MF2070: Introduction to Engineering Design
3 credits
Engineering Research Methodology

Course Memo 2015

Teaching Team

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MANDATORY FOR ENGINEERING DESIGN PROGRAMME

LEVEL/CREDITS: Second level, 3 credits

FINAL GRADE SCALE: A-F

COURSE DESCRIPTION:

The course gives an overview of scientific and industrial development trends within the areas of engineering design and industrial design. Scientific working methods and research methodologies are addressed, both on a general level and within the context of specific research domains. The focus is on how research may be used for the benefit of industry and society by promoting innovation.

This course is largely oriented around self-study of research methodology. Each student is encouraged to read the proposed literature, acquire the necessary subject background knowledge, and then to follow up by talking to experts (e.g. researchers and PhD students at the Department of Machine Design). Students then investigate further by finding their own material, and bringing their new knowledge back to their team, culminating in a final written report to show learning achievements and reflect fulfillment of the course goals.

Introduction to Engineering Design 2015

Learning outcomes

As a result of this course, students will be able to:

- understand different types of research methodologies.
- use self-study and team work to enhance a group awareness of qualitative and quantitative methods and the theory of science.
- clearly grasp the crucial concepts and apply them in the context of engineering design.

Course main content

The course is given in the form of seminars, workshops and an industrial site visit. The seminars are led by researchers renowned for their competence and their collaboration with industry. In advance of each seminar, students attend preparatory workshops and discuss research methods in groups.

Phase 1 – Kick-off: Team formation[1]. Introduction to engineering methodology.

Phase 2 – Researchers Seminars: Students meet five of the Department's top researchers, and one external researcher, each expert in different disciplines of engineering design. These seminars will be organized around 3 main topics (Theory of Science, Quantitative Methods and Qualitative Methods). The teams will have to discuss issues with the researchers in order to gather the information necessary to write the group report. To support, stimulate and encourage these discussions, students are invited to attend a workshop prior to each seminar. Teams are encouraged to send at least 1 representative to each of these workshops, which will highlight the key concepts to understanding each topic in order to get the most out of the Researchers Seminars.

Phase 3 – Group Report: each Team[2] submits a written report that shows that they have sufficiently understood different research methodologies, clearly grasped the crucial concepts and gained the ability to apply these in the context of engineering design.

Course deliverables

One written report, co-authored by a team of seven students (+/- one), covering the issues described on pages 6 and 7 of this document. Format outlined on page 5.

Teams will be assigned by Track Leaders during the kick-off activity. Students who miss the kick-off activity will either submit an individual report or be assigned to a team by the course coordinator.[1] Any changes to these teams need to be approved by the course coordinator.[2]

Reading material

The basic framework for this course is provided by Chapter 1 (The Selection of a Research Approach), Chapter 8 (Quantitative Methods), Chapter 9 (Qualitative Methods) and Chapter 10 (Mixed Methods Procedures) in *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, Fourth Edition, by John W. Creswell (ISBN 978-1-4522-2610-1).

However, to answer the questions described on pages 6-7 of this document, students are required to find additional sources. No specific reading list is provided for these sources, although students can ask the teaching team (and researchers) for pointers to relevant literature.

[1] *Students studying abroad for some or all of Autumn 2015 should see page 4.*

[2] *If a team member seems to vanish during the term, or fails to participate, please inform the course coordinator and engineeringdesign@kth.se.*

Kick-off week

Participation in the kick-off activity is strongly encouraged and crucial for the continuous teamwork required in the course.

Schedule and deadlines

The following schedule is valid at the start of the Autumn term 2015. Students will be notified of any changes / additional information via the MF2070 course homepage on KTH Social, www.kth.se/social.

week	When	What	Where
36	Mon **31 Aug** kl.10.30-12	**Introductory Lecture**	**B2** (Brinellvägen 23, ground floor)
	Tues **1 Sept** kl.13.15-17 kl.13.15-17 kl.13.15-17	**Track Introductions** ***(including Team creation)*** ➢ Machine Design ➢ Internal Combustion Engines ➢ Mechatronics	Rooms as shown: **M35** (Brinellväg 64, 3rd floor) **C435** Brinellväg 85, top floor) **Mechatronics Lab** (Brinellvägen 83, 2nd floor)
	Weds **2 Sept** (kl.8-17)	**Kick-off Competition!**	LabHallen (Brinellvägen 83)
37	Thur **10 Sept** (kl.13-15)	**Theory of Science Workshop**	**M3** (Brinellvägen 64B)
38	Thur **17 Sept** (kl.13-14)	**Researchers Seminar:** **Theory of Science, *joint session***	**M3** (Brinellvägen 64B)
	Thur **17 Sept** (kl.14-15)	**Theory of Science,** ***parallel seminar sessions***	**B242** (Brinellvägen 83), **Studio** (Brinellvägen 85)
39	Weds **24 Sept** (kl.14-16)	**Quantitative Methods Workshop**	~~**M3** (Brinellvägen 64B)~~ **B1** (Brinellvägen 23, ground floor)
40	Weds **1 Oct** (kl.13-14)	**Researchers Seminar:** **Quantitative methods *joint session***	**Q2** (Osquldasväg 10, 2nd floor)
	Weds **1 Oct** (kl.14-15)	**Quantitative methods,** ***parallel seminar sessions***	**Q2** (Osquldasväg 10, 2nd floor) **B242** (Brinellvägen 83)
41	Thur **8 Oct** (kl.13-15)	**Qualitative Methods Workshop**	**Q2** (Osquldasväg 10, 2nd floor)
42	Tue **13 Oct** (kl.10-11)	**Researchers Seminar:** **Qualitative Methods *joint session***	**D2** (Lindstedtsvägen 5, 3rd floor)
	Tue **13 Oct** (kl.11-12)	**Qualitative Methods,** ***parallel seminar sessions***	**E34 & E36** (Lindstedtsvägen 3, 3rd floor)
48	Fri **13 Nov**	**Deadline:** Submission of written report	Via email to Fredrik Asplund
50	Fri **4 Dec**	**Feedback on written team report**	Via email from Martin Törngren / Jonas Westman
2	Mon **11 January** 2016	**Deadline:** Submission of revised written report *(if 1st attempt fails)*	Via email to Martin Törngren / Jonas Westman

Meet the Researchers

Students will have the opportunity to meet and interact with engineering design researchers during the three Researcher Seminars on 17 September, 1 October and 13 October. During the first hour, each researcher will present a particular approach to research in the context of their subject. For the second hour, the students split into parallel seminar sessions, with one researcher in each group. The student report teams may split so that they are represented in each of the parallel sessions, or focus their attention on one researcher each week. During these parallel sessions, the student teams are encouraged to quiz the researchers in depth about the methodologies for their area, to develop an understanding and discussion points within the team in preparation for writing the final report.

There will be a preparatory workshop a week before each seminar to help frame the questions and discussion points.

Theory of Science – Thursday 17 September (**kl.13-14 in M3**; kl.14-15 as shown below)

Mats Magnusson	matsmag@kth.se	Innovation Engineering & Management	Studio
Martha Lucia Arango	martha@beyondresearch.se	Beyond Research (External)	B242

Quantitative Methods – Wednesday 1 October (**kl.13-14 in Q2**; kl.14-15 as shown below)

Jan Wikander	jan@md.kth.se	Mechatronics	Q2
Ellen Bergseth	bergseth@md.kth.se	Tribology	B242

Qualitative Methods– Tuesday 13 October (**kl.10-11 in D2**; kl.11-12 as shown below)

Martin Törngren	martin@md.kth.se	Mechatronics & Embedded Systems	E34
Susanne Nilsson	suni@kth.se	Innovation Engineering & Management	E36

You can read more about each of the researchers on the Department of Machine Design homepage: http://www.kth.se/en/itm/inst/mmk/medarbetare

Time budget

The course awards 3 credits for the fall semester, totaling 80 hours of student work to be spent on the seminars, workshops, self-study (which includes reading appropriate background material, discussions within the report teams) and writing the group report.

Studying abroad Fall 2015?

Since this course is mandatory, students studying abroad are encouraged to find an equivalent research and methodology course at their host institution. If that is not possible, **you must contact the Course Coordinator as soon as possible to discuss** the alternative, which is to become part of a long-distance team taking the MF2070 in Fall 2015. Once assigned to a team, you must be prepared to spend at least 80 hours on self-study and be responsible for staying in close contact with your team mates from September to December. (**Note**: The deadline for getting assigned to such a team is **Tuesday, 8th of September**.)

FALL 2015 REPORT GUIDELINES

Formal Requirements

The following formal requirements are required to be fulfilled by the written report:

- The report shall contain a maximum of 1200 words, with each picture counting for 100 words. The reference section is not counted towards the maximum number of words.
- Any report that exceeds the maximum number of words will be rejected without review.
- All claims[3] should either be:
    1) supported by a citation of a scientific book, journal article or conference article,
    2) based on a discussion of claims that are supported by such a citation, or
    3) based on the teams observations on experiences detailed in a wide variety of scientific books, journal articles or conference articles.

Any report that repeatedly makes claims without external support or believable motivations will be rejected without a complete review.

- The complete sources shall be provided as **separate digital files** together with the report. If the **complete** source is not available in a digital format, or cumbersome to provide as such, then a digital copy of the **relevant chapter** may be provided instead. If the sources are not provided together with the report, then the report will be rejected without a complete review.
- The referenced parts shall be **marked** in the copies (for instance using the highlight tool in Adobe Acrobat). If the appropriate sections are not marked clearly, then the report will be rejected without a complete review.
- The citation style should be consistent and use a numbered format; all citations shall include page numbers;[4] and the digital source files should start with the number used when citing that particular source.

Contents

The quality of the contents shall reflect a work effort of 80 hours by each member of a team of seven students (+/- one). This shall be reflected both in the clarity and depth of the reasoning in the report and the scope of the cited sources. Any report that fails to reach the necessary level of clarity, depth and anchorage in science will be failed.

There are 16 questions (described on the following 2 pages) that each report should aim to address. These issues can be divided among the group members and answered separately, even though you will probably save at least some space by referring to each others' sections.

However, note that each set of issues refers to a specific topic and should be addressed as a whole. For example, the critique regarding the researcher´s efforts (the fourth question in the Theory of Science set) should be connected to your description of these efforts provided in earlier answers (your answer to at least the third question of the Theory of Science set) and not just be a critique of, say, the researcher´s work in general.

The report should deal with questions 1-16. Correct answers to Questions 4, 9 and 15 contribute to a grade beyond C; all other Questions contribute up to this grade.

[3] Use common sense, but err on the safe side of caution.

[4] The page number reference shall be the minimum one, citing an unnecessarily large part of the source will be considered equivalent to not providing any page numbers at all.

Theory of Science

Different research fields are based on different *worldviews* (also called *paradigms*), i.e. a common understanding of what is to be observed and investigated, how observations and investigations should be structured and how the resulting findings should be interpreted. Each worldview will have some definition of what a *scientific* theory is (usually what makes it acceptable), i.e. how it is formed, how it evolves, different properties that can be used to compare one or more of these theories, etc.

1) **Briefly describe the basic assumptions of two worldviews of your choice.**

2) **Note particularly what makes a theory acceptable (i.e. scientific) according to the worldviews. It is acceptable (encouraged) to use the ideas of a particular theoretician for the latter, as long as that theoretician clearly identifies with the worldview in question.**

Individual researchers set up studies within their field, according to the rules of the worldview they work within, and try to advance the shared knowledge within the field.

3) **Choose a researcher[5] and, by referring to this researcher´s way of structuring research, motivate which worldview this researcher subscribes to.**

To conform to the worldview of their research community is often not even a conscious effort by researchers. However, they can often argue why research from other communities is flawed or associated with considerable uncertainty.

4) **Criticize the researcher´s way of structuring research by referring to the assumptions of a worldview other than the researcher´s. Note that there is a difference between research that would be uninteresting to a researcher of a particular worldview, and research that is in conflict with that worldview. The answer to this question should motivate why the latter is the case.**

Note that this question is difficult, sometimes even impossible, to answer with reference to certain worldviews.

Quantitative Methods

Worldviews/Paradigms will often favor, or preclude, certain ways of carrying out studies. The terminology differs between different research fields, but reference is often made to *research designs* (also called *methodologies*) that are acceptable. These constitute a number of instruments for collecting and analyzing data, and a description of how these can best be used together.

5) **Provide a short description of two *quantitative* research designs, defined as such by a scientific source of your choice.**

The research designs define different sets of *instruments (*also called *methods)* that are to be used for collecting and analyzing data. These are designed differently when used together with different worldviews and research designs.

6) **Provide short descriptions of how three instruments can be used in a *quantitative* fashion, as described by a scientific source of your choice.**

7) **Give two different[6] examples of using instruments in a *quantitative* fashion by a researcher of your choice (in a specific case). Include the context in which the methods were used.**

Actual use of a particular instrument can almost always be criticized. This can be due to ethics prohibiting certain methods in certain studies, or because certain conditions under which the

[5] This should be a researcher **from the department** and **among those that you have interacted with during the course**. Contributions from one of their close associates (such as a supervised PhD Student) are also acceptable.

[6] In other words, you should, in total in Question 6 and 7, provide short descriptions of at least **five different instruments**.

study is conducted are not perfect. However, in many cases this critique simply stems from choices researchers have been forced to take to balance between the pros and cons of certain methods, e.g. when one method may make it easier to generalize contributions while another may make it easier to prove correct inferences.

8) Give two examples of different concerns related to the validity of *quantitative* instruments.

9) While referencing one of the validity concerns mentioned in your answer to Question 8, provide constructive criticism regarding the use of at least one of the instruments you chose for your answer to Question 7.

10) Give an example of a common, *quantitative* way of dealing with the validity concern mentioned in your answer to Question 9.

In other words, point out weaknesses in the use of the method in this particular case, not criticism of the method in general.

Qualitative Methods

Worldviews/Paradigms will often favour, or preclude, certain ways of carrying out studies. The terminology differs between different research fields, but reference is often made to *research designs* (also called *methodologies*) that are acceptable. These constitute a number of instruments for collecting and analyzing data, and a description of how these can best be used together.

11) Provide a short description of two *qualitative* research designs, defined as such by a scientific source of your choice.

The research designs define different sets of *instruments (*also called *methods)* that are to be used for collecting and analyzing data. These are designed differently when used together with different worldviews and research designs.

12) Provide short descriptions of how three instruments can be used in a *qualitative* fashion, as described by a scientific source of your choice.

13) Give two different[7] examples of using instruments in a *qualitative* fashion by a researcher of your choice (in a specific case). Include the context in which the methods were used.

Actual use of a particular instrument can almost always be criticized. This can be due to ethics prohibiting certain methods in certain studies, or because certain conditions under which the study is conducted are not perfect. However, in many cases this critique simply stems from choices researchers have been forced to take to balance between the pros and cons of certain methods, e.g. when one method may make it easier to generalize contributions while another may make it easier to prove correct inferences.

14) Give two examples of different concerns related to the validity of *qualitative* instruments.

15) While referencing one of the validity concerns mentioned in your answer to Question 8, provide constructive criticism regarding the use of at least one of the instruments you chose for your answer to Question 7.

16) Give an example of a common, *qualitative* way of dealing with the validity concern mentioned in your answer to Question 9.

In other words, point out weaknesses in the use of the method in this particular case, not criticism of the method in general.

[7] In other words, you should, in total in Question 12 and 13, provide short descriptions of at least **five different instruments**.