Hogeschool van Arnhem en Nijmegen
HAN University of Applied Sciences

2018
2019

Module Systems Modelling

MODELLING SYSTEMS PROJECT (5 EC) – RESEARCH SKILLS

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Preface

This course is mandatory for the professional Master Programme Engineering Systems with the tracks:

- Automotive Systems
- Control Systems
- Embedded Systems
- Lean Engineering
- Sustainable Energy

Class structure: during semester weeks, each Monday (1½ hours)

Planning research skills and professional skills			
			During class
1.	Monday 3 September 2018	18:30-20:00	Introduction: how does this class work?
2.	Monday 10 September 2018	18:30-20:00	How to plan and execute a (research) project
3.	Monday 17 September 2018	18:30-20:00	Formulation of the question
	Homework video in advance	Introduction to research skills	In project groups: work on research question and hypothesis for the minor project research
		Research Skills phase one: formulating the question	
	Homework assignments in advance	Page no. 7	
		Page no. 11	
4.	Monday 24 September 2018	18:30-20:00	Working in project groups, discussions with tutor
5.	Monday 1 October 2018	18:30-20:00	Critical reading, plagiarism, referencing
	Homework video in advance	Research Skills phase two: determining research methods	In project groups: work on research methods for the minor project research
	Homework assignments in advance	Page no. 15	
6.	Monday 8 October 2018	18:30-20:00	Working in project groups, discussions with tutor. Peer feedback on project objectives & research question
	Monday 15 October 2018	Autumn holiday	
7.	Monday 22 October 2018	18:30-20:00	Presentation Study Centre HAN
8.	Monday 29 October 2018	18:30-20:00	Working in project groups, discussions with tutor (feedback chapter 2)

9.	Monday 5 November 2018	Exam week	
10.	Monday 12 November 2018	20:00-21:30	Academic writing
	Homework video in advance	Research Skills phase three: data collection & analysis	In project groups: work on data collection and data analysis for the minor project research
	Homework assignments in advance	Page no. 19	
11.	Monday 19 November 2018	20:00-21:30	Working in project groups, discussions with tutor
12.	Monday 26 November 2018	20:00-21:30	How to write a report with Latex
	Homework video in advance	Research Skills phase four: data presentation	In project groups: work on data presentation for the minor project research
	Homework assignments in advance	Page no. 22	
13.	Monday 3 December 2018	20:00-21:30	Working in project groups, discussions with tutor
14.	Monday 10 December 2018	20:00-21:30	Presentation skills Reporting on your research
		Research Skills phase five (no video)	In project groups: work on writing of research report or presentation
	Homework assignments in advance	Page no. 24	
15.	Monday 17 December 2018	20:00-21:30	Working in project groups, discussions with tutor
	Monday 24 December 2018	Christmas holidays	
	Monday 31 December 2018	Christmas holidays	
16.	Monday 7 January 2019	20:00-21:30	Concept presentations
17.	Monday 14 January 2019	20:00-21:30	Concept presentations
18.	Monday 21 January 2019	Exam week	
19.	Monday 28 January 2019	Exam week	Final presentations

Applied research skills for engineering masters - introduction[1]

This document describes the course *Research Skills*, part of the general module *Systems Modelling*. All HAN engineering master students have to complete this general module, the module is of an introductory nature.

The module is set up as follows: there are five video lectures in which the theory of the specific part of a research project is explained. You are then expected to do the homework assignments, prior to attending class.[2] During class, you will be working in small groups on the topics in a guided application manner.

Below, the five phases of a research project that are used in this course, are listed. It is important to realise that these steps are not linear but may done simultaneously or even in a circular manner. What you must take home from this is the thought that it is a model, useful to structure our thoughts and discussions. If you think that there are things missing, out of order, or superfluous, you are free to adapt the model to your needs. If you do make changes to the model, make sure to provide a convincing argument for doing so!

1. Ask the question: how to formulate an adequate research question that is to the point and measurable.
   a. Orientation in the field/context – valid factors, players, fields of research, existing literature, traditions, which lead to ***An Important Question*** to be answered. Where to obtain such a research question: from a (personal) interest, your client/manager, research program. Discuss at high level how you are going to report on the research, and how you will communicate during the project and wrap-up.
   b. Rewrite this main question into something which you can test against a hypothesis. Discuss your main research question with the problem owner.
   c. Split the main research question into smaller sub-questions that are measurable (or can be tested against a hypothesis) with (different) research methods. Make sure the sub-questions are MECE: mutually exclusive, collectively exhaustive. Test your sub-questions with the problem owner.
2. Research methodology: to pick the most applicable research methods to answer the research question. This includes a plan for data collection. The specific choice of methodology (methodologies) depends on the field of application and the research question.
   a. Choose an appropriate research method to answer each sub-question. Discuss the methodology with the problem owner and – if possible – experts on the topic.
   b. Choose an appropriate method with which you will analyse your data, be it quantitative or qualitative. Plan which data must be collected and the structure of the data to be collected (keep in mind your data analysis method). Thinking about the parameters to be collected and how the collected data must be labelled in advance provides great advantages during the data analysis phase. Discuss your data collection plan with the problem owner and – if possible – experts on the topic.
   c. Perform the data collection in a structured manner and keep a lab journal of your activities.
3. Data analysis.

[1] E.M. Wesselingh. The author can be reached at ellen.wesselingh@han.nl
[2] The homework is not graded, however, you cannot participate in class without having done the homework.

a. Conduct the data analysis in a structured manner: select the appropriate (statistical)[3] tool, defend your choice of methodology, identify weaknesses.
b. Report the analysis activities in a research journal that you keep.
c. Draw conclusions for the different analyses and answer each sub-question with a clear conclusion that actually provides an answer to the question.

4. Reporting: identify your audience, check their expectations (stakeholders analyses); choice of the most applicable platform and writing an article or research report that provides a clear and structured argument which answers the research question.
   a. Decide where do you want to publish your results and review the reporting requirements for the specific platform.[4]
   b. Make a first design of the report. Determine total length of the text, what type of illustrations are needed to highlight important findings, the division of chapters.
   c. Write the article, report or whatever you choose to produce. When the text is lengthy, write chapter by chapter. From the partial conclusions from the data analysis, draw one overall conclusion to answer the main research question. Have your text or chapter(s) reviewed by the problem owner or an expert (or peer review).
5. Communicate the final result with all stakeholders.

Sources (mandatory readings & tools)

Institutional tools

Homework tool: assignments to be handed in through the app. Note that homework is scanned for plagiarism.

Study Centre Techniek https://onderwijsonline.han.nl/manage/content/edit/RDp4O3Dp

Systems Modelling Research skills M SM RS (TM)
https://onderwijsonline.han.nl/manage/content/edit/L4No79NR

Literature

B. Martin and B. Hanington (2012), *Universal Methods of Design - 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions*, Rockport Publishers Inc.

- https://www.bol.com/nl/f/universal-methods-of-design/39682951/ (English version)
- https://www.bol.com/nl/p/universele-ontwerpmethoden/9200000005539881/ (Dutch version)

Educational tools

Methods Pack – find a combination of research methods that suit your needs, HAN & HvA.

Major Project report template, Monsma, S., Stroomer, C., Ammerlaan, T. (2018), HAN

[3] The choice of tool depends on the type of research you conduct (qualitative or quantitative). For the Engineering Master, statistical tools are the most likely choice of tool.
[4] Note that you must have thought about possible platforms for reporting your results at an abstract level, in the phase of defining the research question. I this phase you review the detailed requirements such as length of the document, language and make-up requirements.

Articles

Lacey, A. (2014). *The secret ingredient for a safer bike helmet: paper*. BBC Health Check. Available at https://www.bbc.com/news/health-25681895 or https://www.youtube.com/watch?v=BswK7ranf9M (language course version)

Mabuchi, K. (2012), Tanaka, K., Uchijima, D., Sakai, R., *Frictional Coefficient under Banana Skin*. Tribology Online. Volume 7. Issue 3. Available at https://www.jstage.jst.go.jp/article/trol/7/3/7_147/_article

Cadiergues, M.C (2000)., Joubert, C., Franc M., *A comparison of jump performances of the dog flea, Ctenocephalides canis (Curtis, 1826) and the cat flea, Ctenocephalides felis felis (Bouché, 1835)*. Vet Parasitol. 92(3):239-41, available at https://www.sciencedirect.com/science/article/pii/S0304401700002740

Klöppelt, C. (2018), Meyer, D., *Comparison of different Methods for Encoder Speed Signal Filtering exemplified by an inverted Pendulum*, proceedings REM 2018

Wesselingh, E.M., van Willigenburg, P., Stokman, H. (2015), *Proposal for a transparent sustainable energy market – Privacy by Design as a tool for data protection, and personalisation versus transparency*, poster presentation, available at https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=2070017

Content of this document

Script – Welcome and introductory remarks

Welcome to this course on research skills. In this course, you will learn how to do research in a structured way to obtain the best possible result, and how to provide justification for your choices and actions. The course is structured along a model that consists of five phases, for each phase we start with an introductory video in which we explain the core concepts of that phase. The video is accompanied by homework assignments. We expect you to prepare for class by watching the video. Jot down any questions or remarks that you have following the video, so that you can ask them in class. Preparation for class further requires that you do the homework assignment. Not being prepared means that you will not be able to participate in class.

In order to reach the best possible result in a project that requires research, a structured method is advised. This does not mean that unstructured events can lead to wonderful research, this is what we call serendipity. The invention of penicillin is a famous example of a laboratory experiment gone wrong leading to a breakthrough. Another famous example is the invention of the Post-IT memo, of which the glue was the result of a failed experiment to create a super glue. However, in this course we favour a structured approach for the project activities. This does not mean that you are not allowed to let your creativity work, on the contrary: innovation requires thinking out of the box; hence: invoking your creativity. However, this creativity is guided with structured methods.

A research project consists of two types of activities: first project activities to structure the work, in other words: project management. And then there are the material activities to actually perform the research itself. In order to create a successful research project, both types of activities are important!

There are multiple models to structure your research and as an experienced researcher you can choose the model that best fits your research project. Models are a wonderful thing, that is why there are so many of them. In this course, we use an informal model consisting of five phases as depicted in the introduction. You may divert from this model, but if you do, you must provide a convincing argument for doing so.

In this course, we use various types of educational materials; first of all the videos. Second; the book that is listed as mandatory literature. Third; prescribed research articles and research articles that you find yourself during the literature search in the first phase. Fourth, the methods pack. The book and the methods pack are frequently used in class so make sure to bring them with you to class.

Before we start with the material discussions, it is important to note that the steps as described below are not in a linear order per se, they may be performed in parallel or in a circular manner. For example, you start with the formulation of a research question, but during your research you may realise the question is too broadly formulated, or your original goal was too ambitious and needs to be re-adjusted. In such cases it is necessary to go back to the drawing board and adjust the relevant parts of the work already done.

Homework introduction

Watch the video (3:36 min).

Answer the following questions for yourself:

1. What were your strengths and weaknesses in previous bachelor research?
2. What do you think is the difference between BA and MA level research?

Class activities

Discuss the homework assignments in groups of 3-4 students. Each group presents the results: what are in their view the differences between bachelor and master research? What do they think are their strengths and weaknesses regarding research?

Script – Phase one, Ask the Question

1. *Ask the question: how to formulate an adequate research question that is to the point and measurable.*
   a. *Orientation in the field/context – valid factors, players, fields of research, existing literature, traditions, which lead to **An Important Question** to be answered. Where to obtain such a research question: from a (personal) interest, your client/manager, research program. Discuss at high level how you are going to report on the research, and how you will communicate during the project and wrap-up.*
   b. *Rewrite this main question into something which you can test against a hypothesis. Discuss your main research question with the problem owner.*
   c. *Split the main research question into smaller sub-questions that are measurable (or can be tested against a hypothesis) with (different) research methods. Make sure the sub-questions are MECE: mutually exclusive, collectively exhaustive. Test your sub-questions with the problem owner.*

In this video I explain the activities you typically perform in the first phase of a research project. Note that not all activities take place in a linear fashion; on the contrary. Activities may take place simultaneous, or in a circular manner in which you deepen your understanding of the matter or rewrite questions or hypotheses to be even more concise.

Scientific research – whether it is fundamental, applied, or practical, starts with a clear and concise question. This does not mean that the research question is clear and concise from the start, on the contrary: it takes skills and effort to formulate a question that can be tested and answered using reliable and valid research methods. Any scientific research project starts with asking The Question. In a way, this is not different from design projects, or indeed any type of project: these start with a project objective. In research, the objective is to answer a question, and in order for that question to be answerable, we need some quality control to get a "good" or "sharp" research question.

First, you need to define the context of the project and formulate a research question. The definition of the project context probably means you will interview a problem owner to enable you to formulate the motivation to start the project and the project objective. Both are important justifications for running the project, they define the scope of the project and are part of the project management. From the context, you derive the possibly important variables, advantages and disadvantages of the current situation, and the conclusion whether something has to be changed (or not). The change required defines the project objective. The research question is derived from the project objective and defines the material scope of the research (the content). The research question must fit the timing, means of the problem owner (your team, or the client).

You can get/derive questions from many sources: from your own, private interest or your pet hates, for example. There are journalists who write very enlightening articles or blogs on research questions that are entirely motivated by their personal curiosity and there is absolutely nothing wrong with that! Provided the research is scientifically sound, of course. A student in London was once involved in a traffic accident and as a result executed a research and design project which led to an innovative helmet for cyclists.[5] Or you might want to solve a small but really annoying problem for the company you work for. Companies typically have a number of no so urgent but potentially important projects that lay around. You may scroll this list of topics for a potentially interesting research question. Yet another source may be present if you participate in a research program. Other sources for questions are a literature survey, or informal talks or interviews with stakeholders in the field. What you should take home with regard to the question "Where do I get my ***Important Question to Answer***" is that it can be any source of inspiration!

[5] Multimedia: The secret ingredient for a safer bike helmet: paper

Now that you have some idea of an interesting question, the next step is to derive a "good" or "sharp" research question. I usually refer my students to the project modelling tool SMART for this step. The abbreviation SMART means Specific, Measurable, Acceptable, Realistic, and Timeframe. As this is a tool used for projects, not all variables may be applicable to your specific research project/question. However, usually most (or all) elements apply. After you have formulated a first concept of your main research question, take some time (possibly with friends or colleagues) to evaluate your concept question on these elements. It is especially useful to discuss the concept in a group, as this provides various positions on the quality of your question. This round of peer feedback is the first step in quality control or in scientific research terminology: validation of your research question.

Make sure to validate your main research question. An accepted method of validation is the formulation of a hypothesis; a hypothetic answer to your question. In other words; a hypothesis formulates what you think the answer to the research question is. The hypothesis is formulated in a yes or no manner, not an either-or manner. In case you work with lots of data, a statistical approach is needed and in such cases the hypothesis typically contains a statement about the certainty with which the answer is provided, generally known as a p-value of < 0.5%. We will discuss this type of statement in further detail later.

However, you should understand that not all researchers agree to a statistical approach. The problems of getting reliable data are seldom those considered by statisticians. To give an example: in voting polls, statistics tells that you can expect an accuracy of about 2% by polling 2000 people. Everybody knows that this is not true. This is not because the statistical theory is wrong. The problems are that you cannot get a 'representative sample' and that people will not tell you what they are really going to vote. They may not even know at the moment that you ask. A famous example is the presidential election of 1936. An analytical approach to validate the statistical results is therefore of great value.[6]

The hypothesis is typically divided into a null-hypothesis $H_0$and an alternative hypothesis H_A. The hypothesis and the anti-hypothesis must exclude each other: if either one is true the other must be false by definition. By analogy we may think of McKinsey's MECE principle: ***Mutually Exclusive, Collectively Exhaustive***. Some examples of hypotheses are:

Research question	Null hypothesis H_0	Alternative hypothesis H_A
How can the extremely low friction coefficient of banana skin *compared to other materials*[7] between a common floor panel and a typical shoe sole be explained?[8]	The texture of banana skin is different from the texture of other materials and fully explains the difference in friction coefficient.	The texture of banana skin is ***not*** different from the texture of other materials and thus does not explain the difference in friction coefficient.
Are there statistically significant differences in jump distance *and jump height*[9] between the cat flea and the dog flea?[10]	There are statistically significant differences at p<0.05 for the performance of each species compared using a t-test for length and a Chi-square analysis for height.	There are ***no*** statistically significant differences at p<0.05 for the performance of each species compared using a t-test for length and a Chi-square analysis for height.
What is the most critical phase with regard to the validity of the results in the design process of a feedback control system and why is this phase so critical?[11]	The most critical phase with regard to the results of a designed feedback control process is the modelling phase, because the choice of model defines the validity of the simulation results when compared to the actual results in a field experiment.	The most critical phase with regard to the results of a designed feedback control process is the realisation phase, because inaccuracies during the building phase define the actual performance of the system in comparison to the theoretical performance.

[6] This paragraph is not in the video, it is (partly) written by J.A. Wesselingh. For the story of the US presidential election see https://www.qualtrics.com/blog/the-1936-election-a-polling-catastrophe/.
[7] *Italic text* added after formulating the hypotheses.
[8] Scientific article: Frictional Coefficient under Banana Skin
[9] *Italic text* added after formulating the hypotheses.
[10] Scientific article: A comparison of jump performances of the dog flea, Ctenocephalides canis (Curtis, 1826) and the cat flea, Ctenocephalides felis felis (Bouché, 1835)
[11] Scientific article: Comparison of different Methods for Encoder Speed Signal Filtering exemplified by an inverted Pendulum

Table 1: research question and accompanying hypotheses.

The first research question, "How can the extremely low friction coefficient of banana skin compared to other materials between a common floor panel and a typical shoe sole be explained?", can be further re-written as follows: "Does the texture of banana skin explain the extremely low friction coefficient between a common floor panel and a typical shoe sole, compared to other materials?". You may even remove the common floor panel and typical shoe sole, and transfer those items to the methods section, because these elements were used for the experiments. The your question we be re-written as follows: "Does the texture of banana skin explain the extremely low friction coefficient compared to other materials?".

As we can see in this table with research questions and hypotheses, there are different types of research question. The first question in the table is typically an explanatory, or theory development question. The second question in the table is of a more factual nature: can we determine a fact? The third question in the table is of a more exploratory or diagnostics nature: can we determine the most critical point in a design process? There are different types of research which require a different approach. These are listed in the table below:

Research type[12]		Question type	Example[13]
Theory development	} Theoretical research	Fundamental, explanatory	
Theory testing		Confirmation	
Problem analysis	} Practical research[14]	Problem signalling, investigative	What is exactly the problem, for whom is it a problem, and why is it a problem to them?
Diagnostics		GAP analysis	What are the causes, background and relations of the problem?
Design centred		Problem solving, innovation	How can the problem be tackled in the most efficient way according to criterion X, Y or Z?
Change invoking		GAP analysis, explanatory	Is the realisation of the design adequate according to criterion X, Y or Z?
Evaluative		Confirmation, explanatory	Has the intervention been successful according to criterion X, Y or Z?

Table 2: research types and types of questions.

When the research question is too complicated to be answered straight away, you must divide the main research question into sub-questions. As with the main research question, each sub-question should be formulated clear and concise, and a corresponding hypothesis must be given.

An example of a main question divided into sub-questions:

Is a personalised energy offer from an energy supplier compatible with the best interest of the energy consumer?[15]	Should a commercial offer from your energy supplier be transparent?
	Is a personalized energy offer, fitted to historic energy usage, transparent?
	Is a personalized energy offer comparable to similar offers to, for example, neighbours, friends and relatives?
	How does the customer know to actually get the best offer when the market is no longer transparent due to personalised energy offers?

Table 3: research question divided into sub-questions.

[12] Translation of Verschuren, P., Doorewaard, H. (2007). *Het ontwerpen van een onderzoek*. Vierde druk. Boom Lemma. P. 76-81
[13] Based on Verschuren, P., Doorewaard, H. (2007). *Het ontwerpen van een onderzoek*. Vierde druk. Boom Lemma. P. 98-99
[14] Most likely the research type master students will do in their work.
[15] Scientific poster: Proposal for a transparent sustainable energy market – Privacy by Design as a tool for data protection, and personalisation versus transparency

As we see, the main question does not elaborate on what the best interest for a customer means. The specific context of the project is elaborated in the sub-questions, that focus on transparency. If another party, for example Consumers United, would do the research, they might focus on privacy or the best price instead. That would result in a different set of research questions.

Note that formulating a research question itself requires some preliminary research; you need to do background reading to find out what is already known about the topic from previous research. Or whether your intended research has already been done … This will help you to formulate a sharper research question.

Homework phase one, Ask the Question

Watch the video (11:28 min). From *Report writing for readers with little time*, read chapter 3.1 *Determine the main question* and chapter 3.2 *Formulate background and key questions*.

1. Rewrite at least one of the research questions in the table to formulate another aspect that may be highlighted in the research.
2. Do an introductory literature review to determine a possible research area of interest within the boundaries of the minor project.
3. If possible, discuss the motivation and the project objective with your project group, tutor, and problem owner.
4. From *Universal Methods of Design*, find at least two methods apart from literature review, to determine the type of research question and formulate a concept question. Write down a justification of your choice of methods.[16]
5. Formulate three (or more) questions that you would like to tackle in your minor project, with a null hypothesis and an alternative hypothesis. Do not try to be perfect, this is your first draft of the work to be done.

Class activities phase one

Discuss the homework assignments in your project group. Especially important is to choose one research question from all questions that you've formulated for the homework assignments. Each group presents the results: the most efficient and clear research question, determination of the research area of interest to the project, the (rewritten) research question with null hypothesis and alternative hypothesis. And finally, the justification for the choice of methods to pick this question (and not another one) and why you think you've come to the best possible results in this phase. From your main research question, derive sub questions and repeat the abovementioned step for each sub question.

Take the Methods Pack that is provided in class and pick the methods most suitable for defining your research question from the category Library.[17] With your group, write a justification as to why the methods that you've picked are the most suitable methods for your specific research project. Also write a justification for leaving out the other methods, giving at least an argument for two other methods that might seem useful but are not in your opinion.

Stakeholders may have a predominant say in the research question; identify whether this provides a dilemma for applied research as opposed to fundamental research demands.

Make sure to file the justification in a project file, you will need these notes for writing the Methods section of your final report.

[16] The most likely answers can be found in the accompanying Excel file (for teachers, tutors only).
[17] Most likely answers can be found in the accompanying Excel file.

Script – Phase two, Research Methodology

2. *Research methodology: to pick the most applicable research methods to answer the research question. This includes a plan for data collection. The specific choice of methodology (methodologies) depends on the field of application and the research question.*
   a. *Choose an appropriate research method to answer each sub-question. Discuss the methodology with the problem owner and – if possible – experts on the topic.*
   b. *Choose an appropriate method with which you will analyse your data, be it quantitative or qualitative. Plan which data must be collected and the structure of the data to be collected. Thinking about the parameters to be collected and how the collected data must be labelled in advance provides great advantages during the data analysis phase. Discuss your data collection plan with the problem owner and – if possible – experts on the topic.*
   c. *Perform the data collection in a structured manner and keep a lab journal of your activities.*

In this video I explain the activities you typically perform after you have drawn up a concept of your research question. Note that not all activities take place in a linear fashion; on the contrary. Activities may take place simultaneous, or in a circular manner in which you deepen your understanding of the matter or rewrite questions or hypotheses to be even more concise. As we saw in the video about formulating your research question, the research question had to be rewritten after the corresponding hypothesis was formulated. Once you start thinking about a suitable methodology to answer a research question, you may find out that the question itself is not yet measurable enough and needs rewriting again, in which case you return to the question before you make a final choice for the methodology (or methodologies). In this phase you already have to look forward: the choice of research methodology determines the statistical processing of your data and thus influences the validity of the results.

So now you've drawn up a concept of your research question, sub-questions and corresponding hypotheses. If all is well, giving an appropriate answer to each sub-question will result in an answer to the main research question and the conclusion whether your null hypothesis is valid or not. Now you need to pick one or more methodologies to answer all the questions.

There are many research methodologies, the standard types are literature or desk research, interviews, surveys, simulations, lab tests. But there are many more methodologies and it is important to pick more than one methodology for each research question. Why is it important: you want to assure reliability and validity of the answers found. This can be achieved by use of ***triangulation***:[18] the use of different methods and comparison of the answers thus obtained. It may not always be possible to find – say – three methods to answer one particular question. In such a case, it is important to make an explicit justification why it is not possible to make use of different methods. It is also important to realise that this possibly influences the validity of your results and hence you should be extra careful in making extrapolations in your conclusions.

How to pick one or more appropriate research methodologies to answer each research question? You might stick with a method that you already know, or have used in the past. This has the advantage that you know how to use the method, and what pitfalls there possibly are. However, there are two important drawbacks in this approach. The first drawback is that we often want to do research for innovative reasons: we want to create a new solution to a problem. Using old methods may not give us the most innovative, out-of-the-box solution possible. Further, by simply picking the method that we know, we may not choose the method that best assures reproducibility and validity of our research.

[18] Data Triangulation: How the Triangulation of Data Strengthens Your Research, available at http://www.write.com/writing-guides/research-writing/research-process/data-triangulation-how-the-triangulation-of-data-strengthens-your-research/ (visited 29 June 2018)

Reliability of your research has to do with the reproducibility of the results. If another researcher does the same research, will this lead to the same (or at least similar) results within a certain margin of acceptance? Validity of your research has to do with how appropriate the method is to actually answer the question. For example, if you want to know the opinion of your peers on the usability of the topic research skills for your masters' thesis, would you choose the method of a survey or the method of interviews? It depends on the question that you want to answer!

When choosing an appropriate research method to answer a research question, first you have to explicate what type of question it is, and whether the answer to that question should be given with the use of qualitative or with quantitative methods. It is important to note that in a research project it is perfectly possible to combine qualitative and quantitative methods.

Qualitative and quantitative methods differ in the amount of data that you analyse, and in their scope. A qualitative answer is based on 'soft' facts; the answers cannot be extrapolated without giving the entire context of the method used. For example: which cases were used and based on what arguments, what are the results of a few interviews? If you want to give an quantitative answer, an answer based on 'hard' numbers, this means the use of a suitable method to collect the necessary numbers. Analysis is usually done with statistical methods.[19]

Once you have determined what type of research question you have to answer, you can pick the most suitable method or methods. For example from the book *Universal Methods of Design*, or one of the Methods Packs.

[*show book and methods packs*]

As said before, there are many methodologies that can be used for your research. I will now briefly explain some of the most used methods. However, you have to realise that these are not the only methods that can be used, and you should use the literature and/or the card set to pick at least a number of other methods that I will not explain in this video.

Method: Literature review

The first method, that is used in any research project at least once, is literature review (or literature study, or desk research). In effect, you have most probably used this method in the first phase of your research project, because you need to have some idea of the research already done on the topic that you're interested in. How do you do a well-structured literature review?

First, you make a search plan. Below you see an example of the topics a search plan should include when you first start a literature review. The search plan includes things like key words that you expect to use and places where you think you'll find your information. When you do research, the most likely places to start are a search engine such as Google Scholar (for scientific articles) or Wikipedia as a starting point for the snowball method (use the history to assess the validity of the lemma and the sources in the footnotes for further research). Do note that research requires more in depth sources, but Google Scholar and Wikipedia are good starting points.

Research question	Key word(s)	Synonyms	Abstract terminology	Possible source(s)	Actual source	Summary

Table 4: template search plan.

Once you have done the initial literature review, you can dive into specialized sources such as patent databases, or NEN/ISO norm databases. The way you search databases varies with the type of database or search engine you use. When using a general search engine or database, such as Google, using very generic key words will render millions of results. There is no way you can distinguish the results that might be of interest to your research when you have to go through more than a couple of dozens of search results. You will need to be more

[19] This paragraph is different in the video.

specific in your key words to limit the number of results. However, when using a specialized database, you might need to start with generic key words to get any results at all. If you get no results, you should think about the applicability of your key word(s). Did you find no results because there really are no results, or did you not look in the right places? The latter is more often the case than the former.

Make sure to note the exact places where you found possibly interesting results. From my own experience I can tell you that it is much easier to document too little than it is to document too much! More on searching databases will be explained by our librarians in a separate session.

Method: Interview

An interview is usually conducted in a one-to-one setting, where the interviewer asks questions to the interviewed person. The interviewer usually tries to refrain from giving own opinions, because these might introduce bias into the results. Interviewers on TV do not always take this strategy, because their goal is usually different from an interview for research purposes. A research interview is conducted to gather information, and preferably this is unbiased information.

An interview is an appropriate method to collect opinions, or in depth information, from a small group of people. Interviews may be conducted with stake holders, to collect their requirements. Interviews may also be done with experts, to collect their opinions, or to check whether there are contrasting lines of thought in your research field. If you do a number of interviews and want to compare the results, you probably have to put more structure into the interview, so you may do a qualitative analysis later. In order to do a thorough analysis, the entire interview should be scripted, which is a lot of work. A qualitative analysis may be done by hand, with the use of small memo's, or for example with Atlas TI software.

There are different types of interview. There is the structured interview, in which you have a complete set of questions for your interviewee. This is the type of interview that is used when you want to establish facts, or already know a lot about the subject and want to know how the various stake holders think about certain facts. This type of interview is not very suitable to gather new ideas through association, or in depth reasons behind opinions. For these types of information, you need the unstructured interview. This type of interview starts with one (or a few) introductory questions to give some context. After that, the interviewer asks questions following up on the answers by the person interviewed. These question can be focused to get an in-depth answer to the topic that was raised, or these questions can be used to get a broader understanding of what the interviewed person thinks about the topic in general.

Method: Survey

A survey is an appropriate method to sample a large group, it usually consists of a set of predefined, closed questions, that are asked to a sample of the population that you want to draw conclusions on. A pitfall with surveys is the choice of sample: this must be representative in order to extrapolate your findings to the entire population. If the sample is not representative, you may still conclude things, but these conclusions only hold for the sample, not for the population, making the research much less valuable. To give a metaphor: taking a sample from a population is like a chef tasting the soup just created. If the soup is not stirred before tasting, taking a spoonful from the top layer is not representative of the entire soup.

Surveys are useful to draw conclusions on large populations. The questions are usually of a closed format: the subject has to choose the answer from a limited set of pre-defined answers. This means you have to be careful when constructing the questions and answers, because there are limited possibilities for correction when a question is not well designed. For example in an interview, you have the option to clarify a question or statement, in a survey this is usually not possible. In order to assure the validity of the survey, and to check whether the questions are clear and concise, a test survey is usually conducted among a small sub set of the intended population for validation of the survey.

When doing a large survey, you have to consider the data analysis already when drawing up the survey questions. You also have to consider the method of data collection: how to reach your sample. Simply creating

an online survey with Survey Monkey or one of the many other online survey tools, putting it online and just hope for the best, probably won't work! So you also have to think about how to actively approach the target group, and how to encourage them to fill in your survey. It does help if the goal of your survey is clear to the target group, if they understand the benefits of participation, and when your survey takes only a limited amount of time to complete. And do make sure the technology works, people are really put off when you send them a link and it does not work, or when the survey crashes half way through.

Method: Mathematical analysis and modelling

In beta research, often a theoretical or mathematical model is drawn up first. After all, mathematics is the language for engineering and beta sciences. This mathematical model is the result of analysis, for example the analysis of the physical properties of the system to be controlled. If we take the class room as an example, we have to use a thermal balance to model what type of signal (in this case probably heat by means of hot air or hot water) goes into the system, and what goes out of the system. Take a look at room around you and determine where the heat will disappear from the system. You can then set up a mathematical model which describes the heat flow in and the heat flow out. The basic equations are derived from the laws of thermodynamics, and then modelled to fit the system properties.

The next step is probably to put your model in simulation software (MATLAB Simulink is often used), and run a series of simulations to check how the system works. The advantage of running simulations is that you can easily adjust different parameters, and see how these influence the result. Do note that the difference between theory and practice is much greater in practice than in theory! If possible, you should always check the simulation results in a real live system.

[*show simulation of Bode Diagrams*][20]

Method: Lab testing

And that brings us to the final method that we will discuss in this video: testing in practice. Testing is usually done in a lab setting, but large companies do sometimes build a real factory on a 1:10 scale to actually test a production process. As this is a rather expensive method, it is used at the end of the development process, and only when real large scale production is foreseen. Akzo Nobel in Arnhem used to have such a test factory, where the production facilities were located elsewhere in the Netherlands.

An important note on validation of your lab test setup is calibration of the tools. If you do measurements, you have to calibrate your measurement tools beforehand. If you do not, then there is no way in telling the accuracy of what you've actually measured. You may still be able to draw conclusions, but only relative to a series of measurements, and the value of your conclusions is only very limited.[21]

Another problem you might run into is the sensitivity of the tools with which you do the measurements. If the tools are too sensitive, the data recorded might include so much noise that it is impossible to determine data from the measured signal. In that case, you might have to use a less sensitive setting. Then you might not measure in detail what is happening, but at least you have some data to work with. Or you might need to go back to the drawing board and design a whole new test setup. [22]

Homework Phase two, Research Methodology

Watch the video (17:58 min). From *Report writing for readers with little time*, read chapter 3.3 *Establish the structure via a preliminary table of contents* and chapter 3.5 *Write the first version quickly*.

1. Think about the question asked in the video: what method would be most appropriate to research the opinion of your peers about the usability of the topic research skills for your masters' thesis. Define a question that would be best answered by a survey, and think about (and write down) why this question would be best answered by a survey. Also define a question that would be best answered by interviews,

[20] Not yet available.
[21] This paragraph is different in the video.
[22] This paragraph is not included in the video.

and write down why interviews are the best method to answer this question. In your answer, you should argue why the specific method assures reliability and validity of the answer to the research question.

2. Write down the research question for your project, and from *Universal Methods of Design* choose at least two methods other than the methods explained in the video to answer your research question (or research questions). Your choice must be supported by an outline which makes it crystal clear why this method is the appropriate choice, not just 'because others did it like this'. It helps to identify the selection criteria and the weight you've given to each criterion. Also provide implications for the answers to your question – weaknesses and risk must be stated explicitly. If possible, argue whether countermeasures are an option (provide a 'plan B'). In other words: the argumentation must be solid!

Class activities phase two

Discuss the homework assignments in groups of 3-4 students. Each group presents the results: the justification for the choice of research methods and why you think you've come to the best possible results in this phase.

With your group, pick the most appropriate research methodologies to answer the research question that you want to work on for your project. Take the Methods Pack that is provided in class and pick at least two methods that are most suitable for answering your research question (and sub-questions) from all categories.[23] With your group, write a justification for the methods that you've picked, showing why these are the most suitable methods for your specific research project. Also highlight at least two other methods that might seem plausible but that you have not picked, and justify why these methods are not the most suitable ones in your opinion.

Make sure to file the justification in your project file, you will need these notes for writing the Methods section of your final report.

[23] Most likely answers can be found in the accompanying Excel file.

Script – Phase three, Data Collection and Analysis

3. *Data analysis.*
   a. *Conduct the data analysis in a structured manner: select the appropriate (statistical)[24] tool, defend your choice of methodology, identify weaknesses.*
   b. *Report the analysis activities in a research journal that you keep.*
   c. *Draw conclusions for the different analyses and answer each sub-question with a clear conclusion that actually provides an answer to the question.*

In this video, we will discuss some ways to deal with the data that is acquired during the data collection. Note that not all activities take place in a linear fashion; on the contrary. Activities may take place simultaneous, or in a circular manner in which you go back and forth in collecting your data using different methods. An interview with an expert may cause you to adjust your parameters for your simulation model or lab experiment, for example.

There is a large potential pitfall in the phase of data collection and data analysis. This pitfall is that you generate stacks of data and process them without having a good idea about why you use this data. You must assure that you've thought about why you need this particular data to answer your initial research question! Without a clear view on how each piece of data contributes to the answer of your initial research question will almost certainly result in stacks of data without a link to the answer. Not only does this cause a lot of extra work in analysing all this useless data. If the data contains personal data, you run the risk of non-compliance to the GDPR, the General Data Protection Regulation.

There are types of research that generate stacks of data that have no immediate use. This type of exploratory research does have its own right but is generally unpopular in an applied research context because your problem owner or client tends to want a concrete answer, not more questions!

Before starting data collection, you must think about the type of data you need to answer your research questions. Are you using the method of interviewing a few people for their knowledge or opinions? Do you want to compare their opinions? If you want to compare the answers, then you need the method of a structured interview. If you use this method, it is for example possible to do an analysis on key words. You may type the entire script of the interviews, and compare the answers by counting the number of times a certain key word is mentioned. Key words that are mentioned more often probably indicate an important question or requirement in the field. The data can be analysed by using a software tool, or by hand, with the use of sticky notes.

[*show sticky notes method*]

Do you want to ask a large group of people for their opinion? You may hen use a survey. An online survey has the advantage of efficient data processing afterwards. However, be careful that it is more difficult to assure a proper sample in an online survey. You have to consider how to improve the sample. You could for example exclude certain subjects in the instruction, or you could start your survey with some questions to select the proper subjects for your survey. An example would be if you want to draw conclusions only on study success for male students. In such a case, you want to exclude female students from your survey.

Large quantities of data are usually analysed with statistical methods. Statistics is a topic that requires a course of its own. Should you need more knowledge on statistics, Coursera has a number of excellent courses on statistics. See Coursera.org for the options.[25]

[24] The choice of tool depends on the type of research you conduct (qualitative or quantitative For the Engineering Master, quantitative tools are the most likely choice of tool (but qualitative methods should not be excluded).
[25] https://www.coursera.org/courses?query=statistics

You must think first what type of data you will be collecting. What is the replicability of the data that you will collect? In psychological research the replicability is often poor. This may be due to poor research design, but the problem may also simply be that research on people is extremely difficult to reproduce!

You must also think in advance about an appropriate statistical method. When are your findings valid? The often used method of the Bell curve is not suitable to do research on small amounts of intermittent events. In the Netherlands there was the infamous case of Lucia de Berk,[26] a paediatric nurse who was sentenced to life imprisonment for the deaths of a number of very young children. It later turned out that the statistical methods that were used to build the case against her were unreliable, resulting in a turnover of the verdict.

You must also already think about how to present your data, how do you want to make your point easily accessible to your readers? Do you want to present large tables with vast amounts of numbers, or do you want to structure your data such that you can easily present it in graphs of all kinds? Is a static report the best way to bring your story across or would a video be much more clarifying?

With any method for data analysis, but especially when using statistical analysis, you must aware of another pitfall. Relations between results, known as correlation, are ***not the same*** as causal relations. Two effects might seem to have a relation while there really is an underlying variable that cause both effects. In that case the underlying variable is the relation, but both visible effects have no causal relation whatsoever. Think about this conclusion: “A larger pay check is caused by a bigger shoe size”. Is this a causal relation, a correlation, or may there be an underlying variable? Pause the video here and take some time to think about it. I will present the solution at the end of this video.

In this course you will most probably generate a lot of data by doing simulations. The simulation software also takes care of the presentation of the effects. That means you will have to understand what this software does. If you do not already know the software used, make sure to take time to get acquainted.

Finally, you may need to use the method of case study. In this method, you take one or more applicable cases to analyse possible problems, solutions, and their effects. In this case, you need to define the parameters on which you choose appropriate cases to study. A matrix in which you define the parameters that would make a case comparable to your case may be appropriate for this purpose. For each parameters you compare the possible cases for their applicability, for example by giving them a score. In the final line of your matrix you then count the scores, and so you can calculate the best scoring cases.

	case 1	case 2	case 3	case 4	case 5
Parameter 1					
Parameter 2					
Parameter 3					
Total score					

Table 5: template score form.

All parameters, data and type to be collected, how the analysis is to be done, have to be incorporated in a data collection plan. Note that a data collection plan may be a simple as a single page discussing the simulation software (type and version), underlying hardware type and version, and the number of simulations you are running. The type of research determines how extensive your data collection plan must be.

After you’ve collected and analysed the data, you should be ready to draw conclusions. In order to draw firm conclusions, you must assure that your data collection and analysis methods were valid. Make sure to provide explicit arguments as to the validity of your data and thus your findings. When you get the results of your data

[26] See https://en.wikipedia.org/wiki/Lucia_de_Berk

analysis, be sure to check them against the research questions that you asked at the start of the project, and test the results against your hypotheses.

This brings me to the end of this discussion. What's left is the answer to the question posed: how can we interpret the conclusion that a larger shoe size leads to a bigger pay check? The answer is: an underlying variable. In many western countries, men tend to have bigger shoe sizes than women. And men tend to get a larger pay check …

Homework Phase three, Data Collection and Analysis

Watch the video (10:42 min).). From *Report writing for readers with little time*, read chapter 3.5 *Write the first version quickly*, chapter 4 *Dealing with sources of information*, chapter 7.2 *Feasibility study*, chapter 7.4 *Literature report* and chapter 7.6 *An experimental research report*.

1. Write a data collection plan for your own minor project, including the parameters that you have to collect. Note that such a plan can be as little as one A4 paper, depending on how big your project is.
2. Think about ways to analyse the data in a structured manner, and add these to your data collection plan.
3. Collect some data, and analyse it according to plan. You do this to verify the validity of your plan. What are your findings with regard to the possibility of analysing the data: was your plan clear, concise and complete? If not, you might want to adjust your data collection plan before you collect the bulk of the data.

Class activities phase three

Discuss the homework assignments in groups of 3-4 students. Each group presents the results: the justification for the choice of data collection and why you think you've come to the best possible results in this phase. In this discussion, make sure to link the data collection and analysis to the research question that you have to answer.

Make sure to file the justification in your project file, you will need these notes for writing the Methods section and the Data Analysis section of your final report.

Script – Phase four, Data Presentation and Reporting of Results

4. *Reporting: choice of the most applicable platform and writing an article or research report that provides a clear and structured argument which answers the research question.*
   a. *Decide where do you want to publish your results and review the reporting requirements for the specific platform.*[27]
   b. *Make a first design of the report. Determine total length of the text, what type of illustrations are needed to highlight important findings, the division of chapters.*
   c. *Write the article, report or whatever you choose to produce. When the text is lengthy, write chapter by chapter. Based on the partial conclusions from the data analysis, draw one overall conclusion to answer the main research question. Have your text or chapter(s) reviewed by the problem owner or an expert (or peer review).*

The way you present your results is very important to bring across your story!

Note that for this course, you will not be required to write a research article or make a poster presenting your results. However, other modules in this master's program may require these methods of presentation, and it is very likely you will be required to use these types of presentation for your major project and your future career. Therefore I will touch upon these ways of presenting your results.

How to present data to bring across the story

The data you've collected are the foundation of your story, but you need to think about ways to present the data in such a way that supports your point of view, to an audience. The way you present your data and the conclusions drawn from the data, may make or break your project. When considering how to present your story, think about the characteristics of your audience: technically oriented, business oriented, do they know what your project is about?

At first glance, it might seem a good idea to present all your data in tables. However, bearing in mind that a lot of people are visually oriented in a way that does not support the crunching of many numbers, it is a better idea to think about attractive graphics, or even dynamic graphics to support your story. A picture is worth a 1000 words! Hans Rosling, a former doctor on international medicine, has held a TED talk which shows the power of using data to support your story. You should watch his story: *The best stats you've ever seen*, https://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.

I will now present some ways to present your findings.

Research report

In many cases, results of a research project will be reported in a research report. The exact format of the report may vary with the context. Therefore a first step is always to check whether there is a prescribed format, and what the intended audience of your report is. Find out what the background of the audience is, what they expect and what format they expect. Presenting your findings to peers is different from presenting your findings to a CEO.

All reports usually start with a one-page summary, in which the context, project objective, results, conclusions and recommendations are presented. The report contains an introduction in which the context and project objective are outlined in more detail. It contains a section in which the research question and arguments on the choice of research methodology are discussed. It also contains a descriptive section on the data collection and analysis. Finally, it contains a section in which the conclusions are presented that answer the question you posed in the first place, and – if applicable – recommendations are given. In the main text, be sure to give explicit

[27] Note that you must have thought about possible platforms for reporting your results at an abstract level, in the phase of defining the research question. In this phase you review the detailed requirements such as max. length of the document, language and lay-out requirements.

reference to the source in the literature section whenever you make a claim. A report always contains a sources or literature section, though it is not part of the main text.

For your report, you should give a lot of attention to the writing process. Get yourself familiar with some strategies for efficient writing. For example: draw up a writing scheme first. Input for your writing scheme could be the answer to what you investigated: why, how and what findings you came up with. It is our experience that many researchers often find it much easier to orally explain these things, so why not have a colleague interview you and record what you said as a start of your writing process? You can use this strategy for the whole text, but just as well for each section. The recorded answers are thus your blueprint for the refinement of the text.

Write summaries of interview results in an outline before including them in your data analysis. Think about a logical chapter division and about paragraph construction, linking phrases, grammar and style issues beforehand. The materials in the professional skills section provide you with lots of tools and ideas. Make use of them in the writing process, and keep practising them throughout your studies here. It is the best strategy to be successful when it comes to reporting. And finally, always ask a third person to proofread you text. When you spend a lot of time on rewriting your text, you become blind for mistakes, someone new to the text will easily spot.

Research article

Another way of presenting the results is an article in a journal.[28] An article may be peer reviewed, which is often the case when you publish it in a scientific magazine, or in conference proceedings. But it is also perfectly possible to publish an article in a professional magazine. In that case, there is no peer review, but the editor of the magazine will critically read your article before publishing it. In both cases, you need to consider the public that you want to serve with your article.

In essence, an article follows the same structure that a report has, give or take the quirks of an editor. It contains a summary, introduction, methods section, conclusions and – if applicable – recommendations. It also has a list of sources. An article is usually much shorter than a report, although there are research areas that allow articles of 60-70 pages. In your field of research, a typical scientific article would be about 15 pages max. A professional article is usually about four pages long.

Because you have much less space to present your results, you need to carefully assess what the essential elements of your story are. Start with asking yourself what the most important conclusions are. While you might have – say – eight conclusions, in an article you might have to focus on the most important three conclusions because you have not enough space for presenting and elaborating on all of your conclusions. From the conclusions, you work your way back to the research methods that were used to analyse the data that support these most important conclusions. Then, write up the context and project objective in line with the most important conclusions you draw. And finally, you write up a one-paragraph abstract. The function of the abstract is similar to the summary in a research report.

Presenting research (and design) with a poster

A poster gives you only a limited amount of space to present your results, so you should really focus on the essentials of the story that you want to tell. A poster does offer a lot more visual possibilities to bring the message across, though. Do not dive into details; there is usually an accompanying research article or research report that presents all the details to those who are interested. Think about ways to present the results in an attractive way, you may want to try different types a graphs and pictures, and assess with your peers which one suits your poster best. Make sure to present texts as compact as possible, do not use passive language. Remember: people only have about a minute to watch your poster. See the videos of Chad Wilson for lots of tips on creating a scientific poster.

[28] The list of required articles on page 5 of this study guide contains some examples of scientific research articles.

To produce a good poster that will attract attention, the following elements are essential:

1. *Partitioning* A clear partitioning helps attendants to quickly understand what your poster is about.
2. *Content* Include a compact introduction and conclusions. Introduction, analysis and conclusions are separate parts of your story and are therefore visually separated on the poster.
3. *Essential information* Focus on the essence, do not give too many details. The poster is meant to start a discussion. If two or three people start reading your poster extensively, they will prevent others from seeing it.
4. *Teaser* A poster session at a large conference typically consists of 100 – 150 posters and you have to attract attention for your poster. You can do this by adding 'teaser'. The teaser has to have a connection with the research topic. Think of a challenging title of a non-intuitive conclusion.
5. *Text* Choose a suitable font and font size. In a poster session people walk around, they should be able to quickly read the essential elements of your poster from a distance.
6. *Figures* The figures (infographics) should be self-explanatory, they must be understandable in a matter of seconds. They must be clear and present only the essence, not too many details that distract from the main message.
7. *Sources* At the bottom, include a section with sources.
8. *Affiliations* Include any logos of your research organisation or affiliates who supported the research. Also include the names and affiliations of the researchers.

Presentation

And finally, the dreaded oral presentation to an audience. You can prepare this thoroughly though, and support your talk with a PowerPoint, Prezi or simply black- or whiteboard presentation is often used to present a summary of the results to the stakeholders. This kind of reporting is often used to present a summary of the results to the stakeholders of a project. As with the other means of presentation, you first have to carefully think about the purpose of your presentation and about what your audience may want. A real life presentation means you have little space for much text, but on the other hand you can make use of the interaction to clarify things more in depth, because this type of communication is two-way rather than sending alone.

There are some common pitfalls that you should avoid. First, large amounts of text on a sheet causes the audience to start reading, instead of listening to the presenter. You should make sure that any text or graphics are easily readable from the back of the room. This means that you should use a minimum 14 point letter type, make use of a colour scheme that provides enough contrast, use relatively simple graphs and tables that can be quickly understood.

When the presentation is scheduled, make sure you are in the room well in advance. You can use this time for preparing yourself: make sure all the tools you need are available and do work, check whether your presentation is indeed visible when the room is very light, etc. In summary: to make sure that you are prepared for as many surprises as possible. That will also help to control your nerves. Do not forget to introduce yourself and the purpose of the presentation to the audience. And finally: do not forget to enjoy this opportunity to discuss your ideas with an interested audience!

Homework Phase four, Data Presentation and Reporting of Results

Watch the video (xx:xx min). From *Report writing for readers with little time*, read chapter 5 *Structuring* and chapter 6 *Requirements for each part of the report*.

1. Study the presentation from the Emner program on Data Analysis , Interpretation and Presentation (University of Oslo), see the link in the footnote.[29]

[29] Emner, (University of Oslo), *Data Analysis , Interpretation and Presentation*, https://www.uio.no/studier/emner/matnat/ifi/nedlagte-emner/INF4260/h10/undervisningsmateriale/DataAnalysis.pdf (visited 10 September 2018)

2. Study the guide on Presenting numerical data (University of Leicester), see the link in the footnote.[30]
3. Scan the research articles mentioned in the Sources (mandatory readings & tools) - Articles section on page 5.
4. Watch the TED talk by Hans Rosling (Karolinska Institute), see the link in the footnote.[31] He is brilliant in showing the story behind the numbers.
5. Watch the video's on creating a scientific poster by Chad Wilson (University of Houston), see the links in the footnote.[32]
6. You can find a number of poster templates on the website of Colin Purrington.[33] Pick a template that you think is suitable for your presentation.
7. Should you already want to prepare for the final report, scan the professional skills literature *Report writing for readers with little time*.

Class activities phase four

In your group, discuss the homework. Decide which ways of presenting the results you liked and why you found them attractive.

With your group, pick some data and build a presentation. Analyse the audience and the format that is expected. Each group gives a presentation of the data presented in an attractive manner. Make sure that you can argue why this is a suitable method of presenting the data. Could you give examples of other suitable presentation styles?

Make sure to file the justification in your project file, you will need these notes for writing the final report.

[30] University of Leicester Student Learning Development, *Presenting numerical data,* https://www2.le.ac.uk/offices/ld/resources/numerical-data/numerical-data (visited 10 September 2018)
[31] Rosling, H. (Karolinska Institute) (2006). The best stats you've ever seen. https://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen (19:46, visited 29 June 2018) Gapminder.org
[32] Wilson, C., Cullen (College of Engineering, University of Houston). How to Make an Effective Science or Engineering Poster, Scientific and Engineering Posters, Part 1 - 5, http://www.youtube.com/watch?v=RpRCQaQv2v4 (9:22), http://www.youtube.com/watch?v=CYlyF1q5lAQ (9:19) (note: 10 ft = 3 m), http://www.youtube.com/watch?v=iMsj8FCPb54 (9:31), http://www.youtube.com/watch?v=SQqr4k8moog (8:54), http://www.youtube.com/watch?v=0e8J6lEZk6g (9:12)
[33] Colin Purrington (Brown University), http://colinpurrington.com/tips/academic/posterdesign

Script – Phase five, wrapping up your project

5. *Communicate the final result with all stakeholders.*

The final stage of your project depends largely on the exact project objective that you set at the outset of this particular research project. HAN requires two end products for the minor project: a research report and a 10 minute presentation in which all project members participate. These activities are part of phase four in our scheme.

However, wrapping up your project is just as important. You've just spent a semester doing a very important project with a project group whose members you've come to know well. Evaluating the way your project went is an important step in making it valuable learning experience. In this evaluation, you discuss what you think went right and what you think could be done in a different way the next time you execute a project.

Most of all, when wrapping up your project do not forget to communicate the results to all stakeholders. They might even want you to do a follow-up on the project … And do not forget: celebrate the success with your team!

This concludes the course on Research Skills. I wish you all the best with your studies in the coming years.

Homework Phase five, Aftermath

No video. From *Report writing for readers with little time*, read chapter 13 *Presenting a report orally*.

1. Check your report with the HAN requirements. These requirements are incorporated into the report template provided.
2. Set up a draft presentation with your project group.
3. Think of any questions you may have regarding doing research. This final session is the last option to ask them.

Class activities phase five

Each group presents their draft presentation.

Celebrate your success: what have you achieved so far? Discuss the things that you are really pleased with. For educational purposes (what have you learnt and how can you do even better), also discuss things still to be done.

Check your logbook, compare the results in your logbook to feedback that you've received from your peers in the process. Identify differences.

Discuss your results and questions with the tutor. Draw up new learning goals for your next project.

Appendix – List of verbs and their meaning in terms of research

Data collection plan	
Hypothesis	A hypothetical answer to the research question. In statistics, the hypothesis is very narrowly defined, we use om loose definition. The hypothesis is often used to give the research project a direction. However, in pure exploratory research it is unlikely that an explicit hypothesis will be used, because the research is on unknown terrain by definition.
MECE principle	Mutually Exclusive, Collectively Exhaustive. A method used to define different items when analysing a problem. In the context of research, a method that can be used to create a valid set of sub questions from the main research question.
Model	
Project activities	A description of work break down structure, a breakdown into concrete an relatively small activities (typically the things you do in a work week).
Project objectives	A definition of what the project team wants to achieve with the project, at a more abstract (overall) level than project activities. Project objectives are usually described with action words such as: analyse ..., compare ..., determine ..., develop ..., discover ..., establish ..., evaluate ..., identify ...
Reliability	
Research methodology	The method by which you perform the research, collect the data that you need to answer a research question. The methodology must be suitable to provide a reliable answer that can be validated.
Research question	The project objectives (or project goal) reformulated into a question that can be answered by doing research. Usually the main question is formulated in an open manner, as opposed to a closed yes/no question.
Search plan	
Validation	