Masters Research Handbook

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Contents

Chapter 1

Stage 3: Developing your research design

By now you will have some mastery of the techniques and tools that you need to *do* research at masters level. You may also have ideas about what you still need to do in the next step[•].

With the skills you have so far gained, you're developing into an independent researcher[•] and you may feel that this book holds nothing more for you.

Stay with us a little longer though: the next sections aren't as long as those that you've studied already – you'll be doing more yourself, honing the skills you've picked up as you go along – but they might help to keep you systematic and on the path to submission.

You won't be surprised to know that stage 3 comes next; there's another research increment coming.

- [•] If not, don't worry – we've got you covered with this chapter!
- [•] Being an independent researcher isn't one of the examined outcomes of masters research, but if you're feeling confident in your research that's a good thing.

1.1 Introducing stage 3

LR: update at the end

LR: to check all activity titles at the end

In Stage 3 you will focus on adding detail to both your aim and objectives and your research design. Stage 3 assumes that you have completed your Stage 2 work, and possibly discussed it with your supervisor[•], particularly your research design choices.

With reference to our 5-stage framework, the activities which are in focus in Stage 3 are recalled in Table 1.1, which also provides some guidelines for your interaction with your supervisor during this stage.

- [•] If your proposal still requires some 'remedial' work to fully satisfy your course requirements then you should carry that out before moving on.

Table 1.1: Stage 3 activities Update as necessary)

Research activity	Effort within stage	Suggested supervisor focus
Identifying the research problem		
Adjust, if needed	2%	
Reviewing the literature		
Adjust, if needed	3%	
Setting research aim and objectives		
finalise aim and objectives, and define tasks and deliverables	10%	Suitability of tasks and deliverables from objectives
Choosing the research design		
Complete research design, with detailed consideration of data and evidence, research strategy, research methods and procedures	20%	Suitability of research procedures
Gathering and analysing evidence		
Conduct pilot work to test aspects of your research design	35%	Scope of your pilot work
Interpreting and evaluating findings		
n/a	0%	
Reporting, critical reflection and conclusions		
Assess research progress and write up Stage 3 report	25%	Any further improvements required
Work planning and risk management		
At stage start, review work from previous stage and project risk; adjust plan as needed If you have received feedback from supervisor on your previous stage work, adjust plan to include any revision recommended	5%	Any major adjustment required

Activity: Understanding the effort needed in this stage #1

Consider Table 1.1 carefully, taking notice of the entries in the 'Effort within stage' column. Write down the most time-consuming activities in this stage and what is expected under each.

Discussion

Developing your research design further and conducting your pilot work will constitute your major effort in this stage (55% of the study time in total): your pilot work will be an initial test of some aspects of your research design, including a proof-of-concept application of some of your chosen methods.

1.2 Research design foundation

To make a contribution to knowledge we do research. Practically, to do research, we combine a number of research tasks into a framework. Designing such framework is what we term research design. The framework will depend on the research area, the type of knowledge contribution you wish to make, your mindset as a researcher, and the opportunities and difficulties you may face along the way.

A research framework has many levels. At its foundations are its "ontology", "epistemology", and "methodology":

Ontology is the philosophical study of the nature of existence and addresses the question: "What is the reality that I will research?". Practically, ontology translates to determining what *phenomena* exist in the context of your research, the *relations* that exist between them and how they group together into *categories*.

Epistemology is the philosophical study of knowledge and addresses the question: "How is knowledge generated and from what sources?". Practically, epistemology is about finding out "What people know?", "What does it mean to say that people know something?", and "How do people know that they know?".

Methodology is the system of principles and methods by which you conduct research, that is, investigate, measure, and analyse your research's aim and objectives. Methodology operationalises the "how"

question of knowledge generation, so it is about devising concrete strategies to answer "How will I make my contribution to knowledge?".

As you might have guessed, given that the goal of research is to make a contribution to knowledge, epistemology and ontology are incredibly important in defining what knowledge is in any particular research context and what, in that context, can be known about. Once this choice is made, an appropriate methodology can be devised: hence, methodology depends on choices made in relation to ontology and epistemology.

Fortunately, many others have thought very deeply about ontology and epistemology[•] and, in most areas and for the vast majority of masters-level research, their thinking will suffice. If not, we'd be left in a situation in which even an ostensibly simply statement like "That hat is blue" becomes in need of complex debate (**steup2020epistemology**).

• For instance, if you're interested, you can find a fuller discussion of Ontology and Epistemology in the Stanford Encyclopedia of Philosophy.

Methodology, on the other hand, is something we will spend some time on, particularly how individual research methods combine to produce knowledge contributions through research strategies.

You should be aware that 'methodology' has many meanings in the literature, including the study of research methods, which questions the assumptions that underpin their creation and application. Wikipedia says[•]:

• It could almost be seen as a warning!

Quote

[...] A few theorists reject methodology as a discipline in general. For example, some argue that it is useless since methods should be used rather than studied. Others hold that it is harmful because it restricts the freedom and creativity of researchers. Methodologists often respond to these objections by claiming that a good methodology helps researchers arrive at reliable theories in an efficient way. The choice of method often matters since the same factual material can lead to different conclusions depending on one's method. Interest in methodology has risen in the 20th century due to the increased importance of interdisciplinary work and the obstacles hindering efficient cooperation.

These are not unimportant issues to consider. However, and as for ontology and epistemology, we will leave their discussion to others, content to stand on those giants' shoulders – we take an unapologetically practical approach to research methods, limiting our discussions to what, we feel, are their important characteristics for practice. This doesn't ignore philosophical issues, however: where there are important philosophical considerations to be considered, we address them. This includes questions as to how to choose a particular research method, and what an experienced reader will expect to be answered by it. You can then craft your dissertation to meet those expectations.

1.3 Researcher mindsets

Depending on your background, you may have begun your research studies with a particular mindset – that of a scientist, for instance, or as someone embedded within an organisation. This mindset will flavour your approach to research, but it shouldn't constrain it – there are many options for research and the right one for you might be outside of your current understanding.

Over time, researchers in different communities and disciplines have developed differing mindsets, which are known in the literature as research paradigms[•] You can think of a research paradigm as a philosophical way of thinking, a set of shared beliefs which shape a worldview.

[ADAPTED from https://proofed.com/writing-tips/the-four-types-of-research-paradigms-a-comprehensive-guide/]

We briefly outline the prevalent ones in this section — there is a lot, lot more to be known around this topic, and this introduction only scratches the surface! We provide some references for you to start your own investigation into this fascinating and complex topic, should you wish to.

Each paradigm comes with its own ontological, epistemological and methodological choices. It is important for you to be aware of their existence as this may help you guide your research design choices, even if in practice you will mainly focus on methodological considerations.

• A.k.a. philosophical traditions.

1.3.1 Positivist and post-positivism

The Positivist research paradigm assumes that there is a single, objective reality that can be accurately known, described and explained.

Positivism contributes knowledge as explanations of this reality, constructed from hypotheses which are confirmed through observations and measurements, hence becoming universal laws or facts. As an example, think of Newton's explanation of the action of forces on matter that is encoded as his Three Laws of Motion: these are meant as universal objective truths which apply to the natural world forever.

In assuming a single, objectively knowable reality, positivism removes the researcher as a variable in the research equation: research is necessarily limited to data generation, analysis and interpretation from an objective viewpoint as the basis of knowledge. As such, it befits research where a single objective reality can be assumed, such as the natural sciences, the physical sciences, or whenever very large sample sizes can be used to infer characteristics of a population. It leads the researcher towards quantitative methods.

Positivism emerged in the late eighteenth and early nineteenth centuries in Western societies, fuelled by a growing optimism on the role and power of the natural sciences – as witnessed, for instance, by the universal acceptance of Newton's Three Laws, and their explanatory and predictive capabilities backed up by empirical observations. So much so, that it was the predominant paradigm for almost a century and

a bulkhead against a growing number of worrying observations, including the movements of the planet Mercury•, which didn't reinforce – indeed appear to contradict – Newton's Laws. How could an established truth lead that way? Indeed, Einstein's insight into the intimate connection between space and time inspired a substantial move away from the established Newtonian "laws" and "facts", which were neither any longer **lakatos2014falsificationlaka**.

The need to rethink positivist objective truths was something of a crisis in the positivist movement (see, for instance, **kuhn2012structure**), leading to post-positivism• which introduced the idea of falsification: any posited theory must make predictions which are testable, the currency of a theory being determined by whether or not it had yet been proven false•.

So, both positivism and post-positivism accrete knowledge by formulating generalisations and cause-effect linkages, based on objective, verifiable observations and measurements, and expressed as theories and laws. However, post-positivism acknowledges some of the limitations in such observations and measurement, so that a theory or law will only remain true for as long as it is not falsified by new observations or measurements. There is therefore a shift from certainty (positivism) to probability (post-positivism), with post-positivist researchers encouraged to take multiple measurements and observations, including triangulating their data, to arrive at an objective truth. Thus you might take a post-positivist approach to establishing the linkage between a drug and the alleviation of symptoms: once a generalisation or cause-effect linkage is established, it applies for as long as it remains un-falsified.

Both positivism and post-positivism assume an objective reality and do not admit that the researcher's own mindset and values may influence true knowledge: in being objective and verifiable, different researchers must necessarily arrive at the same truth, as long as the research process is reliable•, that is different researchers can follow the same process to arrive at the same conclusions.

This denial of the researcher's influence on the research is often levelled as a criticism of these paradigms, particularly by social scientists, and has led to new paradigms.

1.3.2 Anti-positivist (interpretivism)

The shift from positivism to post-positivism still preserves the absolute objectivity of reality. In contrast, anti-positivism asserts that different people experience and understand reality in different ways: while there may be only "one" reality, everyone interprets it according to their own views. Simply put, this might mean that generalisations and even cause-effect relationships are subject to individual experience. Think of the

• See **enwiki:1193607156**, for instance.

• Not the most creative name, you must admit.

• Note that falsifiable theories that have been tested and failed can still be useful, perhaps within a restricted context. For instance, Newton's Laws of motion provide a very good approximation at low energies.

• We will discuss reliability in the next section

way that people interpret the (single) power structure within your organisation: typically, different people will describe it in different ways, as it applies to them.

Explaining the name, anti-positivists believe that all research is influenced and shaped by researchers' worldviews, leading to differing interpretations of the same reality. Again, think of the questions you might ask of people within an organisation that leads them to describe the power structure. Different questions can lead to different descriptions.

As a result, anti-positivists gravitate towards qualitative research methods and techniques to understand the different perspectives, placed in an explicative context of their own perspective.

In moving away from objective knowledge, however, anti-positivism raises questions of research validity•, that is of how trustworthy and generalisable knowledge generated as subjective interpretation might be.

• We will discuss validity in the next section.

1.3.3 Constructivism

The Constructivist research paradigm goes further and asserts that reality is a construct of our minds and so is absolutely subjective. Constructivists believe that all knowledge comes from our experiences and reflections on those experiences as formed in our mind. A distinction is also made between reality which is individually vs socially constructed, the latter being the result of social interaction within a specific cultural or historical context.

Due to its focus on experiences and subjectivity, this paradigm is also mostly associated with qualitative research approaches. The researcher focuses on participants' experiences, including their own, constructing knowledge through understanding, sense making and reconstruction.

Establishing research validity is an even more prominent issue with this paradigm.

1.3.4 Critical Theory

The Critical Theory research paradigm originated in the fields of sociology, philosophy and political theory, and asserts that social science can never be 100% objective or value-free. Therefore, like interpretivism, it assumes multiple interpretations of reality in social contexts. However, it goes a step further by asserting that reality is shaped by those who are powerful, who legitimate particular ways of perceiving the world: 'truth' is inherently political, defined by those in charge to the disadvantage of many, and challenged by those who wish to promote equality. As a result, critical researchers seek to challenge the status quo and perceive research as transformative at a social level•, confronting ideology and trying to discover and challenge the mechanisms through which exploitation and disadvantage are perpetuated in society.

• As a result, this paradigm is also called 'transformative' in the literature.

This paradigm focuses on enacting social change through scientific investigation. Critical theorists question knowledge and procedures, and acknowledge how power is used (or abused) in the phenomena or systems they're investigating. Researchers using this paradigm offer historically situated insights into society and its power structures as the basis of knowledge, approaching knowledge contribution through inquiries which are both critical and transformative, aimed at emancipation and restitution to address historical injustices. The researcher values are acknowledged and welcomed as a formative influence on the research.

Rather than reliability and validity, the quality of critical theory research is judged in terms of how well it is situated in its historical context, and the extent it acts as a stimulus for transformation, and the diminuition of ignorance and misconceptions

1.3.5 Indigenous

The paradigms just described have attracted criticisms in that they are seen as Western-European centric, imposed on indigenous cultures as a result of colonialism, hence marginalising indigenous traditions.

In counterposition, an Indigenous paradigm is emerging with the aim of decolonising research. This paradigm emphasises the connection between people, their culture, and the spiritual and natural worlds, valuing knowledge which is local to communities, and holistic in connecting all beings with nature and spirituality.

As a result, indigenous cultural practices and forms of expressions should be reflected in the way the research is conducted, including language, metaphors, oral traditions and indigenous knowledge systems.

From an ontological perspective, therefore, both physical and spiritual realities and their connection matter, alongside reciprocal relations among all living beings.

From an epistemological perspective, knowledge is relational, based on the connection between natural and spiritual worlds, and its generation is a fluid process based on oral traditions, such as storytelling, and inward exploration of personal experience in context. The codification of such knowledge is through community praxis, in which the 'Elders' are often seen as key actors in the epistemological process.

Finally, indigenous methodology is one that favours the collective involvement of indigenous people in developing, approving and implementing the research, leading to knowledge of practical use.

It is important to note that although we have tried to characterise this paradigm in relation to ontology, epistemology and methodology, some scholars reject any such classification, regarding this too as a form of colonialism imposed by a Western view of research paradigms. If you are interested in going more deeply into this debate, you could start from

add references: Hart, M. A. (2010). Indigenous Worldviews, Knowledge, and Research: The Development of an Indigenous Research Paradigm. Journal of Indigenous Voices in Social Work, 1(1).

1.3.6 What's your mindset?

Table 1.2 summarises the main paradigms we have discussed based on their ontological, epistemological and methodological standpoints. From a methodological perspective, we have indicated the main tendency of the paradigm, although the quantitative vs qualitative distinction is not as stark in practice, and a mix of methods often applies.

Table 1.2: Summarising research paradigms

	Positivism	**Post-positivism**	**Anti-positivism (Interpretivism)**	**Constructivism**	**Critical theory**	**Indigenous**
Ontology	one discoverable external reality	one discoverable external reality that can only be known imperfectly	one external reality which is interpreted subjectively	reality as the construct of one's mind	one external reality determined by socio, political and economic power factors	physical and spiritual realities and their connection; reciprocal relations between all living beings
Epistemology	objective laws and theories that can be confirmed empirically	objective laws and theories that can be falsified empirically	subjective interpretations	subjective constructions	social and historical constructions, acknowledging issues of power and social injustice	relational knowledge, indigenous knowledge systems based on oral traditions and inward exploration of experience
Researcher's role	objective, neutral	objective, neutral, aware of cognitive limitations	subjective, bringing own values, experience and bias	subjective, bringing own values, experience and bias	subjective, aware of own social position	researcher as indigenous participant in collective research
Main methods	quantitative	quantitative, with triangulation	qualitative	qualitative	qualitative	qualitative

Your own mindset may lead you to gravitate towards one or more of these paradigms, or even somewhere in between. The next activity should help you reflect on this point.

Activity: What kind of thinker am I? #2

Consider the following question and describe how you would go about answering it:
"What is the colour of swans?"
Then compare your approach to each of the paradigm. Which one is it closer to and why?

Guidance

If you can think of more than one way to approach the question, then describe and reflect on each of them in relation to the paradigms.

Discussion

I can think of a couple of ways I could tackle this question.
The first would be to start by observing the swans that live on the lake near my home, and record my observations. From that I would put forward an initial hypothesis, say that all 'swans are white,' as those are the only ones I can observe locally. I would then look online for images of swans from around the world to see if they match my observations. Having found images of black swans alongside white ones, I would then revise my hypothesis to "All swans are either white or black." This process would continue until I'm satisfied there is no further contradictory evidence I can find, hence conclude that in all probability swans are either white or black. I would have to admit that there may be swans of other colours I've yet to come across, so the statement is open to future challenges. I would also need to be convinced that I'm a neutral observer, able to determine the colour of a swan correctly and reliably. This approach closely aligns with the post-positivist paradigm, specifically: I've made observations, triangulated my direct swan observations with the review of online swan images, and formulated, rejected and then reformulated hypotheses as part of my enquiry process.
My second approach would be to ask other people. For instance, I could set up a crowd-sourcing survey inviting participants to answer the question. By analysing their answers I could then decide if there is enough consensus on the colour of swans: for instance, most participants may have identified swans to be either white or black, although some may have provided more nuanced answers, like yellowish or other. From my analysis I would draw my conclusions which may or may not be the same as in my previous approach. In this case, I would have to worry about who participated in my research. Were there enough participants from around the world to provide sufficient and diverse evidence? To which extent may their colour perception differ? What else could I do to check the validity of the outcome?

This approach aligns with the interpretivist paradigm: I have to accept that, like me, each observer in my study will make their own interpretation of what the colour of a swan is, so that I would have to account for this in my conclusions.

1.4 Research strategies

Each research discipline and area has its more-or-less well-worn paths to a successful knowledge contribution. In Stage 3, you're now at the point where you'll join researchers in your chosen area on one of those paths: as you get deeper and deeper into your research, the steps you'll take will become more and more specialised.

To identify and take such steps, you will need to devise a research *strategy*, by which we man a collection of recipes for doing research that will, if followed accurately, lead to a contribution to knowledge *even in the presence of uncertainty*. When devised, a research strategy consists of research tasks that interact in more or less complex ways, but which are sufficiently detailed that the researcher knows what to do next, even if that means making a choice between two or more next steps.

There's good news and bad news in choosing a research strategy:

- The bad news is that there are many possible choices you could make at any point.
- The good news is that, for your particular area in Masters research, there will likely be only a small subset that you need to know about.

To help you in your choice, our approach in this chapter is unapologetically practical. In Section 1.6, we will layout the options that you have together with reasons for choosing them and reasons for not choosing them. Each comes with a list of key evaluation questions the answers to which you will be expected to present as part of your dissertation. Amongst other things, the answers you give will justify how and why your work makes a contribution to knowledge. These evaluative questions in turn give you targets to aim for throughout your research, you will need to answer each of them – they will be the driver for your research and your writing up.

Before we look at research strategy in detail, we are going to consider the importance of such choice in terms your ability to defend your claim that your research has contributed new knowledge.

1.5 Defending your claim of new knowledge

Being able to assert that you have made a contribution to knowledge is the point of structuring your research through a well thought-out research strategy – hence, the importance of methodology in research.

Choosing a good strategy is only the starting point, however. Having made your claim to knowledge at the end of your project, you still need to defend it in your dissertation. That means considering, essentially, everything that could have gone wrong – any weakness – with the execution of your research strategy, and explaining how you've dealt with it.

Introducing potential research weaknesses upfront and ways to deal with them is the purpose of this section: with this information, you can then be more mindful in the choice and execution of your own research strategy.

Figure 1.1 illustrates the point we are making. At its core is your claimed knowledge contribution at end of your project. Its defence is what you need to argue in your dissertation. Such a defence has to withstand external scrutiny, say that of your examiner or the wider community of scholars, researchers or practitioners your work is intended for. You claim to knowledge is subject to a number of weaknesses (four main types are considered in this section, illustrated as potential 'cracks' in your defence), and should you recognise any of them in your research, then your defence should explain how they've been dealt with (illustrated as bandaids over the cracks). The kind of 'bandaid' will depend on what you decided to do, one of addressing, avoiding, deferring or ignoring the weakness. If you choose to address it, then some specific kinds of bandaid are available to you: the ones we consider in this section are triangulation, reflexivity and critical review.

1.5.1 Weaknesses and ways to deal with them

We can class weaknesses in claimed knowledge contribution (see figure 1.1) as follows:

- validity weaknesses, i.e., the claim you have made to new knowledge isn't sufficiently credible, trustworthy, or accurate to be considered knowledge
- reliability weaknesses, i.e., the procedures that you have used to establish your claim of new knowledge are not dependable, cannot be replicated under the same conditions or are not sufficiently repeatable in other contexts
- bias weaknesses, i.e., the claim you have made to new knowledge has been affected by your implicit or explicit cognitive biases, making the new knowledge invalid

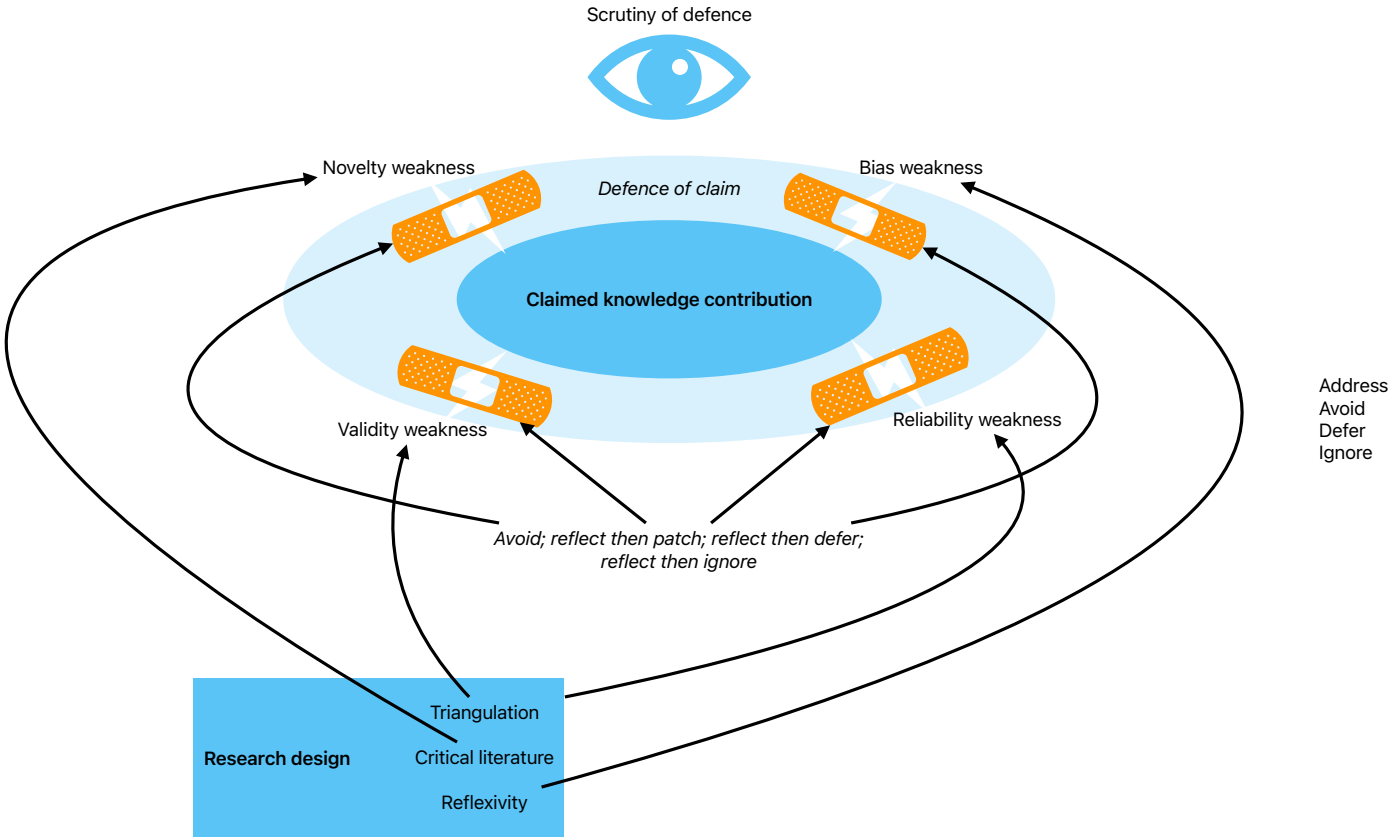

Figure 1.1: Research vulnerabilities — to edit and explain in text

- novelty weaknesses, i.e., the hole in the literature that you claimed existed doesn't actually exist. If there is no hole, then you cannot have contributed new knowledge — perhaps you missed some key papers in your literature survey or, perhaps in the time that you've taken to complete your research, someone else has made a similar contribution to knowledge as that you claim. Alternatively, while a hole may exist, the novelty of your claim may be in doubt — perhaps your research was not able to achieve all that you were hoping for.

There are, of course, also connections between these types of weakness. In particular, if your research strategy is not reliable, then any resulting claim to knowledge is unlikely to be valid. For instance, if the scale you use to measure the weight of an object returns different values every time (it's unreliable), then you can't draw a valid conclusion on the weight of that object. However, reliability is not sufficient for validity. For example, your scale may reliably return the same weight every time, but it may also overestimate the weight: in this case, while your scale is reliable, then you still can't draw a valid conclusion on the weight of the object (unless you know precisely by how much your scale overestimates weights). Bias also affects validity. For instance, you may have a preconception of what the outcome of your research should be, so you discard any evidence to the contrary and only retain evidence that confirms your bias. In this case, your conclusions are untrustworthy, hence invalid. It is therefore essential to consider the weaknesses that may affect your research and take action to ensure they will not impact the validity of your claim.

As you will see in the next section, different research strategies are affected differently by these weaknesses. For instance, research based on quantitative objective measurements will focus more on ensuring reliability than research based on subjective interpretations of qualitative information, where the researcher's bias is more likely to have a negative impact.

In general, the possible actions you can take to deal with potential weaknesses fall into three options[•]:

- avoid the weakness, i.e., choose a research strategy which is not troubled by the weakness. Part of the justification for the choice of research strategy can then be a discussion, if necessary, that the weakness doesn't arise.

- address the weakness, i.e., be aware of the weakness during the research and put in place further strengthening research. This might be, for instance, a second of further iteration of the research strategy which addresses discovered weaknesses in earlier research. This would be reported as part of the research design.

- acknowledge and defer[•], most usually at the end of the research period when the research is complete,

[•] There is actually a fourth way, which is to be aware of the weakness but to ignore it. We do not recommend this as your examiner of your dissertation is likely to have detailed understanding of the research strategy you have chosen, including its potential weaknesses, and is likely to pick any methodological omissions up.

[•] Although it may seem to have similar outcomes, this is a much better strategy than simply ignoring the weakness as, although you don't address it, you make the examiner aware that you are aware of it. It can also give you a very neat way

i.e., write a reflection on the effect the weakness had on the outcomes and commit to addressing that weakness in future research. This would be reported as part of your "Discussion" and "Conclusion and future work" chapters.

If you can't avoid a weakness and you can't defer it, you have to address it. Addressing it means that your examiner will have their questions answered about the weaknesses they know occur in the type of research you're doing. Their evaluation will be through the questions they ask of your research and you must be prepared to answer them.

1.5.2 Where to defend your claim

In your defence of claimed knowledge contribution, you should consider all potential weaknesses in turn – ignoring them leaves yourself open to a negative outcome of expert scrutiny. For each, you should make arguments as to why your claim doesn't suffer from it, or if it does to some extent, that you have dealt with it in a way that ensures there is still a contribution to knowledge arising from your research.

Typically, there are two places at which weaknesses in your claimed knowledge contribution should be discussed:

- in your dissertation, in all cases
- in any *viva voce* associated with your research course•

In general, an examiner will explore such weaknesses through a number of questions they ask of your dissertation. For each research strategy, many of these questions• can be predicted with reference to the types of weaknesses we have discussed above. Somewhere in your dissertation, then, you will need to expose your research strategy weaknesses and argue how your research has addressed them.

Here is an example paragraph taken from an actual dissertation (**miles2019dispelling**) with our commentary on specific points to the right, in the margin:

> My observational study focuses solely• on the external elements of the embouchure and what can be seen in real time with the human eye•, through the recording of video images. My analysis, and the conclusions that come from it, has been made from a purely visual perspective, captured by combinations of

- As not all masters research have an associated *viva voce*, weaknesses should always be addressed in the dissertation itself. Even if your course does have a *viva voce*, it can be a nerve-racking experience to be confronted by an examiner asking questions to which you have no answer because you haven't thought about it!
- If not all; although examiners will have their own way of asking them!
- Being specific on which phenomena are studied...
- ...and on the observations made of them...

camera angles, without needing the use of any complex and expensive technologies[•]. In embarking on this research project, the initial intention was to measure facial muscle activity using Electromyography. This method proved to be too costly[•] and the heavily mathematic and science based analysis process, out of the current skill set of this researcher[•]. Furthermore, due to the significant evidence found in the literature regarding the internal embouchure, the concept of the tongue being a pivotal element in facilitating pitch change has been accepted as fact and deemed unnecessary for further study in this project[•]. Therefore the ultimate goal of my research is to inform the teaching and learning of brass wind performance, with particular reference to the role of the embouchure[•]. With this in mind, it is therefore important that the data obtained through this study be identifiable through the simplest means possible, so that it can be of the most benefit to the brass-playing community[•].

- [•] ...thus correcting any expectations of what might have been achieved...
- [•] ...contextual factors prevented more sophisticated observations...
- [•] ...and initial investigations reveals how difficult this would be
- [•] There was no knowledge contribution to be made in this particular area...
- [•] ...and so the knowledge contribution was ...
- [•] ...and our research goals were set accordingly.

Activity: Which weaknesses are discussed? #3

Consider the extract above alongside our comments. Which kinds of weakness does it refer to? How were they dealt with? Which other weaknesses could have been discussed?

Discussion

We found two potential weaknesses which were considered and addressed in the research:

- novelty: by being specific on the phenomena studied (the external elements of the embouchure), the text clarifies where the claimed novelty of the research lies. This makes it easy to check against related work in the literature, something the text could have mentioned explicitly
- validity: the observation of such phenomena through video images is defended as a valid method in relation to the aim of devising a practical approach to inform teaching and learning. This is in contrast to more sophisticated, but costly, approaches that would have been possible, but deemed unnecessary for the aim of the research.

Other potential weaknesses not discussed are:

- reliability: how reliable were the observations? Would another researcher have reached similar conclusions?
- validity: the study assumes the embouchure is a key factor in the teaching and learning of a brass instrument. Where does this assumption come from?

As this is only a brief extract, it is possible, of course, that these weaknesses were considered and dealt somewhere else in the dissertation.

1.5.3 Approaches to address weaknesses

In this section, we consider three common approaches used to address weaknesses in research.

1.5.3.1 Triangulation

Triangulation **mathison1988triangulate** consists of using multiple data sources and methods, or even multiple researchers, to develop a comprehensive understanding of a phenomena under study and arrive at a particular conclusion about that phenomenon. Triangulation was introduced in the social sciences in the mid 1950s **campbell1959convergent**, and since has become an accepted approach across all disciplines, regardless of research paradigm.

The core idea behind triangulation is that if different data and methods converge towards the same conclusion, then it is more likely that such a conclusion is valid, that rival explanations can be dismissed, that the different procedures followed are reliable, and that the effect of any bias is mitigated. In this way, triangulation makes your research more credible, and your claim more defensible.

However, because triangulation applies many techniques or derives conclusions from many sources, it can result in inconsistent or contradictory findings. So, it is important to understand that triangulation does not necessarily guarantee convergence on a single proposition about a phenomenon. Instead, it provides a rich and complex picture that requires careful interpretation and explanation by the researcher. As a result, triangulation should be used cautiously and researchers should be prepared to explain and make sense of

the various outcomes it may produce. Triangulation also adds complexity and requires more time and effort that must be accounted for.

Main kinds of triangulation include **denzin1978research**; **patton1999enhancing**:

Data source triangulation refers simply to using several data sources. These may be the inclusion of multiple participants to interview, or the consideration of a particular phenomenon under different conditions in space and time. For example, in an educational setting, you may wish to measure the efficacy of an educational programme on different student cohorts, possibly over different academic years, or delivered by different educators. With data triangulation you increase the validity of your claim across different contexts, so that your results are more generalisable.

Investigator triangulation involves several researchers collecting and analysing data•. For instance, you may have different researchers repeating measurements using the same lab equipment and procedures. The involvement of different researchers who independently apply the same techniques to arrive at the same conclusions, increases both reliability and validity of those outcomes, and mitigates against each researcher's bias. This is particularly important in qualitative research where data are often interpreted rather than measured precisely.

Methodological triangulation refers to the use of multiple methods in the examination of a phenomenon•. For instance, a neuropsychologist may combine direct observation of human behaviour with neurological data from brain scans to obtain a comprehensive picture of what motivates people to make certain choices. Methodological triangulation allows strengths and weaknesses of different methods to compensate for each other, increasing both reliability and validity. However, it may be difficult to combine results from different methods because of their differing ontological and epistemic stance.

Theory triangulation refers to the use of different theories or hypotheses to analyse data and interpret phenomena. For instance different motivation theories could be used to study resistance to change in organisations. By employing several theories, findings can be considered from different angles, compensating for possible limitations or biases of each individual theory.

• Because there is more than one researcher involved, it is unlikely that you will be required to perform this form of triangulation in your Masters project. You may, however, be a researcher in the triangulation of another's researcher – your supervisor, for instance – which means that you should be prepared to be involved. Be sure to schedule some time with your supervisor to discuss their needs, should this be the case.

• We deal with mixed method research later in this Stage.

Activity: Distinguishing different kinds of triangulation #4

Consider each of the following examples and indicate which kind of triangulation they represent:

- research on student experience in a university looking at student survey data and students' study results
- research on study practice and academic performance, combining an online survey and interviews with a selected number of participants
- research on sleeping patterns of the elderly, using data from care homes in the UK
- research on volcanos asking vulcanologists around the world to contribute seismological measurements over a period of time.

Discussion

These are example of, respectively:

- data triangulation, in which two different kinds of data are considered
- methodological triangulation, in which two different methods are applied
- data triangulation, in which similar data from different locations are considered
- investigator triangulation, in which several researchers are invited to collect and contribute data. Presumably, this also encompass some data triangulation in the sense that similar data from different locations around the world are collected and analysed.

1.5.3.2 Reflexivity

According to **jamieson2023reflexivity**:

> Reflexivity is the act of examining one's own assumption, belief, and judgement systems, and

> thinking carefully and critically about how these influence the research process. The practice of reflexivity confronts and questions who we are as researchers and how this guides our work.

So, reflexivity admits that the researcher isn't an objective, unbiased observer of truth, but someone whose worldviews and subjectivity influences every step of the research process. Through reflexive practice, the researcher can then engage in a more honest and transparent research process, increasing research reliability and mitigating bias.

Note that there is a difference between reflection and reflexivity. Reflection is usually done retrospectively: you could reflect on something that has happened during your study to identify important lessons for the future. In contrast, reflexivity takes place throughout the research process — before, during and after, hence has the potential to shape it. Also reflection focuses on things you have done, while reflexivity explores motivations — your assumptions, beliefs, biases, etc., behind those actions.

Reflexivity is relevant and applicable to all types of research. Qualitative research has the longest tradition of reflexivity, with qualitative researchers encouraged to examine and openly acknowledge their own beliefs and biases, and their impact on the research. In quantitative research, the acceptance of the importance of reflexivity is growing, and goes alongside an acknowledgement that there are limitations and biases in the scientific method too, so that quantitative research is not a 'gold standard' of objectivity.

Reflexivity should be embedded in all steps of the research process. In the early stages, it can apply to the choice of research problem or questions, by guiding the researcher to consider explicitly subjective factors which may explain why that particular choice was made and why the researcher is best placed to research it. In data collection, reflexivity can expose biases and unchecked assumptions which may affect how samples and data sources are selected or participants are recruited. In data analysis and their interpretation, reflexivity may lead to uncover reasons why certain evidence is given more weight or meaning, while other is discarded, for instance due to confirmation bias. In formulating conclusions, reflexivity can support "thinking about thinking"•: the process of questioning the way we think to assess how valid and reliable our conclusions are. This is particularly important because while the human brain has the potential for logic and critical thinking, these are not innate skills: rather they need developing, akin to the skills that one must develop to become, say, a proficient musician or mathematician. Psychologist have uncovered that left untrained, our brain tends to make mistakes, which stem from a variety of factors•, including errors in perceptions, flawed memories, heuristic thinking, logical fallacies and cognitive bias. Reflexivity can help us become aware of these tendencies.

• So-called 'meta-cognition'

• A fascinating series of lectures on this topic is "Your Deceptive Mind: A Scientific Guide to Critical Thinking Skills" by Steven Novella.

Activity: Reflexivity practices #5

Conduct a web search on reflexivity practices adopted by researchers. Briefly summarise what they are, and how they are useful. Comment on which of such practices you could adopt in your work.

Discussion

You may have found some or all of the following:

- Reflexive writing, such as research journals, diaries, fields notes and memos. These are common tools used by the reflexive researcher at any point in the research process to record assumptions, experiences, observations, perceptions, procedures, and decision points. They are used to bring into focus the researcher's intention and gaps in their knowledge or thinking, as well as interpersonal dynamics, including power ones.
- Positionality statement. This is a kind of reflexive writing aimed at describing researcher's characteristics (such as age, social class, race, etc.) and beliefs (such as political, philosophical, etc.) which may influence the research.
- Narrative autobiography. This is also a kind of reflexive writing focussed on the researcher's life experiences and motivations which may influence the research, particularly the researcher's interaction with participants and understanding of participants' accounts. The aim is to better prepare the researcher for their interaction with participants, so it is best conducted when planning data collection/generation.
- Reader-response exercise. This addresses how the researcher's own assumptions and experiences may affect their interpretation of participants' accounts. It consists of including a layer of codes to indicate how the researcher reacts to and interprets participants' accounts in relation to their own background and personal history. As such, this practice is useful during data analysis and interpretation.
- Collaborative reflexivity. This entails engaging in reflexivity as part of a research team, with collaborators questioning assumptions and decisions. It assumes mutual trust, and a commitment to ethics and rigorous research, regardless of seniority or status. It applies to all stages of the research process.

1.5.3.3 Returning to the literature

Addressing novelty weaknesses means returning to your literature review as your research progresses and understanding increases to cast an increasingly critical eye over it, and possibly widen its scope to further related work which may have been published more recently. Each source should be reconsidered for what you thought it originally said and what you now think it says, using any difference• to drive further reflection on your findings, methods, data generation, or even research problem. This process will help you both ensure there continues to be a gap your research can contribute to, and assess the extent of the novel contribution your research can make in relation to related work which has already been published.

• In the best case, there will, of course, be no difference!

As in the example we included at the end of Section 1.5.2, while defending your claim or explaining your research design, your reader can be made aware of this process and how it has altered your research. Deepening the critical nature of your literature review allows your reader to understand that you are a reflective researcher and can turn any novelty weakness into a research strength!

1.6 Your research strategy candidate list

While your own research strategy will be specific and unique to your project in the way it informs the research you will conduct, standard research strategies have emerged over time, influenced by research paradigms and research practice within specific disciplines. Each of them can be seen as a sort of 'recipe' which summarises common ways to conduct academic research: by adopting or combining some of these strategies, you can come up with your own specific instance for your project.

There are many standard research strategies in the literature, often with many variants: the 12 strategies we consider in this book are discussed in this section. The outcome of working through this section should be your choice of a candidate research strategy that:

- is a good fit for your research problem, i.e., that will allow you to develop a contribution to knowledge arising from your research problem
- makes the most of your current research skills and resources, i.e., the background knowledge and skills you bring to the research, the time that is available to you, and it fits with your research context.
- can be evaluated through a list of questions that could be asked of it by a knowledgeable evaluator, such as an examiner.

Table 1.3: Research strategy choice

Research Strategy candidate	Considered	Excluded	Reason excluded
Survey	☐	☐	
Design and Creation	☐	☐	
Experiment	☐	☐	
Case study	☐	☐	
Action research	☐	☐	
Ethnography	☐	☐	
Systematic research	☐	☐	
Grounded theory	☐	☐	
Phenomenology	☐	☐	
Simulation	☐	☐	
Mathematical and logical proof	☐	☐	
Mixed methods	☐	☐	

From the first two of these, you will gain an understanding of which steps you will be required to take to generate, analyse and interpret research data that, when complete, will make your contribution to knowledge. From the third of these, you'll be able to structure your research report – your dissertation – by describing your answers to the evaluative questions.

The 12 candidate research strategies we consider are listed in Table 1.3. For each, after a brief description explaining the focus of the strategy, we will:

compare to structure of each strategy section, at the end of editing

- describe what kind of knowledge contribution that can be made through it
- describe the ways in which data is generated and analysed within the strategy
- describe how a contribution to knowledge using the strategy will be evaluated
- ask "Is this strategy right for me?"
- provide a number of references that give more detail, if you are seriously considering the strategy

This is a lot to digest! Rather than going through all the information about each strategy in turn, we recommend you take the following steps to first reduce your list of candidate strategies from which to arrive at your chosen one.

Step 1 Consider a strategy, and read its description and type of knowledge contribution that can be made through it. Compare these with your research problem to check whether that research strategy should be a candidate for your project. When you have done this, you should check its tickbox in the first column of Table 1.3 – I've considered the strategy. If there's a clear mismatch with your research problem, you should check the tickbox in the second column – that the research strategy has been excluded – and give a reason why you have excluded it – say, the knowledge contribution it makes is not of the correct form – and you can move onto the next research strategy and repeat this step. The "Reason excluded" column will be used in the your dissertation to justify your choice of research strategy so think deeply about what you write here – you can use the text of the knowledge contribution and subsequent subsections to frame your reason for excluding it. Whatever you do, don't leave it blank!

Step 2 If you have not excluded the research strategy, then you should read further – next come the methods you would use to generate and analyse data. This gives you another reason to exclude a research strategy – that the data or participants your research needs are not accessible or the methods are not feasible within your project•. If this analysis leads you to exclude the research strategy, complete• the second tickbox column and record the reason, then move on to the next research strategy going back to Step 1.

Step 3 If you have not been able to exclude the research strategy, then you should read the "Evaluation" section•. These are questions you should be able to address once your research is completed, and which you should keep in mind from the very start. If you feel you are unlikely to be able to address them, then this gives you another reason to reject the strategy. Once again, if you have excluded the strategy, tick the box in column 2, record the reason in column 3, then move on to the next strategy and restart the process.

Step 4 If you have not been able to exclude the research strategy, it's time to look at "Is this strategy right for me" section. This lists a number of other things you should consider that might lead you to exclude it, particularly in relation to skills you may be needed, or other features of the strategy which may not align with what you can achieve within your project. If you came to reject the strategy, as before, tick the box in

- Of course, you will need to choose *one* research strategy, so be careful not to exclude something that, perhaps with some adjustment, can be made to work.
- This time, the reason will be something to do with data generation techniques not accessible.
- Perhaps taking notes on things you haven't immediately understood.

column 2, record the reason in column 3, then move on to the next strategy and restart the process. This section may include alternative strategies you could consider next, otherwise, just proceed through the list.

We have wrapped up this process in the following activity, which constitutes the most substantial practical work for you to carry on in this sub-section:

Activity: Arriving at your candidate strategy list #6

Copy Table 1.3 to your favourite word processor or spreadsheet application. Apply the process above until you have considered all the strategies, updating your table as you go along.

Guidance

The aim of this activity is to help you narrow down the possible choices of candidate strategy for your project, without having to dive into the detail of all 12 strategies presented.

Once you have exhausted all the strategies, there are three possible outcomes:

- you find yourself with a single candidate research strategy, in which case you should go for it!
- you find yourself with a number of candidate research strategies, in which case you can make a choice based on your skillset, how much fun you think you could have applying it, or any other criteria you wish. You may also like to think about mixing up bits of each to give you your own mixed methods research strategy
- you find yourself without a choice, in which case you've probably been too picky... and you should try again – you can't do research without a research strategy and you're unlikely to come up with one not on this list – a completely novel one.

In all cases, you should discuss the outcome with your supervisor:

Activity: Discussing your choice with your supervisor #7

Arrange a time to talk to your supervisor about the process you have followed to identify possible choices of research strategy for your project, and what the outcome was.

Guidance

As an expert in the research process and in your field of study, your supervisor will be able to advise on whether the choices you have made are appropriate, or even recommend strategies you should consider in details.

1.6.1 Survey research

Survey research focuses on collecting, in a standardised and systematic fashion, up-to-date, real-world data from a sample of the population which is the focus of your research. Depending on the population and selected sample, large amounts of data may be collected.

1.6.1.1 Knowledge contribution

The contribution to knowledge of survey research is to uncover patterns that can be generalised from the sample to the target population.

A typical application of survey research is to predict the outcome of an upcoming election by polling data from a sample of voters.

1.6.1.2 Data generation and analysis

For your data collection, you need to identify upfront which data you will collect in a standardised matter, your target population and sample. The sample must be representative of the population in the sense that it should reflect accurately population characteristics.

Suggested by the name, a survey – a standardised set of questions administered to a number of respondents – allows the researcher to gather information about a population. Surveys can take many forms, from interviews to questionnaires to focus groups, but authors vary on what they consider appropriate•. They can be administered via the internet (more traditionally by mail), over the phone, or even face-to-face. Mixed-mode surveys combine these options into more complex instruments, perhaps using a broader but simpler questionnaire to identify potential participants for a deeper face-to-face interview to follow.

In your data analysis, you seek patterns in the sample data collected to arrive at generalisations to the wider population. Statistical analysis is usually applied, possibly complemented by some thematic analysis, if open-ended questions are also included to elicit qualitative data.

• Be sure to consider any supplied preparatory reading on the survey research strategy to ensure that you meet your supervisor's (or other's) expectations of what will be appropriate.

1.6.1.3 Evaluation

The following questions are typically asked of survey research:

1. Reliability:
   - Are the sampling frame[•] and sampling techniques[•] used adequately explained?
   - Are the data generation and analysis methods adequately described?
   - Do they survey questions allow for consistent and dependable measures by different respondents?
   - Are significant differences between respondents and non-respondents discussed?
2. Validity:
   - Is the sampling frame appropriate? Does it provide sufficient coverage of the target population in terms of its characteristics of interest?
   - Is the sample representative? [•]
   - Is the response rate adequate? How were non-respondents handled?
   - Do they survey questions allow to measure or assess all that is needed?
   - Has statistical, or other, analysis been appropriately applied?
   - Are generalisations made about the target population appropriate? What reasoning chains have led to such generalisations?

• The sampling frame is the set of individual units of the population from which the sample is drawn. Such individual units may be participants or data points in a data set.

• We will look at sampling in Stage 4.

• This relates to the question of whether the sample is sufficiently large and/or as diverse as the population.

1.6.1.4 Is this strategy right for me?

This strategy sets certain requirements of the researcher for them to be successful. These include that:

1. you must have access to an appropriate population sample, so that a sufficient volume of data can be collected and deep analysis performed. If this is not possible, for instance, because you have limited access to the population, you might like to consider case study research instead.
2. the phenomena and characteristics of the population which are of interest should be measurable through questions asked through a survey. If this is not the case that then you're not going to be able to make a contribution to knowledge about those phenomena or characteristics, and you might like to

consider phenomena that can be measured, or a different population for which those phenomena can be measured.

3. while this strategy may produce lots of data in a relatively short time, the depth in the data can sometimes be lacking, given the focus on what can be measured. If deeper or more nuanced data is needed, then you may like to consider case study research instead.

4. conducting a survey means that you'll be analysing phenomena using point data, i.e., data that were collected at a point in time – that time at which the survey was answered. If your research requires longitudinal data, i.e., data that could change over time, then survey research becomes more difficult as you might need two or more surveys to collect the changing data. While it's not impossible to do this, it adds many complications: earlier participants might not be available for later surveys, their mindsets might have changed in the intervening period, etc. If this is the case, then you should consider whether the choice of phenomena is appropriate. Alternatively, you might like to consider one of the experimental research strategies described below.

5. while repeated surveys may be used to investigate causes and effects, the difficulty of doing this is one reason to reconsider phenomena or use an experimental research strategy instead. In all cases, surveys are not suitable to investigate the mechanisms behind cause and effect relationships.

6. conclusions from survey research rely on the veracity of the responses received. If there's any reason to doubt your respondents' honesty, additional care should be taken. There are techniques to avoid this (see **<empty citation>** for instance) but they add complexity to the strategy. If the development of a relationship of trust between researcher and population is critical to the research, then some form of ethnographic research might be more appropriate.

1.6.1.5 Suggested further reading

add annotated bibliography

dillman2014internet, kalaian2008encyclopedia

1.6.2 Design and creation research

The design and creation research strategy• focuses on developing novel solutions to problems, a problem being a need in context. The solution should be an artefact, by which is meant anything designed and

• AKA Design Science Research.

constructed by humans: this is a very broad definition, encompassing all that does not exist in nature, including any artificial object, construct, process, policy, model, method, etc.

1.6.2.1 Knowledge contribution

The contribution to knowledge is that which can be learned from the design and creation of the artefact as the solution to a problem. Knowledge contributions therefore come from an exploration of the problem, of the artefact itself, and its design, development, use, or other characteristics of the real-world problem solving process – for instance, whether it is linear or iterative, or the ways in which problem and solution understanding and validation are conducted.

This strategy leads to tangible artefacts which fit real-world contexts, and it is particularly suited to emerging and rapidly changing technology-related fields of study, where new problems emerge all the time and known solutions are sparse or become rapidly obsolete, hence necessitating continuous innovation. Lots of research in Computing is an expression of this strategy, for instance designing computational systems able to emulate human cognition, as is the case of AI•.

• Artificial Intelligence

1.6.2.2 Data generation and analysis

Data generation is through the problem-solving process of articulating the problem, and designing and constructing the solution artefact, with the interactions between actors (customers, clients, designers, others), technologies and/or knowledge as the source of data. Modelling techniques are widely applied, possibly informed by data collection techniques, like reviewing existing documents or interviews with stakeholders and experts or observation of people's behaviour. Prototyping is often used to produce proof-of-concept artefacts to test, demonstrate and improve the design.

Data analysis focuses on knowledge generated in the evaluation of both problem and artefact, including solution characteristics in relation to the extent they address the problem – the identified need in context. Specific evaluation techniques will depend on the nature of the artefact, and may include problem owner•'s validation, and various forms of testing, or end-users' evaluation and feedback.

• By problem owner we mean the person or people who have expressed the need to be addressed and are able to establish whether the solution has met it.

1.6.2.3 Evaluation

look up more in the literature

Evaluation of the design and creation research strategy typically consists of the following questions:

1. Novelty:

- What is the novelty in the artefact, its design, development, and/or creation?
- To which extent does the artefact address the problem? Have its efficacy and utility been demonstrated? What evidence is provided?

2. Reliability:
   - Are all stages of the problem solving process discussed, including interactions with stakeholders?
   - Are the ways data are generated and analysed, both in problem and solution space, adequately described?
3. Validity:
   - Are appropriate approaches applied in the design and creation of the artefact?
   - How is the artefact assessed? Are the assessment criteria appropriate and documented? How were they determined?
   - Which generalisations are made from the design and creation of the artefact? Are they appropriate?

1.6.2.4 Is this strategy right for me?

For this strategy to be successful:

1. There must be demonstrable novelty. You must be able to argue that your research does not focus on 'normal' design, that is you are not simply re-implementing a solution to a well-known problem through a well-known development process and well-practiced skills•. If you cannot clearly identify that novelty, then you will not be able to claim a contribution to knowledge.
2. There should be a problem owner which is separate from the researcher, and who sets the requirements and context for the artefact, with the researcher working on its development for that context to meet those requirements. If you do not have access to a real-world problem owner then this strategy is not applicable.
3. If the problem owner is, say, your employer or a business you are collaborating with, and for which addressing the problem is a matter of urgency, then you must establish whether it is feasible for you

• Learning new skills may be valuable from a personal perspective, but will not, by itself, make a contribution to knowledge – learning them means that they exist already!

it used to talk about client, but I think that's too specific; for instance, there may an open challenge expressed and acknowledged in the academic literature, in which case the problem owner may well be the community?

to deliver a novel solution in a timely fashion. Research always brings a level of uncertainly so that estimating time to success, or if success is even possible may not be easy. If you can't ensure feasibility within the timescale of your project, then you may need to rethink the problem to address.

1.6.2.5 Suggested further reading

add references from DSR literature

oates2008researching,brocke2020introduction

1.6.3 Experimental research

Experimental research provides a controlled environment in which cause and effect relationships can be investigated, expressed as a hypothesis•. The strength of an experiment is that it can reduce the influence of confounding factors on a cause-effect relationship.

• A hypothesis is a tentative statement about the relationship between the phenomena to be tested in the experiment.

The potential scope of application of the experimental research strategy is wide, ranging from scientific experiments under laboratory conditions controlled by the researcher to field experiments involving people in a real-world setting in which some factors may be outside the control of the researcher.

There are pros and cons of each. While laboratory experiments are very reliable due to the high level of control, they can be very artificial, with little or no relation to a real-world context. The opposite is true for field experiments.

1.6.3.1 Knowledge contribution

The experimental research strategy contributes to knowledge through allowing cause and effect relationships between real-world phenomena to be established.

For instance, you may run an experiment to test whether the use of mobile phones just before going to sleep disrupts people's sleeping patterns.

1.6.3.2 Data generation and analysis

The experimental research strategy revolves around making an intervention within tightly controlled parameters. Observations and measurements are made of before and after the intervention and a comparison is made. Any difference is assumed associated with the intervention made.

For instance, in establishing a causal relation between the use of mobile phones and sleeping patterns, we could investigate the effect of the blue light emitted by a mobile phone on reducing the production of

melatonin: this is the hormone which controls a person's sleep-wake cycle, so that its reduction is likely to disrupt a person's sleeping pattern. We would then measure the amount of melatonin produced by the body (these are our measurements) with and without exposure to the blue light of a mobile phone (this is the intervention), then analyse any difference to establish whether a causal relation exists.

So, you generate data through observations and measurements under different experimental conditions, and analyse your experimental data to explain causal relationships between the factors under study.

Depending on the complexity of the relationship between cause and effect, more or less complex experimental designs can be used. Those involving an inaccessibly large population of individuals, as might be the case for a medical drug trial, use sophisticated techniques to choose representative samples, as well as sophisticated statistical analysis to test hypotheses.

However, even simpler "local" cause-effect hypotheses may rely on the availability of a fully equipped scientific laboratory to work.

1.6.3.3 Evaluation

Typical questions in the evaluation of the experimental research include:

1. Reliability:
    - Are the experimental variables manipulated or measured adequately described?
    - Is there a clear account of what is controlled?
    - What are the experimental procedures? Are they sufficiently detailed so that the experiment can be repeated by an independent third party?
    - In a social setting, what information is given about participants and how they were found?
    - What information is given about the apparatus and the process used to make measurements?
2. Validity:
    - Was a hypothesis or predicted outcome of the experiment clearly stated?
    - If a population sample was selected for the experiment, how representative is it? How was it selected? Which measures were taken to avoid sample bias?
    - If statistical analysis is applied, how adequate is it? Have appropriate statistical tools been used and their use justified?

- Are confounding factors or outliers identified and discussed?
- Are the statistical and other analyses convincing of the conclusions?
- Has the experiment being replicated?

1.6.3.4 Is this strategy right for me?

Although widely applicable, the experimental research strategy has some counter-indications:

1. when testable hypothesis cannot be formulated, concerning the cause-and-effect relationships of interest
2. when the cause/effect relationship is very complex, for instance, depending on many factors, which cannot be accounted for in an experiment
3. when confounding factors and variables cannot be isolated, or no level of control is possible
4. when the experiment is a one-off and cannot be repeated
5. if you don't have access to specialised equipment required
6. if you don't have (or can't develop) statistical analysis skills required

1.6.3.5 Suggested further reading

oates2008researching, johannesson2014research, field2002design

1.6.4 Case study research

Case study research proceeds through the in-depth study of a notable instance of a phenomenon within its real-world context, particularly when it not possible to separate the phenomenon from its context. The study of a single phenomenon requires the researcher to delve deeply into the context of that phenomenon, whether that be a project, an organisation, an engineered system, a policy, an economic or historical setting, or other. Case studies allow the researcher to study complex phenomena where several factors are at play, and to explore alternative meanings and explanations.

1.6.4.1 Knowledge contribution

Case studies focus on the 'how?' and 'why?', so that the knowledge contribution is a detailed insightful account of the phenomenon in its natural context, including when appropriate its relationships with other phenomena, and relevant processes and causal chains.

What you seek with a case study can span from exploring possible questions or hypotheses for follow-up research, to explaining why certain outcomes have occurred, to investigate changes over time. For instance, an example of case study could be a detailed investigation of the US Equifax social security breach of 2017, in which 143 million of their consumer records were stolen by hackers. This may be descriptive of the chain of events that took place or explicative of why things happened the way they did, or both.

Therefore, case studies come in many forms, including:

- exploratory: in which the researcher explores a research problem sufficiently to be able to conduct a further study. If you're considering studying for a PhD after your Masters research, then this might provide a head-start for your future research
- multiple: in which two or more instances of the phenomenon are chosen, which present both similarities and differences, to provide an even richer analysis of the phenomenon in its context
- longitudinal: in which the researcher considers the state of a phenomenon over time. This offers a natural storytelling context in which change in the phenomenon and/or its context can be analysed.

Combinations of the above are also often adopted, allowing even deeper exploration of both relationships between phenomena and how they develop over time or in response to contextual factors.

1.6.4.2 Data collection and analysis

Case studies require you to collect empirical data from a great variety of sources, and to focus on depth rather than breadth. Therefore, all data collection techniques which allow you to do so may be used, from observation of the phenomena *in situ* and the context and processes in which it participates, to surveys of those that experience the phenomena in context (through interviews, questionnaires, *etc.*), allowing for multiple stakeholder views to be taken into account, to studying forensically existing documents that directly or indirectly describe the phenomena. This will lead to much data to be collected — mainly qualitative, but also quantitative to some extent, so that their analysis can be very rich and complex.

1.6.4.3 Evaluation

An experienced researcher evaluating case study research will ask the following questions:

1. Reliability:
    - Has the type of case study conducted been clearly described and justified?
    - How were ethical considerations taken into account, particularly in relation to participants and confidential information handled?
    - Were the data generation and analysis methods adequately described?
    - Are the procedures followed appropriated documented?
2. Validity:
    - Have the criteria for choosing the particular case study been described and justified? Is the choice appropriate for the phenomenon studied?
    - Did the data generation methods generate the right type of data about the phenomenon in sufficient depth and quantity?
    - How was a detailed investigation of the phenomena conducted? Was the researcher able to work within the case study context?
    - Does the research adequately describe the relationships between phenomena and the processes in which the phenomena participate?
    - Is the data analysis systematic and transparent? Are the steps taken to arrive at conclusions clearly explained?
    - What generalisations were made from the case study research? Are they appropriate for the phenomenon and its context?

1.6.4.4 Is this strategy right for me?

There are conditions for this strategy to be successful:

1. Case study research requires you to have access the phenomenon in its context to be able study it holistically and generate rich, detailed descriptions. As an example, if you're not a teacher, it might be difficult to gain access to a classroom to study student/teacher interactions. If access is an issue, then you should consider a different strategy, like systematic research reviews, which work from secondary sources.

2. Access to data sources, such as policy, processes or procedures within an organisation, may rely upon interaction with others. Even if you already have a good relationship with them they might not have the time to assist you sufficiently for your data generation to be successful within the timeline of your project. If time is an issue you should consider alternative sources, or even a different research strategy.

3. Being embedded within the context of the phenomenon, as might be the case, for instance, of an employee of an organisation, facilitates the investigation of the phenomenon. In this case, however, alternative research strategies are also applicable, such as ethnography or action research.

4. You must have the required knowledge to understand the phenomena under study. For instance studying the processes by which an engine controller in an aircraft is designed may require a detailed understanding of technical documentation, language and even mathematical or computational theories. Acquiring this knowledge from zero as part of your research may not be possible or may consume too much time•. In such cases you should reconsider the phenomenon to study.

5. You need to make a judicious choice of case study to be able to make any generalisations about the phenomenon beyond the particular instance. If you don't have access to a significant instance of the phenomenon and generalisation is an important consideration, then you should consider a different research strategy.

• The success of your research will depend critically on climbing any learning curve quickly and successfully, even if that learning curve looks like El Capitan!

1.6.4.5 Suggested further reading

yin2009case, oates2008researching

1.6.5 Action research

Action research focuses on real-world situations for which improvement is sought through participatory and collaborative research. Its focus is on practice change, and continuous learning and improvement via an iterative 'plan-act-reflect' cycle which generates both knowledge and action.

1.6.5.1 Knowledge contribution

Action research should make both a contribution to knowledge *and* to practice: an action researcher strives to generate knowledge and action to address important problems that people experience in their practices, so that the knowledge contributed originates in real-world needs. The researcher is an active participant in the research, rather than solely an observer, alongside other collaborating practitioners: in fact, collaboration, alongside reflection, is a key element of this strategy.

The outcomes of action research may be new theories or methods alongside their direct implementation to improve practice within a specific professional or social setting. For example, in an educational setting, where this strategy is widely applied, a group of teachers may come together to study the composition and effectiveness of homework at each school grade, with a view to improve the balance between knowledge-based and practice-based learning.

1.6.5.2 Data generation and analysis

Similar to case studies, action research requires you, and your collaborators, to collect empirical data from a variety of sources to gain a deep understanding of the current practical situation to be improved. Common methods which allow you to do so include observations, surveys, focus groups and document reviews. In this case too, both qualitative and quantitative data are collected and analysed.

1.6.5.3 Evaluation

The evaluation of action research will include the following questions:

1. Reliability:
    - Has the work used an iterative cycle of plan-act-reflect? How many cycles were conducted?
    - Was the research collaborative? Is the level of collaboration achieved appropriate?
    - Were the data generation and analysis methods appropriately described?
2. Bias:
    - Have the researcher's personal stake and potential biases been discussed? Was a reflexivity account included?

- Is there a reflection on self-delusion and group-think of the collaborators? How was this mitigated? Was the mitigation successful? If not, what was the outcome?

3. Valididty:

   - Was the learning from the plan-act-reflect cycle clearly identified and discussed?
   - Were the data generation methods appropriate, and was enough data generated?
   - Were detailed descriptions and accounts of findings provided?
   - Has the research generated both knowledge and action leading to change? How useful or impactful on practice are they?
   - Were generalisation made and appropriately supported by evidence, including triangulation?

1.6.5.4 Is this strategy right for me?

There are conditions for this strategy to be successful:

1. Action research focuses on action aimed at solving real-world problems in professional and other social contexts. If that's not the case for your research, then you should consider a different strategy.

2. The action researcher is expected to be embedded in the context in which the research takes place, and have a professional stake in addressing the problem beyond the research itself, for instance, as an employee of an organisation. If this is not the case for your project, then you should consider case studies instead.

3. Action research requires the involvement of other practitioners as collaborators in the research. This goes beyond being merely participants in surveys or observations: instead it requires a much higher commitment and continuous involvement in the study. If this is not possible, you should consider case study research instead.

4. Action research works through reflection, and continuous learning and improvement. As such, it does not exhibit the same level of scientific rigour as, for instance, an experiment. If scientific rigour is needed in your research, then you should consider a different strategy.

5. Action research may not be suitable to study complex causal-effect relationships. If you need to establish one such relationship, then you should consider the experimental strategy instead.

6. Generalisation can also be difficult to achieve with action research. If you need to be able to generalise your research widely, then consider case studies instead.

7. While action research is accepted and commonly applied in some social sciences, like education and healthcare, this may not be the case in your discipline. You should therefore check with your supervisor whether this strategy is acceptable or you should consider a different, strategy.

1.6.5.5 Suggested further reading

oates2008researching,johannesson2014research

1.6.6 Ethnography

The ethnography research strategy aims to study the culture of a group of people in their natural setting.

1.6.6.1 Knowledge contribution

Ethnography contributes to knowledge by providing a cultural characterisation of the group under study. Such characterisation should be one that the group members recognise and find familiar, and should be inclusive of various cultural facets, both social and economical, rather than focusing solely on one specific aspect.

While ethnography was originally developed within the discipline of anthropology, particularly for the study of indigenous populations, it can be applied widely in social settings, for instance to study the work culture within a particular profession or organisation, or the culture of online communities within social media.

1.6.6.2 Data generation and analysis

The researcher is expected to join the group and share what the group members' experience in their natural social setting in order to gain an insider's perspective and arrive at a rich, detailed characterisation. This requires the researcher to make detailed participant observations, appropriately recorded in field notes, accompanied by gathering detailed data through interviews and document reviews, linking them to the existing literature and reflecting on what they have learnt from their own experience, including their state of mind and emotional reactions. Data generation and analysis are predominantly qualitative.

1.6.6.3 Evaluation

Evaluating ethnography may involve asking the following questions:

1. Reliability:
    - Are field notes sufficiently rich and detailed? Do they capture people's actions and behaviours, and the motivating reasons?
2. Validity:
    - Is the cultural characterisation obtained sufficiently rich to account adequately the group's beliefs, customs, behaviours and interpersonal relations?
    - Was adequate time spent with the group in their natural setting? What reflection has been done on such time?
    - Are data appropriately interpreted through a cultural lens?
    - Is the ethnographic characterisation a standalone description, or has it been linked to theory, other ethnographic studies or issues in other cultures?
3. Bias:
    - Does the research include a reflexive account of the researcher?

1.6.6.4 Is this strategy right for me?

There are conditions for this strategy to be successful:

1. Ethnography requires you to be a researcher located within the context of your situated research. This can take extensive amounts of time, such as might be the case if the context of your research is the organisation for which you work. However, if you have yet to have identified the context, or have yet to reach out to it, then this requirement may mean that ethnographic research will not be successful. If you are not already close to your context of research, you may wish to consider case study research instead.

2. Even if you are already located within the context of your ethnographic research, the context must be accepting of an ethnographic approach for your research to be successful. An organisation, for instance, in which there is a culture of strict compartmentalisation may not provide sufficient opportunities for ethnographic research.

3. In ethnographic research you allow the culture under study to determine the outcomes of the research, so you should approach it without any preconception or bias. If there is any possibility that you could be biased to a particular outcome – as might happen if you feel you already know the outcome and are simply trying to confirm this – then ethnography is unlikely to lead to a successful outcome for your research. Any competent ethnographer will be particularly sensitive to expressions of bias, even if they aren't even intentional. Indeed, such bias may preclude any successful research strategy being applied.

4. Ethnography can lead to rich descriptions of complex social settings, and the characterisation produced may be very deep in representing a particular group culture. However, this may be difficult to generalise to other social groups or settings. If generalisation is an important aspect of your research, then you should consider case studies instead.

1.6.6.5 Suggested further reading

oates2008researching,johannesson2014research

1.6.7 Systematic research reviews

A systematic research review is used to generate new insights from published work, linked to a clearly defined research problem or question.

1.6.7.1 Knowledge contribution

A systematic research review is meant to advance a field of study by providing insights from across the literature not contained in individual research papers. It uses a rigorous set of criteria to identify, select, and critically appraise relevant research from previously published studies in order to generate a scholarly synthesis of the evidence in relation to an explicit research problem or question.

For example, a systematic research review could be conducted to generate new insights on the effectiveness of a specific medical treatment, in order to advance evidence-based medicine: published articles on randomised controlled trials for that treatment could be reviewed and a judgement made based on a synthesis of the results from the accumulated body of work.

1.6.7.2 Data collection and analysis

In a systematic research review you only use evidence from published studies and rely on explicit, reproducible methods for identifying the relevant research to review. Specifically, you must decide upfront your research problem/question and the set of criteria you will use to select, compare and evaluate those studies, and combine their results.

The type of analysis you will conduct will depend on the nature of the evidence you are considering and combining. In *narrative reviews*, a narrative synthesis is produced of qualitiative results, while in *meta-analysis*, statistical techniques are used to analyse and combine quantitative results. Combinations of the two are also possible.

1.6.7.3 Evaluation

Evaluation of the systematic research review will involve answers to the following:

1. Reliability:
    - Are the criteria used to select, exclude, evaluate and combine the published research explicit and reproducible? Were there any deviations from this protocol and, if so, are they explained, justified and documented?
2. Validity:
    - Has the researcher accessed all relevant published research in the area?
    - Have the relative strengths and weaknesses of the research reviewed been described? To which extent have conflicts between sources been identified and, when appropriate, resolved?
    - In combining results from different studies, are significant differences between those studies appropriately acknowledged?

- To which extent has a definitive synthesis from the literature been achieved? To which extent are the limits of current knowledge described?
- To which extent has precision and/or generalisability been improved through the systematic research review?
- In meta-analysis, to which extent have statistics been used to produce overarching conclusions? Were the studies sufficiently homogeneous for meta-analysis to be feasible?
- In narrative reviews, to which extent potential bias has been acknowledged and mitigation measures applied?

1.6.7.4 Is this strategy right for me?

You should consider the following points when choosing this strategy:

1. A systematic research review is both systematic and extensive in its coverage of the topic of interest. This requires you to have a very good grasp of the subject area in order to establish appropriate criteria for the selection of all relevant published work, and this may lead to a large body of work to review. If you lack such knowledge of the filed of study or the time to conduct an extensive review of the literature, then you should consider a different strategy.

2. A systematic research review assumes that there is a substantial body of knowledge already published from which new insights can be generated. In emerging research areas, this may not be the case, so that a systemic research review is unlikely to reach any meaningful synthesis. If there is paucity of literature on your chosen topic, then this strategy is not for you.

3. You need relatively easy access to the academic literature to be able to select the body of work to review, for instance, through a university library with a large research collection in your chosen discipline. If not, you will need to devise alternative ways to access the relevant literature, like contacting the author(s) directly. Although most authors will be happy to send their published research to you, the round trip time can introduce lengthy delays in the research process as you wait for the requested research to arrive. You may also need to be persistent to ensure that a busy author is aware of your research need. If you don't think you will be able to access easily a large proportion of the published work you need, you should rethink your research strategy.

4. Systematic research reviews are required to be transparent, reliable, and easy to replicate. You will be expected to have stated explicit inclusion and exclusion criteria so that another research would be able to arrive at the same collection of published work, and ensure that no inherent bias has influenced such choice. Choosing appropriate criteria may be difficult and may require you to iterate, starting perhaps from a broader focus, then narrowing it down as your research progresses. This, too, can be time consuming, so if your time is limited, you should consider a more time-efficient strategy for your research, perhaps one which allows you to generate your own primary evidence.

1.6.7.5 Suggested further reading

wright2007write,moher2009preferred,pollock2018systematic

See **moher2009preferred** for PRISMA statement, a 27-item check-list. The aim of the PRISMA Statement is to help authors improve the reporting of systematic reviews and meta-analyses. PRISMA may also be useful for critical appraisal of published systematic reviews. However, the PRISMA check-list is not a quality assessment instrument to gauge the quality of a systematic review. http://prisma-statement.org/prismastatement/checklist.aspx

1.6.8 Grounded theory

Grounded theory aims at defining theories• on social phenomena based• on empirical data. The intention is for the theory to emerge from the collection and analysis of the data, rather than using the data to confirm or disprove a previously formulated theory, or test a previously formulated hypothesis.

• In simple terms, a theory is a system of ideas intended to explain something.

• I.e., 'grounded', hence the name!

1.6.8.1 Knowledge contribution

Grounded theory contributes knowledge in the form of theories concerning complex social phenomena, striving to provide explanations of people's choices and actions grounded in those people's own accounts and interpretations.

For example, grounded theory could be used to formulate theories on what motivates people to join or leave a particular organisation, or why employees may feel fulfilled or frustrated in their workplace.

1.6.8.2 Data collection and analysis

Grounded theory requires the systematic collection and analysis of data without any preconceived belief or theoretical framework. The data are collected, coded and analysed to identify emerging concepts, categories and relationships. The process is iterated with new data used to review and revise those concepts, categories and relationships until no more can be gained from further data collection and analysis. At this point a theory is put forward based on what was derived from the data. In this process, it is essential to be open to multiple explanations, and to explore the data from all angles in order to gain a fresh perspective.

1.6.8.3 Evaluation

The following questions should be addressed in evaluating grounded theory research:

1. Reliability:
    - Was the process followed to arrive at the theory appropriately described? Was it systematic and iterative?
2. Validity:
    - Were sufficient data collected and described? How relevant were they to the phenomenon under study?
    - Which concepts, categories and relationships were generated by the research? How are they grounded in the data? How do they contribute to the theory?
    - Has the phenomenon been examined under a broad range of conditions and from a variety of perspectives?
    - Is the theory plausible in relation to the data? Does it provide sufficient explanation of the phenomenon under study? Is it general enough to account for variation in conditions and context of application?
    - Can the theory be easily understood by its intended users? How useful is it in helping them understand their social reality and be the basis for action?
3. Bias:
    - Is there a reflexivity account of the researcher to guard against possible bias?

1.6.8.4 Is this strategy right for me?

In choosing this strategy, you should consider the following:

1. Grounded theory is about letting the "data to do the talking" **drew202310-grounded**, so you should not have any prior belief, theory or hypothesis you wish to put to test. If that's not the case, other strategies are more appropriate, like case studies, ethnography or experiments.

2. Grounded theory requires you to gather a significant amount of empirical data, making sure you examine a social phenomenon under various conditions and from many perspectives. If you do not have access to such data, then grounded theory cannot get started, and you should consider other strategies.

3. Grounded theory is generally time consuming, given the iterative nature of the process of gathering and analysing data. If time is an issue in your project, then you should choose a more time-efficient strategy, like case studies or experiments.

4. Grounded theory aims at generating theories concerning social phenomena. If a new theory is not the aim of your work, then you should choose a different strategy, like ethnography or case studies.

5. Grounded theory is particularly useful when there is a paucity of theories in relation to the phenomena of interest. If there are already several theories available, it is less likely grounded theory will be able to contribute something new. In such cases, you should rethink whether a new theory is actually needed or choose a different aim and strategy for your project.

1.6.8.5 Suggested further reading

smith1997understanding,drew202310-grounded,corbin1990grounded,strauss1998basics,gibson2013rediscovering,charmaz2014constructing

1.6.9 Phenomenology

Phenomenology is a research strategy that focuses on people's conscious experience of a phenomenon, that is how people perceive and give meaning to it, including any feeling and emotions it evokes.

1.6.9.1 Knowledge contribution

Phenomenology contributes knowledge by providing insights into people's lived experience, seeking to describe or interpret the essence of a phenomenon from the perspective of the people who have experienced it.

For instance, a phenomenological study of patients emergency care could focus on the experience of nurses and doctors in emergency departments.

1.6.9.2 Data generation and analysis

Data generation in phenomenology is primarily through in-depth, unstructured interviews and focus groups, which should allow participants to give their own account of their experience and surface key issues, without being influenced by the researcher. These are often complemented by participant observation, in which the researcher is immersed in the day-to-day activities of the study participants, hence sharing their experience of the phenomenon of interest. Audio and video recording, alongside field notes and journals are used to record data.

Data gathering typically results in a large quantity of qualitative data, which are both detailed and unstructured, so that qualitative methods are then needed for their analysis. The analysis process requires the researcher to set aside any preconception, assumption or bias[•] and focus solely on the data, considering every participant's statement or expression as equally important and relevant.

[•] This is referred to as 'bracketing'.

1.6.9.3 Evaluation

The following questions should be asked of phenomenological research:

1. Reliability:
    - Are the criteria for selecting the study participants properly explained and justified?
2. Validity:
    - Is the phenomenon accurately and objectively described? Is the account provided one that can be recognised by anyone who has experienced that phenomenon?

- How have similarities and differences in the participants' experience of the phenomenon accounted for in the study? How are they dealt with in the data analysis, particularly in the coding and categorisation process?

3. Bias:

   - Is there a reflexive account of how judgments were suspended to focus on the analysis of experience?

1.6.9.4 Is this strategy right for me?

In choosing this strategy, you should consider the following:

1. The focus on phenomenology is lived experience, to uncover what is really like to experience a phenomenon from the perspective of those who have lived through it. If you do not have access to participants who can share their experience, then you should consider a different strategy.

2. Phenomenology asks you to suspend any prior belief on the phenomenon and only focus on the participants' experience. If you have a theory or hypothesis you want to test, then you should choose a different strategy.

3. The amount of qualitative data to gather and analyse is considerable, and this can be very time consuming. If time is an issue in your research, then you will need to choose a more time-efficient research strategy.

4. Phenomenology is about going deep into the experience of a phenomenon, and this constrains the number of participants in your study. If you are more interested in gaining consensus from a large number of participants, or making general predictions from your sample data, then you should choose something else, like survey research or grounded theory.

1.6.9.5 Suggested further reading

Activity: Considering phenomenology #8

Having read the above subsection, do you consider phenomenology to be a serious candidate for your research strategy?

Guidance

If so, add the following references to your list of reading: **merleau1956phenomenology**; **anderson1991qualitative**; **smith2018phenomenology**; **shudak2018phenomenology**; **academic-educational-materials2019understanding**; **office2020the-phenomenological**; **groenewald2004a-phenomenological**; **hycner1985some**

1.6.10 Simulation

The simulation research strategy builds an explicative mechanism to imitate or reproduce the behaviour of a real-world artefact or system.

1.6.10.1 Knowledge contribution

Simulation contributes knowledge by allowing the study of the simulated artefact or system under different conditions, in order to answer "What if?" questions, make predictions or gain insights on behaviour or properties, particularly when this can't be easily achieved directly on the real-world artefact or system.

Simulations are used in all disciplines and vary greatly in their purpose, nature and design. For instance: financial simulations are used to study the behaviour of the global stock market; climate simulations to study possible effects of climate change; engineering simulations, to test the properties of materials under different stress conditions; social simulations to study human behaviour in social settings, to name just few examples.

1.6.10.2 Data generation and analysis

Data are needed to inform the simulation design. Their kind and how to obtain them will depend strongly on the nature of the artefact or system under study and what your research aim is, so that all known methods for

data generation apply. For instance, to simulate a new aircraft design under different wind conditions, you may need to gather data on the physical characteristics of the aircraft and the materials to be used to build it, alongside meteorological data which can be used to perform tests under different simulated conditions. On the other hand, to simulate how size and age of a population may change in future decades within a particular geographical region, you may need to gather data on current population size and age, birth and mortality rates, migration rates in and out of the region, and conditions which may affect them over time.

Data are also needed to establish measures and criteria to evaluate whether the simulation is sufficiently representative of the artefact or system being simulated. This may involve comparing simulation outputs with empirical data or theoretical predictions, or gathering expert opinions on such outputs, with the aim of establishing the extent expectations are met or significant discrepancies exist.

Whichever methods you use to gather data for your simulation design, once constructed, the simulation should allow you to generate observations of the simulated artefact or system, both past, present and future, the latter being a unique characteristic of this research strategy•. Such observations can then be analysed in order to address the research question, as well as to evaluate the simulation against the established measures or critera.

• All other strategies can only look at the past or the present.

1.6.10.3 Evaluation

Evaluation questions specific to this strategy include:

1. Reliability:
    - Is the simulation design appropriate to address the research problem/answer the research question?
    - Were simulation performance measures or criteria clearly established? How were they chosen and why?
    - How was the simulation constructed? Were the appropriate computational/mathematical/statistical techniques applied?
2. Validity:
    - Were appropriate data gathered to inform the simulation design? How were they chosen and why?
    - How was the simulation tested and improved during its development? Were different testing methods applied and the results documented?

- How close are the simulation's outputs or behaviours to the real-world data? How was this established? Do the results make sense?

1.6.10.4 Is this strategy right for me?

Is you are considering the simulation research strategy, then you should consider the following questions:

1. The design and construction of a simulation requires advanced computational skills, often alongside mathematical and statistical skills. Do you already have such skills? If not, you are unlikely to be able to develop them in the time of your project, and should consider other research strategies instead.

2. Do I have access to the data, and possibly stakeholders, needed for the design and evaluation of the simulation? Without such data it is unlikely you would be able to build a representative simulation, hence you would not be able to generate valid and reliable results. In such case, you should consider other strategies.

1.6.10.5 Suggested further reading

Activity: Considering simulation #9

Having read the above subsection, do you consider simulation to be a serious candidate for your research strategy?

Guidance

If so, add the following references to your list of reading: **dooley2017simulation**

1.6.11 Mathematical and logical proof

A mathematical proof is a rigorous argument that demonstrates the truth of a certain proposition starting from certain assumptions. As long as the assumptions are true, then an argument is constructed in a way that guarantees that the proposition is also true. Such argument is termed 'deductive' as it starts from the assumptions and arrives at the proposition as the conclusion of the reasoning.

When the reasoning is carried out within a fully formal logical system, then we have a logical proof.

1.6.11.1 Knowledge contribution

Mathematical and logical proofs contribute knowledge in the form of true propositions, which are the means by which Mathematics functions and grows its scope and applicability.

Within a mathematical system, such truths are absolute, something which does not hold in any other scientific discipline: even in the natural sciences and by taking a (post-)positivist stance, truths are always only tentative and falsifiable, in that they hold only until new evidence emerges to contradict them.

1.6.11.2 Data generation and analysis

In this strategy, it does not make sense to talk about data generation and analysis.

Instead, all mathematical disciplines, relies on sets of assumptions and previously proven propositions which are taken as the starting point to generate, through proofs, new propositions, that is new truths.

1.6.11.3 Evaluation

A new proof is subject to the scrutiny of the community of mathematicians, which employs various means to check both assumptions and reasoning, so as to reach a verdict on the reliability and validity of the proof.

Such means may include using alternative deductive reasoning to check they can reach the same conclusion, using examples in support of the reasoning, or even recreating a mathematical proof within a fully formal system or using a computer-based automated checker, when applicable. You could adopt some of these approaches to improve or defend the reliability and validity of your proof.

1.6.11.4 Is this strategy right for me?

If you are considering this strategy, you should ask yourself:

1. Mathematical and logical proofs only make sense within research which is amenable to formalisation. Is that the case for your project? If not, then the notion of proof may not apply and you should consider an empirical research strategy instead.

2. You will need to be a skilled mathematician or logician to come up with a proof that can withstand the scrutiny of the mathematical community. Do you possess such skills? If that's not the case, then this strategy may not be for you•.

• One way to determine whether your background is suitable would be to read the first few pages of **lakatos2015proofs** (up to page 9 is available through google books).

3. Ideally, you should seek formative feedback from an experienced mathematician as you develop your proof, to reduce the chance of mistakes or reasoning pitfalls. Do you have access to such an expert advice? If not, you should discuss with your supervisor to ensure they do have the skills to take up that role.

1.6.11.5 Suggested further reading

Activity: Considering mathematical and logical proof #10

Having read the above subsection, do you consider mathematical and logical proof to be a serious candidate for your research strategy?

Guidance

If so, add the following references to your list of reading: **Kleene1964introduction**; **lakatos2015proofs**; **antonini2011examples**; **johannesson2014research**

1.6.12 Mixed methods research

The mixed methods research strategy• combines elements of both qualitative and quantitative research, with the aim to increase both breadth and depth of understanding of the phenomenon under study, and corroboration of results, giving more confidence in the conclusions reached. As a result, triangulation is in-built within the strategy.

• Mixed-method research should not be confused with *multi-method research*, which simply indicates the use of many methods, possibly all qualitative or quantitative.

1.6.12.1 Knowledge contribution

The knowledge contribution is the combination of the knowledge contributed by each of the methods applied, appropriately synthesised by considering connections and contradictions between qualitative and quantitative data.

Mixed method research is particularly suited to interdisciplinary research and to the study of complex situations or social settings, particularly when one kind of method alone would not deliver the desired depth of understanding or richness of results. For example, within urban planning, you may be interested in improving pedestrians' safety, so that a mixed methods study may consider both quantitative data on

pedestrian accidents and qualitative data on pedestrians' experiences and perceptions in order to identify both safe and dangerous areas to both learn lessons and plan remedial actions.

1.6.12.2 Data generation and analysis

How data are generated and analysed will depend on how the different methods are combined. Typical combinations include:

- parallel, in which separate qualitative and quantitative methods are applied to gather different sets of data. For instance, your collection of pedestrians' accident data, and pedestrian's opinions may occur in parallel, independently of one another, then the results may be analysed and compared.
- sequential, in which the methods are applied one after the other, with outcomes from the first used to inform the second. For instance, you could start with the pedestrians' experience, then collect accident data on areas which are perceived as particularly safe or dangerous.
- nested (or embedded), in which a quantitative method is applied within a wider qualitative method (or vice versa). For instance, the focus may be primarily on the qualitative pedestrians' experience, within which some statistical analysis is applied, for instance, to look for correlations between such experience and accident data.

1.6.12.3 Evaluation

Evaluation questions for this strategy will include questions on the specific methods which are combined, alongside the following questions on their combination:

1. Reliability:
    - How was the use of mixed methods justified in relation to the phenomena of interest? How has the study benefitted from their combination?
    - Is the way the methods are combined appropriately described?
2. Validity:
    - How were connections between qualitative and quantitative findings established?
    - How were conflicting or mismatched results from the different methods handled?

1.6.12.4 Is this strategy right for me?

If you are considering mixed methods research, you should take the following into account:

1. Mixed methods research requires competence in more than a single research method, which takes time to develop. If your Masters project is your first research project, it is unlikely you will have a developed understanding sufficient to apply the mixed methods research strategy, and you should consider a single method strategy. However, if your work is part of broader mixed methods research, perhaps led by your supervisor, then you may be able to contribute by focusing on the particular method you are being asked to work with.

2. Collecting and analysing both qualitative and quantitative data requires substantial time and resources. If this is going to be an issue, then a strategy with a single method focus would be a better choice.

1.6.12.5 Suggested further reading

Activity: Considering mixed methods research #11

Having read the above subsection, do you consider mixed methods research to be a serious candidate for your research strategy?

Guidance

If so, add the following references to your list of reading: **johnson2007toward**; **denzin1978research**; **webb2000unobtrusive**

1.7 Choosing and drafting your own research strategy

By now you should have narrowed down your list of candidate strategies to few choices, and possibly discussed those choices with your supervisor. This is the time to learn more about them in order to make a final choice for your your project.

Activity: Choosing your research strategy #12

For each candidate strategy in your list, go to its "Further reading" section and access the academic literature cited to learn more about the strategy, and how you it may apply practically to your project. At the end of this process, you should reach a decision on which research strategy you will adopt. You should also have gained a good understanding of how to apply it.

Guidance

The references we have provided are only a starting point, so you should also explore other literature on the topic. Your supervisor will also be able to suggest further reading.
As you read the literature, you should take notes to augment the summaries we have provided in the previous section, reflecting your deeper engagement and growing understanding of each research strategy. You should pay particular attention to possible data generation and analysis methods under each strategy, reflecting of which may be most applicable to your project and how, alongside any risk or other factor which may affect their successful application.
It is not necessary for you to learn the fine details of each method at this point. However, by the end of this activity, you should have a clear idea of which methods you will be focusing on in Stage 4, in which you will engage with the specific procedures to apply those methods in your own project.

Your final activity in this chapter is a writing tasks: to draft your chosen research strategy, as a starting point for the narrative you will require to develop during the remainder of the project and eventually include in your dissertation. We recommend you apply the template in Table **??** to structure your writing.

Table 1.4: How to summarise your research strategy

Section	**Content**

Activity: Sketching your research strategy #13

Apply the template in Table **??** to provide a first draft account of your research strategy.

Guidance

This first draft will be necessarily tentative, but it is a good starting point that you can populate and revise as alongside your increasing understanding and practical application of your strategy.
It is important that you engage with all elements of the template, including the evaluation section: although your full evaluation will only be completed at the end of the research, it is important you start thinking about the questions you will need to address. This, in turn, will help you ensure that the steps you take to apply the methods within the strategy are likely to provide satisfactory answers to those questions.