. study. The problem must be translated into good research questions. Research questions are the cornerstone of research design. They represent the facets of research that the study will explore.

Miles et al. (2014) identify the following types of questions addressing different kinds of knowledge:

- **Questions of 'what'**: For instance, "What is the impact of X on Y?" and "What are the components of X?". They focus on the nature of something, e.g., systems, components, and tools.
- **Questions of 'how'**: For example, "How is X developed?" and "How does X affect the quality of Y?" They focus on processes, such as a protocol or the process of designing a system.
- **Questions of 'why'**: For instance, "Why is X better than Y?" They focus on understanding something based on principles, explanations, and causation (cause-effect and influence-affect relationships).

Since informatics is an applied, constructive, and exploratory research domain, the TP may involve a variety of questions covering the three categories.

Figure 4 shows a template for developing research questions in studies related to constructive research, such as design science research. Studies using this template are structured according to three sets of questions (Thuan *et al.*, 2019):

- **Way of knowing**: Questions about what knowledge is available about the research problem, considering both the prior knowledge (state-of-the-art) and new, contributed knowledge.

- **Way of framing**: Questions about which concepts are necessary to frame the problem. They consider both the internal (properties, components) and external aspects of the problem (requirements, constraints).
- **Way of designing**: Questions about how the problem can be solved, considering aspects such as conceptualization, operationalization, and evaluation.

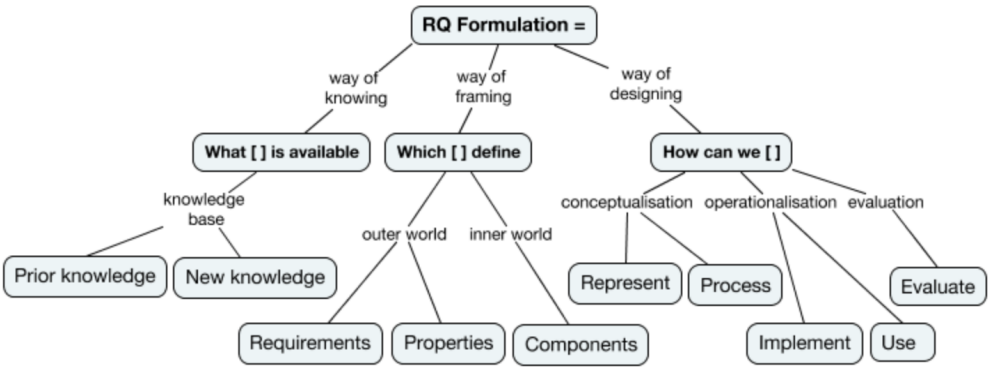

Figure 4. Research questions

Bordens and Abbott (2014) note that research questions should fulfill some essential criteria:

- They should be answerable. Not all questions can be answered.
- They should be answerable by scientific means (i.e., objective and precise, reproducible under the same conditions, and confirmable by others).
- They should be relevant, not trivial, or already established questions. A question is relevant if it allows discriminating between several competing answers.

10 Constructs

Constructs are a fundamental part of research design, where you state and argue for tentative answers to the research questions. Constructs are treated as objects under investigation and scrutiny (Ravitch and Riggan, 2016).

Constructs are logical building blocks. The study takes some building blocks at face value (e.g., assumptions, pre-conditions, and pre-existing findings) as they are thought to exist. The study also explicitly proposes and evaluates other building blocks for success and failure. The process of assessing a construct for failure is known as falsification (Popper, 1972).

Constructs should be stated formally and concretely. Vague constructs must be avoided because they are formulated in a way that cannot be reproduced. Based on anecdotal evidence, some statements found in TPs but failing to pass the required threshold for constructs include:

- "I will explore the adoption of X in…": Expresses an intention, not a proposition. The knowledge contribution is vague. Therefore, it cannot be falsified.
- "I will develop X for…": It is expressed in a too practical way. There is no commitment to a specific knowledge contribution.
- "X can be used to develop Y": The suggested impact of X on Y is unclear and cannot be precisely evaluated.
- "Can I build X?": It is a question, not a proposition.
- "The adoption of X can improve Y": The suggested impact of X on Y is unclear and cannot be precisely evaluated.

Some good examples of constructs include:

- "The adoption of X improves Y using criterion Z": Proposes a causal relationship between X and Y, which can be explicitly evaluated using Z.
- "By changing X in Y, the design of Z will improve using criterion W": Proposes causal relationships and an evaluation criterion.

A hypothesis is a specific type of construct. Hypotheses are educated guesses about the answers to research questions (Marczyk *et al.*, 2010). A hypothesis operationalizes the research question in a way that can be tested using a set of clearly defined boundary conditions, variables, and indicators (Shepherd and Suddaby, 2017).

Formulating a hypothesis is a complex task that requires argumentation, explanations, and justifications anchored in existing literature. Considering this level of detail and sophistication, you should not present a hypothesis in the TP's introductory chapter. Hypotheses must be formulated after the literature review, problematization, methodological discussion, and formulation of research questions. Only then can hypotheses be fully appreciated.

Formulating hypotheses is not a mandatory requirement in informatics. Many Ph.D. theses in informatics do not formulate them. This happens because they are particularly adequate for some study types (e.g., descriptive research) but not others. For instance, many studies in informatics tend to be exploratory or focus on design and development (e.g., building algorithms and architectures), where formalized answers may be challenging to establish a priori. Focusing on sound research questions seems more advisable than flaky hypotheses. A hypothesis that states, "I can build X," is a disservice to research in informatics.

A solution artifact is also a type of construct. A large body of research in informatics involves designing and building solution artifacts. Unlike other research domains where the main goal is to generate theoretical knowledge (e.g., structural parameters in structural equation modeling), in informatics, solution artifacts are an essential part of knowledge. In particular, solution artifacts provide expository instantiation, i.e., they illustrate how a problem can be solved, assist in understanding the solution, and provide the means for testing purposes (Gregor and Jones, 2007). As with other types of constructs, solution artifacts should also be formally stated.

Solution artifacts cannot be entirely black-boxed by the TP. In particular, details about the nature of the artifact, properties, inner components, and behavior are essential for others to recreate solution artifacts and apply them in different contexts (Simon, 1996; Walls *et al.*, 1992). Therefore, these details are essential elements of knowledge in informatics and should be briefly overviewed by the TP.

11 Research objectives

Research objectives express the study's targets and may include intermediate (e.g., building a dataset) and final objectives (e.g., validating a proposition). Research objectives are helpful in organizing the research process, as they clarify the "definition of done." Consider the following dependencies and logical organization:

- Research design → Research questions
- Research questions → Research objectives
- Research objectives → Research process

Note that, according to this structure, research objectives are subsidiary of research questions. The TP should reflect this dependency. The lack of research questions can make it difficult to understand why a study is relevant. The lack of research objectives can make it difficult to understand how a study will unfold. An overemphasis on research objectives may suggest a lack of understanding of the study's expected knowledge contributions.

12 Research process

The research process organizes the end-to-end research activities necessary to accomplish the research objectives. Considering the philosophy of science, the research process addresses two logics: the logic of discovery and the logic of justification (Bird, 2012). The logic of discovery considers the procedure for building new knowledge, while the logic of justification considers the procedure for validating those ideas (Gregor, 2017). Understanding how to articulate these two logics in the research process is essential. Without a clear logic of justification, it is difficult to explain how a study will deliver the intended contributions; without a clear logic of discovery, it is difficult to demonstrate how a study will explore new ideas. Figure 5 illustrates the research process, connecting motivation, problem statement, research questions, objectives, and process (Thuan *et al.*, 2019).

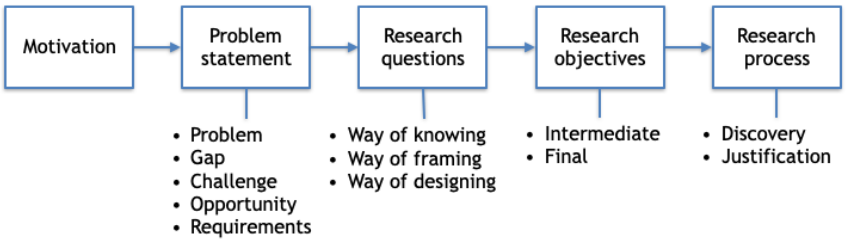

Figure 5. Research process

13 Contributions

Assume that the examiners will conduct a cost-benefit analysis of the study. The expected contributions of the study should be discussed against the opportunity and cost of doing the research. If a greater weight comes to the researcher's side, then the research is justified.

As noted earlier, in informatics, there is a strong tendency to consider solution artifacts as the main contributions of a study. However, solution artifacts should be complemented with other types of knowledge like:

- **Requirements and meta-requirements**: Demonstration of how a solution artifact addresses a set of requirements or a class of goals to which the solution artifact applies (Walls *et al.*, 1992). Requirements and

meta-requirements are essential to demonstrate that a solution a study provides is not a single occurrence but a repeatable resolution.

- **Justificatory knowledge**: Description of the principles, theories, and methods shaping the design and construction of solution artifacts (e.g., Agile principles, user-centered design) (Gregor and Jones, 2007).
- **Design process**: The decisions and activities leading to the artifact construction. These may be necessary to reproduce the solution artifact.

14 Planned activities

A project plan may be essential for Ph.D. research in informatics. This often happens because the study is part of a funded research project approved by external organizations to execute predefined activities.

Planning typically involves well-defined and coordinated steps, milestones, schedules, and deliverables. It is focused on execution, fostering motion and practicality. On the other hand, research design concerns knowledge generation in dialogue with existing knowledge and is more focused on theoretical and methodological maturity.

Since informatics is an applied domain, some natural and extensive juxtapositions exist between the project plan and the research design. After all, many Ph.D. studies require extensive planning related to software development. Some planned activities may be necessary to experiment with ideas but not necessarily contribute significantly to knowledge. For instance, building a data set may be required to develop and fine-tune an algorithm. Still, the data set per se cannot be considered a contribution to knowledge unless it has unique, innovative features (which should be targeted by research questions). On the other hand, Ph.D. studies must also develop and justify new knowledge contributions, which emerge and evolve from a combination of project work with theoretical thinking (Gregor, 2006).

However critical the project execution may be, it cannot be confounded with theoretical thinking. As the TP primarily supports the development of a Ph.D. thesis, it should emphasize theoretical thinking over execution. Once again, the distinction between the logic of discovery and justification is important. The logic of discovery relies on the execution of coordinated steps to generate new ideas. The logic of justification depends on theoretical thinking, including analytic, descriptive, explanatory, predictive, and prescriptive, to generate research contributions. The TP should primarily focus on the research design and consider the planned activities as being subordinate to the research design. Planned activities should only be discussed after the research design has been fully settled.

15 Document Structure

A recommended structure for the TP is as follows:

- Abstract
- Introduction
- Background
- Related work
- Research design
- Research process
- Conclusions
- References

15.1 Abstract

The abstract should provide a concise summary of the study. It is preferable to use a structured abstract, for example:

- **Research problem**: Avoid focusing on objectives and/or activities. The study should emphasize problematization and knowledge generation.
- **Research design**: Briefly mention the key research questions, constructs, and approach.
- **Expected results**: Indicate how the research advances knowledge.

The abstract should have around 200-500 words.

15.2 Introduction

The introduction should be linear and concise (usually 1-2 pages). Focus on telling a good story (Figure 3). Avoid waffle speech, i.e., too many grand ideas, open issues, digressions, historical accounts, unclear directions, and lack of meaning. Sometimes, researchers start with a grand idea and finish with a minor, incremental goal. Calibrate the challenges and goals so examiners can immediately focus on the story. Remember that the examiners may not know the research field in detail. Talk to a broad audience. Avoid bringing in too many technical details into the introduction.

Do not present research questions, propositions, or hypotheses in the introduction. These essential elements of research require significant contextualization and precision, which are impossible to achieve in the introduction.

15.3 Background

Position the research, identifying the wider and specific fields of the study (e.g., wider: information systems, specific: microservices) and identifying the adopted worldview. Identify the key concepts of the field.

15.4 Related work

Summarize the existing literature related to the study. Refrain from digressing too much. You do not need to go way back. Focus on contemporary views. Do not simply list topics, trends, or papers. Instead, build a conceptual framework showing major challenges, different pathways, and viewpoints.

Check the quality of the selected references. Also, check the overall recency of the citations. Too many old references may indicate that the topic is well-known or abandoned.

Identify who has been leading the research on the selected topic. These researchers should take center stage. Discuss existing reviews and meta-reviews on the chosen topic. Synthesize the literature review and point out the research gap.

The size of this section is highly variable but consider 10-20 pages.

15.5 Research design

Detail the elements of the research (Figure 2). You can organize the discussion in three main acts. In the first act, briefly recap the background and related work, culminating in a formal problem statement. In the second act, discuss the study's research questions and main constructs. They are the focal point of your study. Finally, in the third act, discuss the research approach, contributions, and importance. Give examples of studies adopting similar research designs. Act two should be formal, precise, and consistent.

The size of this section is highly variable, but consider 1 page for the first act, 1-2 pages for the second act, and 2-5 pages for the third act. Consider that, if the discussion about methods and operationalization becomes too large, some details could be sent to an annex.

15.6 Research process

Detail how the research design will be operationalized, considering, in particular, how the research questions will be answered and how the main constructs will be validated. Provide enough details for the examiners to understand exactly what you want to achieve and determine if everything is sound and feasible.

For each research question, define a plan that includes activities (e.g., conceptualize, build, evaluate) and outcomes considering both artifacts (e.g., algorithm, prototype, system component, data) and knowledge (e.g., descriptions, explanations). Explain how the plan will unfold by articulating the set of objectives-activities-outcomes. The whole research process should be easily understandable. Regarding the outcomes, note that some artifacts may be solution artifacts (e.g., systems and tools) or parts of solution artifacts (e.g., software components). Other outcomes may include the justification (e.g., design principles), demonstration (e.g., principles of form and function), and validation (e.g., simulation) of solution artifacts.

Since the defined constructs must be tested, discuss what evidence (logical or empirical) will be gathered. Evidence can be related to truth (either a proposition is true or false) or utility (e.g., utility of a software component for developers). Explain how evidence will be gathered (e.g., lab data, simulation, questionnaires).

This section should have 5-10 pages.

15.7 Conclusions

A TP does not require a conclusion; if there is one, it will necessarily be light. Revisit the story told in the introduction and highlight that the TP covers the whole story.

15.8 References

References are essential and should be managed appropriately. Sloppy references tell a lot about your research. Use an adequate referencing tool. Zotero is highly recommended.

The most common citation scheme for a Ph.D. thesis is (Author-Date). Do not use the [Number] scheme, often found in conference papers.

Be careful about what you cite. Check the quality of the study and publication outlet before you cite. Avoid, at all costs, using shady and obscure sources. Stand on the shoulders of giants.

Carefully calibrate the number of references provided. Having too many references supporting a specific topic is useless and suggests a lack of selectivity.

References

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