Stepping Stones

Investigating Engineering Education

The Experiment Kit

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1. Question Formulation

This kit addresses how students and academic staff perceive engineering in Sweden and in Swedish education. As this study is situated uniquely in Swedish education, it allows exploration of "a Swedish perspective" on engineering. Such perspectives are of interest because, as a practical profession it is likely that conceptions of engineering will be strongly influenced by national and institutional cultures.

Study's focal questions:

- How do students and academic staff perceive engineering in Sweden and in Swedish education?
- What are conceptions of engineering in Sweden?
- How is Swedish engineering education "constructed"?
- What do Swedish students perceive they are learning about engineering?
- What does the collection of studies suggest about preparation for engineering professional practice in Sweden?

Subsidiary queries:

- Are there differences between first-year and final-year conceptions of "engineering"?
- Are student conceptions different to those of academic staff?
- Are conceptions of those within education different to those of practicing engineers?
- Are there gender differences?
- Are there differences between different sub-disciplines of engineering (mechanical engineering, civil engineering, software engineering etc.)?

Study's approach:

This study comprises four tasks:

A web-based survey. This is an adaptation of a comprehensive and validated survey of student's perceptions of engineering developed in the US. It will provide broad-based and comparable data from many institutions.

A concept map task. Participants are asked to construct a "concept map" from engineering terms we provide. The approach is a familiar one in engineering education research (Turns et al, 2000). The terms have been chosen from international and Swedish sources.

A "critical incident" interview, in which participants are asked to recall a particular experience from their past which encapsulates their concept of "what engineering is".

A photo elicitation, where participants are shown three images and asked what associations they have for them with "engineering".

Links to relevant theory

Investigating conceptions of engineering may provide insights into why people enter, leave, and remain in engineering – an issue that is a growing concern in Sweden as well as the rest of the world. One study found that high school girls and K-12 educators in the US get messages that (1) engineering is perceived to be a man's profession and (2) engineering is a challenging career path that stresses the importance of superior math and science abilities (EWEC, 2005). High school girls

in the US do not get messages about the relevance or rewards of being an engineer – in particular, messages about an engineering lifestyle that might align with personal and career motivations (e.g., a rewarding and enjoyable job, a good working environment, making a difference, make a good salary, and be flexible). Although the girls in this study enrolled in science and mathematics courses at the same rate as boys only 10% report an interest in becoming an engineer.

There appear to be disconnects between engineering practice and engineering education worthy of deeper investigation. Dahlgren & Pramling (1985) found that practicing engineers perceive the practice of engineering as underutilizing the broad knowledge gained in academic settings. Another study seeks to uncover "accidental competencies" that engineering students learn in college and transfer to practice in unexpected ways (Walther & Radcliffe, 2006). There also appear to be disconnects between what practicing engineers find rewarding and public messages regarding how to be successful in engineering. For example, in a large scale study it was found that what practicing engineers find rewarding about being an engineer (involvement from start to finish on a project, having an impact, interesting and diverse problems to solve which often involve creative thinking, sense of success, etc.) is often not emphasized when asked what advice is important for pursuing an engineering career (excel in both math and science, challenging but worth the effort, etc.) (EWEC, 2005).

Curriculum development draws upon and is shaped by conceptions of professional practice. Curriculum development is also informed by understanding students' conceptions and misconceptions within that domain and efforts to promote conceptual change (e.g., Posner et al, 1982, Sinatra & Pintrich, 2003). As such, it is important to characterize beliefs and values regarding engineering in order to identify appropriate targets of instruction and learning assessments.

Much of the existing work on conceptions of engineering has focused on pre-college education. A common approach has been to use the "Draw-an-Engineer" task (Knight & Cunningham, 2004). This instrument builds from theory on the extensive use of drawing (e.g., "Draw-a-Scientist" task or DAST) by children to capture understandings and perceptions of fields that are otherwise difficult to ascertain (e.g., Cunningham, Lachappelle & Lindgren-Streicher, 2005; Thompson & Lyons, 2005). The DAST was originally developed by Chambers (1983) as an open-ended test to investigate children's perceptions of scientists. It has been used extensively as a research, evaluation, and instructional tool.

When considering the use of this task in a college setting, the technique has significant drawbacks. For example, drawing of this kind is not a common activity in adult life and adults may feel constrained by their confidence in their drawing ability. One method that allows a similar perspective is the photo elicitation method (Harper, 2002). Photo elicitation has a long history either as its own form of inquiry or as embedded broadly within ethnographic work (Becker, 1974; Prosser, 1998). This method is based on the idea of inserting a photograph (either generated by the subject or by the investigator) into a research interview. Harper (2002) notes that photos prod latent memory, sharpen memory and reduce areas of misunderstanding, respond to how people think visually, elicit longer and more comprehensive accounts than interviews, make visible the invisibility of interpretations that often involve assumptions about shared experiences, elicit values and beliefs, and connect to core definitions of the self to society, culture, and history.

Photographs used can range from collective to personal accounts of experiences and settings. Photo elicitation has been used as a central technique for studies that focus on social class and organization, community and historical ethnography, identity, and culture (including interpretations of "work").

Justification of approach:

- **Domain independence**
  The use of general "engineering" terms make the tasks independent of any specific sub-discipline (e.g. mechanical engineering, or software engineering), so that comparisons can be made across engineering domains.
- **No imposition of existing overview**
  The general aim of this study is to attempt to elicit knowledge which is not pre-defined. Therefore, the tasks are elicitative, to see if students have underlying structures for engineering concepts.
- **Triangulation**
  The study combines different approaches and collects both qualitative and quantitative data, in order to provide opportunities to contradict or corroborate within the study, by comparing the different data.
- **Building on existing work**

  This study is, in part, replicative, building on previous work for which there are validated instruments and standardised data available.
- **Scale**

  The quantity of institutions means that the number of participants recruited is at a scale unusual in the literature.

2a Data collection specification

For each institution:

Collection of background data:

If you need to recruit subjects from another institution, you will need a collaborating academic within that institution. Work with the academic ***early*** to complete Human Subjects Approval at that institution.

Assign each participant a unique identifier of the form: F01 (First Year Student 01) G01 (Graduating student), A01 (Alumni) or E01 (Educator), appended to your institution code (thus the first "first-year" subject for your University would be FF01). If there are two researchers at a single institution ensure you spread the range of numbers between you. That is, one start their series with 01 and the next with 30 (or another suitably high number).

Data collection from participants:

Data Collection Overview:

1. Before – well before – the start of semester, complete Human Subjects Approval.
2. Within the first few weeks of the academic year, recruit to the WebSurvey, both incoming first-year students and graduating students. A "graduating student" is one who is preparing to "leave your institution" – in other words we are interested in students who are in the last year of 3, 4, and 5 year programs. You may recruit as broadly as you can within engineering (including computer science) so we maximize our chances to get a perspective on a wide range of programs.
3. Towards the end of the first semester, or start of second semester, recruit to the "concept map" task. Make sure you liase with Arnold Pears ***early*** to schedule a date for data collection.
4. During the second semester, conduct interviews ("critical incident" and photo elicitation) with students and staff.

Minimum data collection:

- Web Survey. You should aim to gather data from as many as possible relevant students (wide recruitment will also allow you to "publicise" the Stepping Stones work and target recruitment for the more in-depth elements of the study). 50 would be a realistic minimum.
- Concept-map and interview data for 10 students, 5 first-year and five final-year from engineering programs.
- Concept-map and interview data with 2 academic staff members from engineering.
- Collect information about your university (e.g., a general description of the school, the kinds/numbers of students, the kinds/numbers of programs). This should be publicly available information. It will be used to explore differences across schools (for those who are interested).

Because of natural attrition, and because the study requires data collection in separate instances, these minimum figures are *residual*: that is, remaining at the end of the study. You will have to

gather initial data on more students (probably 50% more) to be assured of being left with sufficient students to complete the data collection.

- It would be highly desirable to have concept map and interview data from recent alumni, or other practicing engineers. However, as this is a difficult constituency to access there is no minimum requirement.

2b Details/phrases that may be useful with regard to Human Subjects Approval forms

This research is part of a national, multi-site project to investigate student attitudes to engineering education. The subjects will be taking an engineering degree. Each subject will be asked to:

- Complete an on-line survey derived from the Center for the Advancement of Engineering Education (CAEE) Academic Pathway Study (APS) survey.
- Draw a concept map from given terms related to engineering and engineering education,
- Be interviewed. The interview will focus on "critical incidents" in the students past and their contribution to the students' attitude towards engineering. The interview will include a photo elicitation.

Each task will be completed separately, and each task may be completed by different participants. However, there will be a sub-set who completes all three tasks. The survey and concept map task should each take no more than half an hour; the interview no more than one hour. Data arising from the survey will be captured electronically; from the concept map task on paper and electronically; the interview will be captured by written notes and audio recording.

Subjects will be drawn from students enrolled in engineering degree programs; their age range will be 18-65.

Personal data – age, gender, institution and degree program – will be associated with the elicited material. The name (or other identifiable data, such as student number) of participants will be known to internal investigators, but will not be stored or made available to researchers outside of this institution.

RESEARCH SUBJECTS' INFORMATION SHEET

You have been asked to participate as a subject in a study that is part of a multi-site national research project investigating attitudes to engineering and engineering education. This research is designed to investigate students' attitudes over a range of tasks. For this part of the study you will be asked to complete a concept map, which should take no more than 30 minutes.

We ask that you use "smart pen" technology to do this, so we may preserve and record the order in which you construct the map. At the end of the sessions, you will be asked to complete a questionnaire.

Some personal data – your age, gender, and institution – will be associated with the task materials, and data from other tasks in the study. However, neither your name (nor any other identifiable data, such as student number) will be stored after the data collection is complete, nor made available to researchers outside of this institution. All data gathered will be used solely for the purposes of this research project.

You may obtain answers to any pertinent questions about this research by telephoning <insert name> on <insert telephone number> during the following times: <insert availability>

If you decide not to participate, your refusal will involve **no** penalty and **no** loss of benefits to which you are otherwise entitled.

Participation in this study is voluntary, and you may withdraw your consent to participate at any time without penalty.

You have the right to receive a copy of any consent form that you sign and of any written consent documentation information that is used in obtaining your consent.

In order not to bias subsequent participants, please do not discuss details of this task with other students.

RESEARCH SUBJECTS' INFORMATION SHEET

You have been asked to participate as a subject in a study that is part of a multi-site national research project investigating attitudes to engineering and engineering education. We would like to interview you to investigate your background and attitude to engineering, and ask that we may record the interview.

Some personal data – your age, gender, and institution – will be associated with this interview data and other study data. However, neither your name (nor any other identifiable data, such as student number) will be stored after the data collection is complete, nor made available to researchers outside of this institution. All data gathered will be used solely for the purposes of this research project.

You may obtain answers to any pertinent questions about this research by telephoning <insert name> on <insert telephone number> during the following times: <insert availability>

If you decide not to participate, your refusal will involve **no** penalty and **no** loss of benefits to which you are otherwise entitled.

Participation in this study is voluntary, and you may withdraw your consent to participate at any time without penalty.

You have the right to receive a copy of any consent form that you sign and of any written consent documentation information that is used in obtaining your consent.

In order not to bias subsequent interviews, please do not discuss details of what we talk about with other students.

Human Subjects Research Consent Form

Letter of Informed Consent

I, (print name in full) _____ am a student registered at <insert name of institution>. In signing this consent form, I agree to volunteer in the research project being conducted by <insert your name here> between <enter dates here>. I understand that the research being conducted relates to attitudes to engineering and engineering education. I understand that data from the tasks I complete will be used in aggregate, and that excerpts from tape-recorded verbal communications with the researcher will be studied and may be quoted in papers, journal articles and books that may be written by the researchers.

I grant authorization for the use of the above information with the full understanding that my anonymity and confidentiality will be preserved at all times. I understand that my name or other identifying information will never be disclosed or referenced in any way in any written or verbal context.

I understand that my participation is entirely voluntary and that I may withdraw my permission to participate in this study without explanation at any point up to and including, the first day of June 2007.

Signature

Date

Medgivande till forskning med människor

Deklaration av medvetet samtycke

Jag, (skriv ditt fullständiga namn) _____ är en registrerad student vid <*ersätt detta med institutionens namn*>. Genom att skriva under detta medgivande, samtycker jag till att frivilligt delta i det forskningsprojekt som genomförs av <*ersätt med forskarens namn* > under tidsperioden mellan <*ersätt med startdatum*> och den 30:e juni 2007. Jag är införstådd med att forskningen som utförs är relaterad till attityder till ingenjörsskap och ingenjörsutbildning. Jag är medveten om att data från de aktiviteter som jag deltar i kommer att användas i sammanställd form, att utdrag från inspelad muntlig kommunikation med forskaren kommer att studeras och att de kan komma att citeras i forskningspapper, tidskrifter och böcker som publiceras av forskarna.

Jag godkänner användning av den ovan nämnda informationen under förutsättning att min anonymitet och sekretess kommer att bibehållas under forskningsarbetet och för all framtid, och vidare att varken mitt namn eller annan information som kan identifiera min person kommer att avslöjas eller refereras till i något skriftligt eller muntligt sammanhang.

Mitt deltagande är helt och hållet frivilligt och jag, utan förklaring, kan dra tillbaka mitt medgivande till att delta ända fram till och med den 30:e juni 2007.

Ort och datum

Underskrift

2c Background data

- Study Code:
- Age:
- Gender:
- Program enrolled in:

Additions for working engineers:

- How long have you been working as engineer (if appropriate)?
- What was your highest degree and when did you receive it (if appropriate)?

Additions for engineering teachers:

- How long have you been teaching engineering (if appropriate)?
- How long have you been at this university (if appropriate)?
- What program(s) do you teach in (if appropriate)?
- What was your highest degree and when did you receive it (if appropriate)?

2d Specification of setup

There is no prescribed order to the tasks. However, if you are doing the interview and concept map in one sitting – do the interview first. If you are having the same people do the interview and concept map – try to do the interview first (if you are unable to – remember to document the order of tasks).

For the first time you see a participant, make sure you have:

- Human Subjects' Information Sheet and 2 copies of the Consent Form (one for them and one for you)
- The background questionnaire

If you are doing Concept Maps first, make sure you have:

- Sufficient sets of "introductory task", "engineering concepts task" & "participants debrief" sheets

If you are doing the Interview first, make sure you have:

- A working tape recorder (or other recording device)
- Enough tapes & batteries
- The image set

2e Administrator's script (concept maps)

CONCEPT MAP TASK: ADMINISTRATOR SCRIPT & NOTES

- If this is the first time you have seen these participants, make sure you get background data and a consent form from each of them. Otherwise, make sure they remember their study code (you may need to remind them).

INTRODUCTORY STATEMENT

Good morning (afternoon, evening). My name is ___. Thank you for coming. We are interested in understanding students' attitudes about, and understanding of, "engineering". We are interested in learning about your perspective.

We will be using a tool called an "Explanogram" to record your thoughts. We will show you how to use it, give you an introductory task to help you get familiar with the tool, and then give you a task to complete. The entire activity should take approximately 30-40 minutes to complete.

Please be sure to mark each piece of paper with your Study Code.

DEMONSTRATING THE USE OF "EXPLANOGRAM" TOOL (10 MINS)

- **Arnold Pears**

INTRODUCTORY TASK (10 MINS)

1. Hand out the "Introductory Task" sheet.
2. Remember—have an extra copy of the tasks for yourself.
3. In general:
    a. Encourage participants to talk aloud – it can help them process the information if they "get stuck". It may also be useful to document anything they share regarding what is difficult and what is easy.
    b. The terms are organized alphabetically. This is done to limit a sense that there is an important pattern in the way the words are placed on the page (e.g., a right answer).
    c. If a participant asks about what a word means, rather than define the word encourage them to "do their best". Most likely they will try to incorporate it or they will leave it off to the side, unconnected. This is important data.
    d. Some people may feel that concept map tasks are a test – that there ***are*** right answers. You may need to repeat that "there are no right or wrong answers – that there may be multiple ways of organizing these terms and that we are interested in your perspective."
    e. Regarding the explanogram tool: Remember to hit "save" and "new" for each new sheet of paper. Also, remember to put study ID on paper as well as number consecutive sheets. Also, check after introductory task to see if it is working properly. Store

consecutive activities on one pen and download after administration of the concept map task is completed.

f. If the participant asks if they can add words – tell them that they can add labels to groups of words, but not to add new terms to their list to organize.

4. For the introductory task, the goal is to familiarize participants with the idea of creating a concept map (creating groups, links, naming links). If participants are spending more than 7 minutes, they may be getting too involved in creating a good map. At this point you may want to assess if the introductory task has met its goal and encourage the participants to move onto the actual task.

ENGINEERING CONCEPTS MAP (20 MINS)

5. Hand out the "Engineering Concepts Task" sheet.
6. In general:
    a. Some participants may want—or need— two iterations to create a map (perhaps to test their ideas, or to make the map more legible). Be prepared to provide them with an opportunity to create a second map. Remember to document both maps and identify which map was drawn first.
    b. Some participants may prefer creating visual representations; some may prefer more verbal representations. If you feel that someone is more verbal than visual you may clarify that creating a "sentence" is similar to creating a "map" (both forms promote organizing ideas in relation to each other).
    c. Some participants may want to use terms more than once. If they ask, say this is OK.
    d. Some participants may want to use concepts as names for a group of concepts. If they ask, say this is OK.
    e. To help make sure that all terms are used – encourage participants to cross terms off the list. When participants appear to be done, encourage them to double check their work.
    f. On average the task generally takes about 15-20 minutes. Some participants may need more time. This is OK.
    g. Regarding the explanogram tool: Remember to hit "save" and "new" for each new sheet of paper. Also, remember to put study ID on paper as well as number consecutive sheets. Also, check after introductory task to see if it is working properly. Store consecutive activities on one pen and download after administration of the concept map task is completed.
    h. If the participant asks if they can add words – tell them that they can add labels to groups of words, but not to add new terms to their list to organize.

PARTICIPANTS' DEBRIEF (5 MINS)

7. Hand out the Debrief Sheets. You will be using the explanogram tool for the debrief. Don't forget to save the last diagram and start a "new" one. In this way, all the concept map data is in one file.
8. At the end of the task, after the participants have left:
    a. Confirm that words on the map are legible. If they are not, add a note to clarify terms. It is important to do this immediately after the task is over since the session will be fresh in your mind and you will have a better chance of resolving any confusion later.

b. Document and attach any comments – such as difficulties observed, engagement in the task, technical difficulties with the explanogram tool, etc.

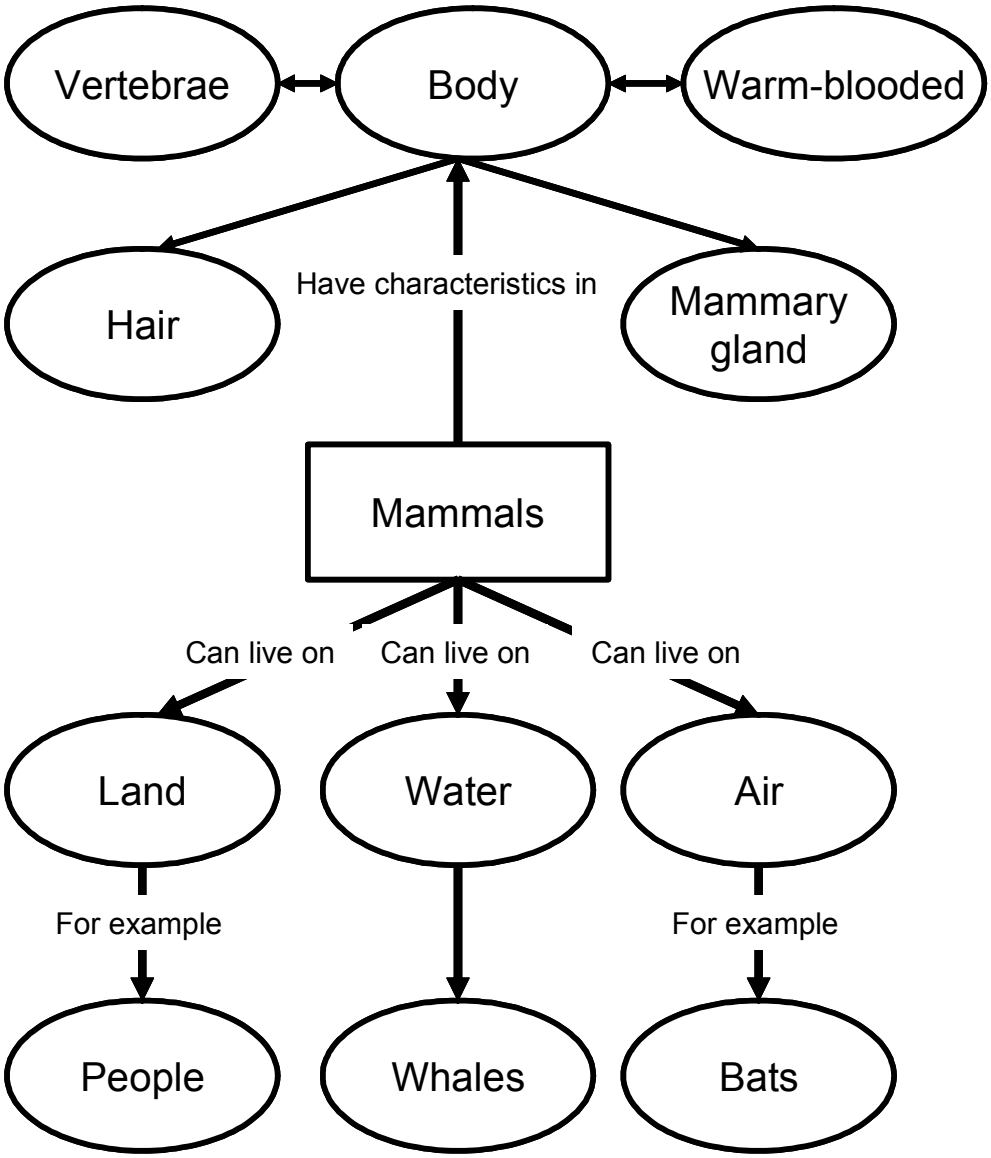
2f Participant materials (concept map)

INTRODUCTORY TASK

For this task you will be asked to create what is called a "concept map diagram".

Your goal is to organize the concepts in the list below into a map that represents how you believe these concepts are related.

A sample concept map is provided below. As the figure shows, a concept map consists of a set of concepts and labelled links between concepts that show the

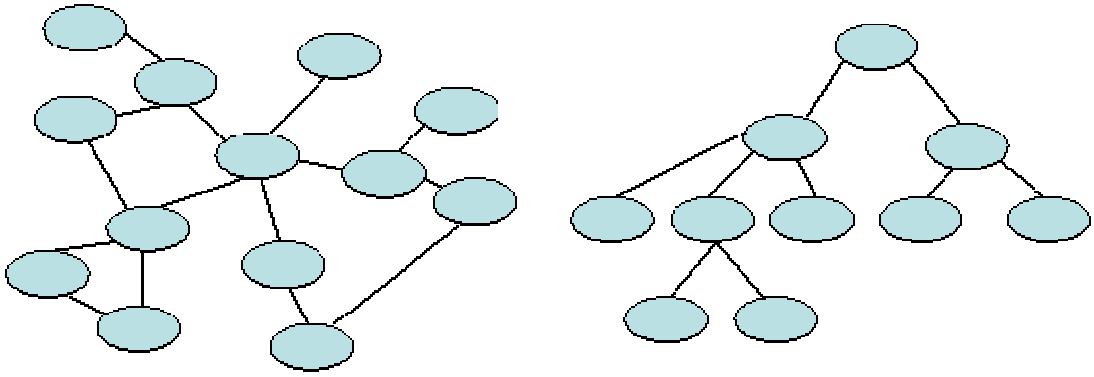


organization of concepts. For example, the person who developed this concept map has indicated a relationship between the concepts of mammals and land via the connection of these concepts with a line.

Instructions:

1. Read through the list of concepts below
2. Use the "explanogram" pen to arrange **ALL** the concepts into an organization that makes sense for you
3. Label the links between concepts

There are no right or wrong answers – there are many possible organizations – we are interested in your perspective. Concept map diagrams can take many forms – as shown in the figure below. However, there is no "correct" form – it all depends on what one sees as the relationship between the concepts in the map.



Apple	Book	Carrot	Coffee
Flower	Herring	Horse	Lamp
Milk	Spade	Stick	Water

ENGINEERING CONCEPTS TASK

INSTRUCTIONS: Your goal is to organize the concepts in the list below into a map that represents your beliefs and perceptions about "engineering". There are no right or wrong answers.

- Read through the list of concepts below
- Use the "explanogram" pen to arrange **ALL** the concepts into an organization of relationships that makes sense for you
- Draw and label links between concepts
- Check that you have used all the terms

There is no right or wrong way to arrange the concepts. There could be many organizations – we are interested in your perspective.

Analysis	Communication	Complexity
Design	Economics	Environment
Engineering	Ethics	Experimentation
Impact	Implementation	Innovation
International	Judgement	Mathematics
Modelling	Multidisciplinary	Research
Safety	Science	Society
Sustainable	Teamwork	Technology
Theory	Uncertainty	

PARTICIPANT TASK DEBRIEF

Q1 Which terms on the list most represent university-level courses you have taken or are currently taking?

Q2 Which terms on the list most represent your educational experiences outside of the classroom (e.g., internships, student clubs)?

Q3 Which terms on the list least represent university-level courses you have taken or are currently taking?

Q4 What was difficult about this task?

Q5 What was easy?

2g Administrator's Script (interview)

BEFORE EACH PARTICIPANT ARRIVES:

- Check the batteries and the recorder. Make sure there is enough space on the memory card.
- Check the microphone battery.
- Make sure your interview room does not have any distractions (turn off phones, close door, etc.)

REMINDERS:

- Make sure you fill in the background questionnaire for each participant before you start.
- Make sure you complete the Interviewer Reflection form immediately after the interview is completed and preferably, before the next participant arrives.
- Questions 1 through 3a should proceed in that order – do not reorganize them. Once you have exhausted the questions in 3b, proceed to Questions 3c and d (in that order).

INTRODUCTORY STATEMENT

Good morning (afternoon, evening). My name is ___. Thank you for coming. We are making a study of students' attitudes to, and understanding of, "engineering". We believe you are well-qualified to talk to us about <insert subject studied>. The purpose is to get your perceptions and your experiences. There are no right or wrong or desirable or undesirable answers. I would like you to feel comfortable with saying what you really think and how you really feel. The entire interview should take approximately 30 minutes to complete.

RECORDING INSTRUCTIONS

If it is okay with you, I will be recording our conversation. The purpose of this is so that I can get all the details but at the same time be able to carry on an attentive conversation with you.

PREAMBLE/CONSENT FORM INSTRUCTIONS

Before we get started, please take a few minutes to complete these documents. Feel free to ask me any questions you may have. (Give them the consent form & background questionnaire. After these are completed and returned, turn the recorder on.)

VERBALLY ID THE RECORDING

1) Date; 2) Interviewer Name; 3) Time; 4) Location University/Department); 6) Participant Study Code

REQUEST FOR GENERAL AIM

Q1 In a few words, what would you say real engineering is?

Q2 Can you give me some examples of engineering in the world? (If the participant asks "what is in the world" encourage them to interpret it as they see fit.)

ELICITING CRITICAL INCIDENT

Q3 Can you think of an engineering experience you have had that you particularly enjoyed? Or an experience that you felt represented your ideas of engineering? We are interested in something that actually happened to you.

<Pause to make sure they have something in mind. The goal here is to let them first 'think' of a situation and then follow up with some questions. If you find it awkward, you may say "First, can you think…" Make sure you give them some time to think of something>

a. Can you give a brief overview of the experience?

<The questions in 3b (unlike questions 1-3a) are there as a guide and may be used out of order. The point is to get them to clarify and provide detail of the experience, so that they remember it more clearly and convey the important details to you. You don't have to ask all of these, or any of them>

b. What did that experience involve?

i) Scale: was it a big thing? Or a more private, "aha" moment?
ii) Setting: where did this happen? Was it at home, or in school, or somewhere else?
iii) Circumstances: was this one in a sequence of things, or a one-off? Were they doing something normal, or unusual?
iv) Client: was it when you were involved in an engineering experience yourself? If so, whom were you working for?
v) Groups involved: were you working with others at the time? Were you in a team? Were you working with other teams?

c. What is it about that experience that summarises "engineering"?

d. Why do you think this particular experience came to mind? Why was it important?

PHOTO ELICITATION

Thank you. I'm going to show you some photographs now.

Q4 *What associations of "engineering" does image <insert image identifier> have for you?*

Repeat with subsequent two images. Leave the images on the table. If the participant refers back to a previous image, or makes a comparison between two, make sure to verbally ID the ones they are referring to, either by content "that's the bicycle" or by identifier "image A".

Please retain the order of images A, B, and C. The order is critical to the task. Also, once you have used image A you can "shortcut" the elicitation question to something like "what about this one" for the next image. Also, don't move onto the next image until the participant has "exhausted" what they had to say. You may find that they pause for a moment, this is OK – you don't want to move them onto the next image until they're easy.

As a future note regarding transcription:

- include pauses or laughter, e.g., [pause] and [laugher]
- include time stamps (e.g., 5 minute intervals as a guide for later)
- include line numbers to the right or left (as guide for later)
- include in transcript interviewer statements (as a guide for later)

Then finally to close, ask them:

Q5. *After everything we've talked about, what would you say "engineering" is, for you?*
Q6. *Do you think that your views on what engineering is have changed over time?*

- *If so, in what way?*
- *If not, why do you think this is?*

Q7. *Can you think of a specific time or issue that challenged your view of what "engineering" is?*

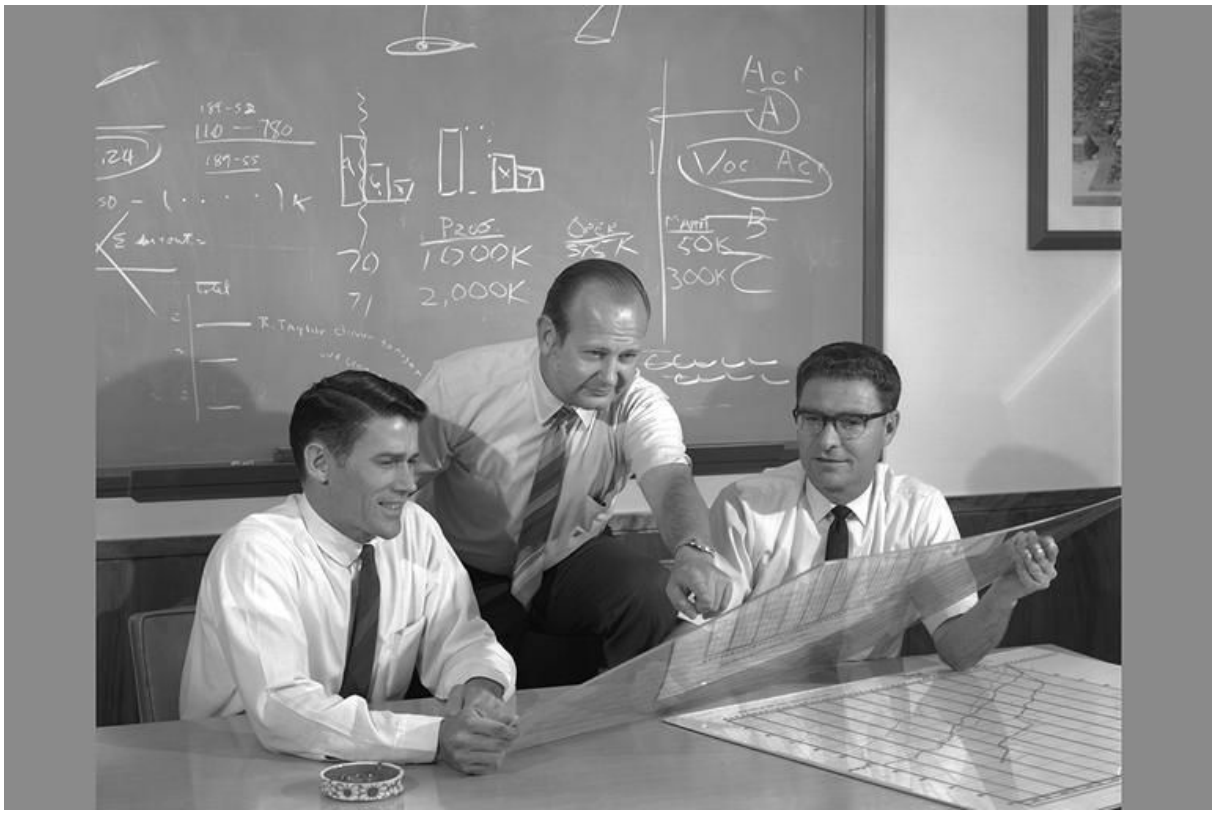
Q8. *Is there anything you would like to add?*

INSTRUCTIONS:

After the participant leaves the room, please take a couple of minutes to indicate your reactions and observations about the interview. An electronic copy of this form has been provided. Feel free to use this hard copy for your own notes, but please make sure to submit the electronic. ***Please complete this form immediately after the interview and before the next participant arrives.***

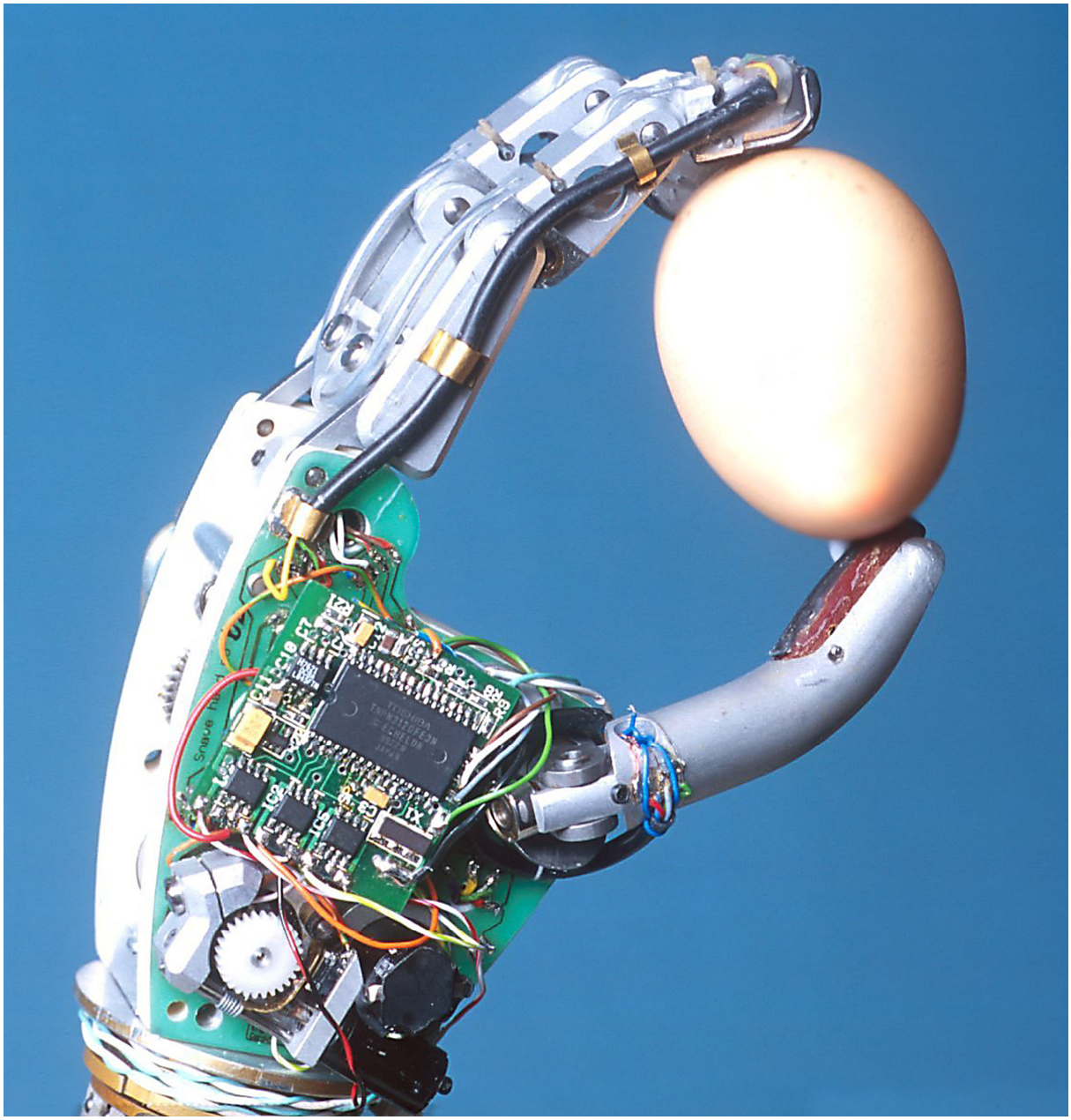
Your name (the interviewer):	
Participant Study Code.	
Date of Interview.	
Please describe the participant's attitude toward the interview.	
Please describe any unusual circumstances and/ or events that had any bearing on the interview. (Such as interruptions, language difficulty, etc.)	
Please describe anything else that happened during the interview that has any bearings on the study's objectives.	
Additional comments.	

2h Image Set



A

B



C

2i Web Survey Questions

The *Stepping Stones* survey has been adapted, with permission, from the Academic Pathways Survey (APS), developed by the Center for the Advancement of Engineering Education (http://www.engr.washington.edu/caee/). This version of the survey is solely for use within Sweden, and must not be used in the USA.

0 When did you begin at your current University?

- ○ 2006
- ○ 2005
- ○ 2004
- ○ 2003
- ○ 2002
- ○ 2001 or earlier

1 What is your expected year of graduation from university?

- ○ 2007
- ○ 2008
- ○ 2009
- ○ 2010
- ○ 2011
- ○ 2012
- ○ 2013
- ○ 2014 or later

2 Did you study elsewhere (universitet/högskola) before coming to your current University? If so, how many years did you complete before you transferred to your current University? If none, please jump to question 6.

- ○ None

○	One year completed
○	Two years completed
○	Three years completed
○	Four years completed
○	More than four years completed

2a How many study points (högskolepoäng) did you gain from this study?

3 Where did you study? (name and country of most recent universitet/högskola)

4a	What kind of program are you taking?
○	3 year program
○	4 year program
○	4.5 year program
○	5 year program
	Other (write in)

4	Do you intend to complete your engineering degree?
○	Definitely Not
○	Probably Not
○	Not Sure
○	Probably Yes
○	Definitely Yes

5 What kind of study program are you taking?

Use of the survey is confined to Sweden.
Use of this survey means an agreement that the survey will not be shared ***in any way*** with colleagues from the US

- ○ Aerospace engineering & mechanics
- ○ Astrophysics
- ○ Bio-based products engineering
- ○ Biomedical engineering
- ○ Biosystems & agricultural engineering
- ○ Chemical engineering
- ○ Chemistry
- ○ Civil engineering (väg och vatten)
- ○ Computer engineering
- ○ Computer science
- ○ Electrical engineering
- ○ Geological engineering
- ○ Geology
- ○ Geophysics
- ○ Information technology
- ○ Materials science & engineering
- ○ Mathematics
- ○ Mechanical engineering
- ○ Mediateknik/Interaktion och design
- ○ Software engineering
- ○ Physics

○ Statistics

○ Arts & humanities

○ Education

○ Other (write in)

7 Do you intend to work as an engineer, conduct research in engineering, or teach engineering for at least 3 years after graduation?

○ Definitely Not

○ Probably Not

○ Not Sure

○ Probably Yes

○ Definitely Yes

9	We are interested in knowing why you are studying engineering now. Please indicate below the extent to which the following reasons apply to you:	Not a reason	Minimal Reason	Moderate Reason	Major Reason
	Technology plays an important role in solving society's problems	○	○	○	○
	Engineers make more money than most other professionals	○	○	○	○
	My parent(s) would disapprove if I chose a degree other than engineering	○	○	○	○
	Engineers have contributed greatly to fixing problems in the world	○	○	○	○
	Engineers are well paid	○	○	○	○
	Engineering is an occupation that is respected by other people	○	○	○	○
	My parent(s) want me to be an engineer	○	○	○	○
	An engineering degree will guarantee me a job when I graduate	○	○	○	○
	Engineers are creative problem solvers	○	○	○	○

	A person working at/from a university has encouraged and/or inspired me to study engineering	○	○	○	○
	A non-university affiliated mentor has encouraged and/or inspired me to study engineering	○	○	○	○

10	Please indicate how strongly you disagree or agree with each of the statement:	Disagree Strongly	Disagree	Agree	Agree Strongly
	I prefer studying in a group to studying by myself	○	○	○	○
	I prefer working as part of a team to working alone	○	○	○	○
	I get along well with others in study situations	○	○	○	○
	I am a collaborative person	○	○	○	○
	Creative thinking is one of my strengths	○	○	○	○
	I am familiar with what a practicing engineer does	○	○	○	○
	I am skilled at solving problems that can have multiple solutions	○	○	○	○

11	Rate yourself on each of the following traits as compared to your classmates. We want the most accurate estimate of how you see yourself. (Mark one in each row.)	Lowest 10%	Below Average	Average	Above Average	Highest 10%
	Self confidence (social)	○	○	○	○	○
	Leadership ability	○	○	○	○	○
	Public speaking ability	○	○	○	○	○
	Math ability	○	○	○	○	○
	Science (naturvetenskap) ability	○	○	○	○	○
	Computer skills	○	○	○	○	○
	Communication skills	○	○	○	○	○
	Ability to apply math and science principles in solving real world problems	○	○	○	○	○

	Business ability	○	○	○	○	○
	Ability to perform in teams	○	○	○	○	○
	Critical Thinking skills	○	○	○	○	○

12	How important do you think each of the following skills and abilities is to becoming a successful engineer? (Mark one in each row.)	Not Important	Somewhat Important	Very Important	Crucial
	Self confidence (social)	○	○	○	○
	Leadership ability	○	○	○	○
	Public speaking ability	○	○	○	○
	Math ability	○	○	○	○
	Science (naturvetenskap) ability	○	○	○	○
	Computer skills	○	○	○	○
	Communication skills	○	○	○	○
	Ability to apply math and science principles in solving real world problems	○	○	○	○
	Business ability	○	○	○	○
	Ability to perform in teams	○	○	○	○

13	Please rate your satisfaction with this institution on each of the aspects of campus life listed below. If you do not have experience with this aspect, mark N/A.	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	N/A
	Quality of instruction by lecturing staff (lärare)	○	○	○	○	○
	Quality of advising by lecturing staff (lärare)	○	○	○	○	○
	Availability of lecturing staff (lärare)	○	○	○	○	○
	Quality of instruction by teaching assistants (handledare)	○	○	○	○	○

	Quality of advising by teaching assistants (handledare)	○	○	○	○	○
	Availability of teaching assistants (handledare)	○	○	○	○	○

14	Please rate your satisfaction with each of the following at this institution. If you do not use the service or facility, mark N/A.	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied	N/A
	Computer facilities	○	○	○	○	○
	Libraries	○	○	○	○	○
	Classrooms	○	○	○	○	○
	Supplemental instruction	○	○	○	○	○
	Academic advising	○	○	○	○	○
	Laboratories	○	○	○	○	○

15 *From the start of this academic year*, how often have you taken courses which required your engagement in individual and/or group projects?

○ Never

○ Rarely

○ Occasionally

○ Frequently

16	Think about the engineering classes you have taken since the beginning of the Spring term (engineering, math, and science classes). Indicate how often you:	Never	Rarely	Occasionally	Frequently	N/A
	Came late to engineering class	○	○	○	○	○
	Skipped engineering class	○	○	○	○	○
	Turned in engineering assignments that did not reflect your best work	○	○	○	○	○
	Turned in engineering assignments late	○	○	○	○	○

	Thought engineering classes were boring	○	○	○	○	○

17	Think about the elective classes (courses other than engineering, math and science) you have taken since the beginning of the Fall term. Indicate how often you: (Mark N/A if you have not taken any elective classes.)	Never	Rarely	Occasionally	Frequently	N/A
	Came late to elective class	○	○	○	○	○
	Skipped elective class	○	○	○	○	○
	Turned in elective assignments that did not reflect your best work	○	○	○	○	○
	Turned in elective assignments late	○	○	○	○	○
	Thought elective classes were boring	○	○	○	○	○

18	How often have you interacted with the following people since the beginning of the Fall term (e.g. by phone, e-mail, Instant Messenger, or in person)? (Mark one for each item.)	Never	1-2 times per Term	1-2 times per Month	Once per Week	2-3 Times per Week	Daily
	Lecturing staff (lärare) during class	○	○	○	○	○	○
	Lecturing staff (lärare) during visiting hours	○	○	○	○	○	○
	Lecturing staff (lärare) outside of class or visiting hours	○	○	○	○	○	○
	Teaching Assistants (handledare) during class	○	○	○	○	○	○
	Teaching Assistants (handledare) during visiting hours	○	○	○	○	○	○
	Teaching Assistants (handledare) outside of class or visiting hours	○	○	○	○	○	○

19 What portion of the courses you have taken from the start of this academic year have been taught primarily by non-Academic staff (for example teaching assistants or technicians)?

○ None

○ Very little

○ Less than half

○ About half

○ More than half

○ All or nearly all

20	From the start of this academic year, what portion of your classes used the following teaching methods?	None	Very little	Less than half	About half	More than half	All or nearly all
	Lectures	○	○	○	○	○	○
	Individual Projects	○	○	○	○	○	○
	Team Projects	○	○	○	○	○	○
	Labs	○	○	○	○	○	○
	Seminars	○	○	○	○	○	○

21 To what extent have your courses required your engagement in individual and/or group projects?

○ Too Few

○ Enough

○ Too many

22 Some people are involved in non-engineering activities on or off campus, such as hobbies, civic or church organizations, campus publications, student government, sports, etc. How important is it for you to be involved in these kind of activities?

○ Not Important

○ Somewhat Important

○ Very Important

○	Essential

23 How often are you involved in the kinds of non-engineering activities described above?

○ Never

○ Rarely

○ Occasionally

○ Frequently

24	Thinking about your university experience since the beginning of the Fall term, please indicate how much pressure you are feeling related to the following:	No Pressure	Reasonable Pressure	Extreme Pressure
	Course load (amount of course material being covered)	○	○	○
	Course pace (the speed at which the course material is being covered)	○	○	○
	Balance between social and academic life	○	○	○

25 How well are you meeting the workload demands of your coursework?

○ I am meeting all of the demands easily

○ I am meeting all of the demands, but it is hard work

○ I am meeting most of the demands, but cannot meet some

○ I can meet some of the demands, but cannot meet most

○ I cannot meet any of the demands

26	How stressed do you feel in your coursework right now?
○	No stress
○	Some stress

○	Reasonable stress
○	Significant stress
○	Extreme stress

27 Do you have any concern about your ability to finance your living during your university education?

○ None (I am confident that I will have sufficient funds)

○ Some (but I probably will have sufficient funds)

○ Major (not sure if I will have sufficient funds to complete university)

28	How do you meet your university expenses (e.g. books, living expenses)?	None	Very little	Less than half	About half	More than half	All or nearly all
	Self (income)	○	○	○	○	○	○
	Self (savings)	○	○	○	○	○	○
	Parents and family	○	○	○	○	○	○
	Employer support	○	○	○	○	○	○
	Scholarships and grants	○	○	○	○	○	○
	Loans	○	○	○	○	○	○

29 Do you have family members who are working engineers?

○ Yes

○ No

30	Do you have close friends who are working engineers?
○	Yes

○ No

31 How much exposure have you had to a professional engineering environment as a visitor, intern (praktikant), or employee?

○ No exposure

○ Limited exposure

○ Moderate exposure

○ Extensive exposure

32 About how many hours do you spend in a typical 7-day week doing each of the following?	0	1-5	6-10	11-15	16-20	21-25	26-30	More than 30
Preparing for courses (studying, reading, writing, doing homework or lab work, analyzing data, rehearsing, and other academic activities)	○	○	○	○	○	○	○	○
Working for pay	○	○	○	○	○	○	○	○
Participating in co-curricular activities (organizations, campus publications, student government, sports, etc.)	○	○	○	○	○	○	○	○
Relaxing and socializing (watching TV, partying, exercising, etc.)	○	○	○	○	○	○	○	○
Providing care for dependents living with you (parents, children, partner, etc.)	○	○	○	○	○	○	○	○
Commuting to class (driving, walking, etc.)	○	○	○	○	○	○	○	○

33 Please rate the overall quality of your university experience so far:

○ Very dissatisfied

○ Dissatisfied

○ Satisfied

○ Very satisfied

34 What did you do this past summer that was particularly important to you?

35 Did your summer experience advance your interest in studying engineering?

○ Yes

○ No

36 Did you participate over the summer in any of the following? (Mark all that apply.)

○ Engineering related internship/job

○ Engineering related research

○ Engineering related coursework

○ N/A

37 In the space provided, list 5 terms you would use to describe "engineering":

38 In the space provided, list 5 terms you would use to describe "design":

39 In the space provided, list 5 activities you think engineers do at work.

40 Of the 20 items below, please put a check mark next to the five you think are MOST IMPORTANT for working engineers.

○ Business knowledge

○ Communication

○ Conducting experiments

○ Contemporary issues

○ Creativity

○	Data analysis
○	Design
○	Engineering analysis
○	Engineering tools
○	Ethics
○	Global context issues
○	Leadership
○	Life-long learning
○	Management skills
○	Math
○	Problem solving
○	Professionalism
○	Science
○	Societal context issues
○	Teamwork

41 Your sex:

○ Female

○ Male

43 Status:

○ Swedish native

○ Swedish citizen

○ Permanent resident (permanent uppehållstillstånd)

○ International student (please specify nationality)

○ None of the above

44	Do any of your immediate family members hold an engineering degree? (Mark all that apply)
○	No
○	Yes, both parents
○	Yes, father only
○	Yes, mother only
○	Yes, brother(s) or sister(s)

45 What is the highest level of education that your mother completed? (Mark one box)

○ Did not finish gymnasiet

○ Graduated from gymnasiet (tog studenten)

○ Attended högskola/universitet but did not complete degree

○ Completed a kandidatexamen

○ Completed a magisterexamen

○ Completed a civilingenjörexamen

○ Completed a doktorsexamen

46	What is the highest level of education that your father completed? (Mark one box)
○	Did not finish gymnasiet

○	Graduated from gymnasiet (tog studenten)
○	Attended högskola/universitet but did not complete degree
○	Completed a kandidatexamen
○	Completed a magisterexamen
○	Completed a civilingenjörexamen
○	Completed a doktorsexamen

47 What is your best estimate of your parents' total income last month? Consider income from all sources before taxes. (Mark one)

○ Less than 5,000 SEK

○ 5,000-7,999 SEK

○ 8,000-10,999 SEK

○ 11,000-13,999 SEK

○ 14,000-18,999 SEK

○ 19,000-23,999 SEK

○ 24,000-28,999 SEK

○ 29,000-33,999 SEK

○ 34,000-38,999 SEK

○ 39,000-48,999 SEK

○ 49,000-58,999 SEK

○ 59,000-68,999 SEK

○ 70,000-88,999 SEK

○ 89,000 SEK or more

3. Analysis Protocol

Survey

The survey is organized into a set of validated constructs (Eris, 2005). As such, analysis will be organized by these constructs and utilize appropriate statistical techniques.

Concept Maps

Concept maps are representational tools for organizing and representing associative networks of knowledge (i.e., semantic networks and knowledge maps). Representations generally include the concepts (words enclosed in boxes or circles), the links between concepts (lines or arrows) and their semantic relationships (words on the lines) (Novak, 1998). Concept maps often represent hierarchical relationships with the most inclusive concepts are the top of the map and less inclusive concepts at the bottom of the map. Links may cross areas within the map (called "cross-links") to illustrate the relationship between a concept in one domain area with a concept in another domain area.

Concept maps have been used as learning, research, and evaluation tools in engineering (see Turns et al, 2000). They have also been found to be effective in identifying valid and invalid ideas held by science students (e.g., Edwards & Fraser, 1983). Terms used in concept map activities may be generated by the learner or externally. Analysis of concept maps focuses on the content (e.g., nature of the terms in the map) and structure (e.g., relatedness of pairs, number of links, hierarchy clusters) of the map, and for maps with externally generated terms a goal is to facilitate comparisons across learners (particularly expert-novice like differences).

Analysis of concept maps focuses on the **content** and **structure** of the map, and for maps with externally generated terms a goal is to facilitate comparisons across learners (particularly expert-novice like differences). Analysis may include (1) the number of links, (2) the number of cross links, (3) the number of hierarchy levels, (4) how concepts are grouped, and (5) the relatedness of pairs of concepts (e.g., as compared to more expert-like organizations of a set of domain relevant concepts). For example, analysis goals could be to characterize where the term "engineering" appears on the map or characterizing what terms are used as central ideas.

Because we will be using the "Explanogram" tool, data collection will be effectively "time-stamped" which allows additional analysis opportunities such as investigating the process of creating the map (terms that were placed first or last, placement of terms over time, etc.).

Interview Data

Interviews should be transcribed. Each investigator should be familiar with their own material. Analysis may include extracting common constructions from experience ("engineering" may be a matter of scale), grouping by similar critical incidents (they may involve the participant in building something) or by type (they may involve hitting obstacles in a process).

4. Background

Design of study materials & pilot studies

The design of the tasks had a number of developmental inputs.

1. Conceptions of, and attitudes about, engineering

The Academic Pathway Study survey (Eris et al, 2005) provides baseline information and a rich set of national data. Items in the survey have bee analyzed for construct validity, and the survey has been used multiple times in multiple contexts in the US. Because the survey was developed for a large-scale study in the US, future work should allow Swedish data to be effectively compared with US data. We changed items which identified context and background to Swedish equivalents, deleting items where no equivalent existed. All of the questions relating to the APS constructs were preserved, either unchanged or with additional explanation for the Swedish national context. A list of all changes is attached as Appendix A.

2. Critical Incident

The inclusion of an interview fulfilled the purpose of introducing *Stepping Stones* participants to a qualitative method. The choice of "critical incident" elicitation was influenced by discussions with Carsten Schulte and Llewellyn Mann. We developed a preliminary interview protocol and piloted it with 3 academic and postgraduate staff. The initial "framing" questions, drawn directly from Flanagan (Flanagan, 1954) paper were found to be very difficult for participants to interpret. The questions were adapted, firstly to include the word "real" and secondly to prompt the participant to think of concrete examples of engineering activity. These were piloted with 3 further postgraduates and 2 graduate students, and found to be easier for participants to understand.

3. Photo Elicitation

Our decision to use images was influenced by the Draw-An-Engineer Task (DAET) conducted with pre-university students. We rejected the use of it in as a component, because we believed that perceptions of drawing ability, and inhibitions over lack of draughtsmanship skills would prejudice our older study population. We chose instead to use a set of images of engineering as prompts.

Images were piloted over several iterations, across a total of 10 participants. Our selection of images was guided by the principles in Harper (Harper, 2002) that presenting familiar images leads to superficial recognition, but little further insight. We tested—and rejected—several images of engineering classrooms, which simply elicited the response "They're learning engineering". Following Harper, we then selected an historical image, an image of low-tech engineering, and an image of high-tech engineering. These were piloted and found to have the desired "frame breaking" effect (that is, they stimulated participants thinking about "engineering" beyond their initial thoughts and expectations). In testing the order in which images were presented, the best results from were obtained when the "low tech" image was placed between the other two.

4. Concept maps

Terms used in concept maps may be generated by the learner or generated externally. Analysis focuses on content and structure of the maps (Turns et al, 2000). For this concept map activity, terms were generated externally. The primary set of 18 terms was derived from recent reports characterizing the goals of engineering education as represented in accreditation policies (Turns et al, 2000). The original terms include: research, science, experimentation, engineering, uncertainty, theory, society, evaluation, modeling, ethics, economics, impact, design, environment, implementation, teamwork, communication, and analysis. Terms were modified ("uncertainty" to

"complexity") and appended based on an analysis of recent documents regarding the nature of Swedish engineering education (Maury, 2004). Additions include sustainable, innovation, judgment, multidisciplinary, international, mathematics, and technology.

5. Literature

References (papers included in the Kit)

Literature that contributes to the question

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Turns, J., Temple, J. & C. J. Atman (2000). "Students' Conceptions of their Engineering Discipline: A Word Association Study". Proceedings of the Annual American Society for Engineering Education Conference.

Literature that contributes to the methodology

Eris, O., Chen, H., Bailey, T., Engerman, K., Loshbaugh, H. G., Griffin, A, Lichenstein, G., and Cole, A *Development of the Persistence in Engineering (PIE) Survey Instrument* (2005) Proceedings of ASEE conference

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Background (optional, additional reading)

Conceptual change and conceptions of engineering (other examples)

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Newstetter, W.C. and McCracken, W.M. (2001). "Novice conceptions of design: Implications for the design of learning environments. In C. M. Eastman, W. M. McCracken, & W. Newstetter (Eds.), *Design Learning and Knowing: Cognition in Design Education*. (pp.63-78). New York: Elsevier.

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Concept map background and examples in engineering

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Image References

Image A Date: 04.21.1970 Title: Ames engineers Allen Faye, Merrill Mead and John "Jack" Boyd discuss aircraft design and handling ID: A70-1881 Credit: NASA Ames Research Center (NASA-ARC) http://ails.arc.nasa.gov/CumulusImages/Previews/PCD2378/Photos/768%20x%20512/37.jpg

Image B Credit: Practical Action/Zul. Practical Action is registered charity No 247257, http://www.itdg.org/

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Appendix A

Web Survey Adaptations

The *Stepping Stones* survey has been adapted, with permission, from the Academic Pathways Survey (APS), developed by the Center for the Advancement of Engineering Education (http://www.engr.washington.edu/caee/). In its originating context the APS was used as an instrument in a longitudinal study.

For the purposes of the *Stepping Stones* survey, we have preserved the item codes, so that data from the US and Sweden might be compared at some future point. However, this version of the survey is solely for use within Sweden. We have made the following adaptations:

Global changes

- The term "university" was substituted for "college" throughout
- The term "lecturing staff" was substituted for "faculty" throughout – and later modified for correct language
- The phrase "social fraternity or sorority" was deleted throughout
- All references to time – changed to "fall" term (unless referenced summer)

Item changes

	Stepping Stones variations	APS originals
0	New question unique to this study "When did you begin at your current university?" (Rationale – needed a "start point" to clarify what kind of program (3,4,5 year programs) – culture issue)	
1	Unchanged	
2	"Did you study elsewhere (universitet / högskola) before coming to your current University? If so, how many years did you complete before you transferred to your current University?" Revision - clarify whether or not military service "counts" (culture issue) Clarify "study" via use of universitet / högskola	"How many years of university did you complete before you transferred to the University of X?"
2a	Inserted: "How many study points did you gain from this study?"	

3	Required write-in rather than drop-down list "Where did you study? (name of institution)" Revision – clarification on "institution" (language issue) – replaced with "universitet / högskola" Revision – account for number of international students: "Where did you study? (name and country of most recent universitet / högskola)"	
4a	Addition of new question "What kind of program are you taking?" (Rationale – need to distinguish 3, 4, 5 year programs)	
4	"Do you intend to complete your engineering degree?" Revision – note deleted "civilingenjorsexamn degree?" due to existence of question 4a (kind of degree)	"Do you intend to complete a major in engineering?"
5	"What program are you taking?" Added write-in box for "Other" (so list can be inclusive to all programs) Revision – clarification to "kind of study program" (language issue) Addition of "software engineering" and "mediateknik / interaction och design" (a noticeable field in Sweden) Deleted "Social Science" has having no meaning in Swedish context.	"What do you intend to major in?"
6	Deleted. Inappropriate to Swedish context	"If you intend to DOUBLE MAJOR, what is the second major you intend to complete?"
7	"Do you intend to work as an engineer, conduct research in engineering, or teach engineering for at least 3 years after graduation?" Revision –clarification over "practice" (language issue)	" Do you intend to practice, conduct research in, or teach engineering for at least 3 years after graduation?"

8	Deleted. It would be effectively impossible in Sweden to pursue non-engineering graduate education if you have a first degree in engineering.	"If you are thinking of going to graduate school NOT IN ENGINEERING, please mark your most probable area of study"
9	Changed item 38508 to "A member of the academic staff, teaching assistant or other university affiliated person …" Changed item "My parent(s) would disapprove if I chose a degree other than engineering" A person working at/from a university has encouraged and/or inspired me to study engineering Language and cultural issues	"A faculty member, academic advisor, teaching assistant or other university affiliated person …" My parent(s) would disapprove if I chose a major other than engineering A member of the academic staff, teaching assistant or other university affiliated person has encouraged and/or inspired me to study engineering
10	Unchanged	
11	Unchanged Revision to item – clarification of "science ability" to "Science (naturvetenskap) ability" (culture / language issue).	
12	Unchanged Revision to item – clarification of "science ability" to "Science (naturvetenskap) ability" (culture / language issue).	
13	Unchanged (except global "faculty" substitution, as above) Revision – clarification regarding lecturing staff (lärare) and teaching assistants (handledare) (language and cultural issue)	
14	Revision – clarification regarding "tutoring" (language and cultural issue) – changed to "supplemental instruction"	
15	Unchanged Did not revise "project" (language issue – projects vs. assignments). Rationale – likely that US students had similar issues interpreting what is a project and what is homework – the question is more about individual vs. group work	
16	Did not revise "engineering classes" to compulsory classes since there are apparently many levels of mandatory courses and the issue is less about what is mandatory and more about a particular course topic (engineering/math/sci)	

17	Changed "Think about the elective (courses other than engineering, math, and science) classes you have taken …" "elective" (cultural / language issue)	"Think about the liberal arts classes you have taken …"
18	Revision – changed "spring" to "fall"; Added clarification to lecturing staff and teaching assistants; changed "office hours" to "visiting hours" (cultural issue)	
19	Revision – clarification regarding "graduate student" to "What portion of the courses you have taken since the start of this academic year have been taught primarily by non-Academic staff (for example teaching assistants or technicians" (cultural issue). There was a request to add "I don't know" since it is believed that many students will not know if lecturers have graduated or not. We chose not to do this since it changes the item scales (and potentially the validity of the survey).	
20	Revision – clarification on "classes" to "courses" (language issue)	
21	Unchanged	
22	Unchanged (apart from global "fraternity" deletion, as above) Revision – clarification on "civic" to "community" (language issue)	
23	Unchanged	
24	Unchanged Revision – change "spring" to "fall" – some concern regarding the meaning of the question (course load / work load) but did not change the terms	
25	Unchanged Did not revise "workload" (not sure if this is a language issue or a difficulty issue)	
26	Unchanged Did not revise "reasonable" – could not find a useful alternative (language / cultural issue. It was thought that it was a good thing – a positive thing - to have "reasonable" stress.)	
27	Unchanged Revision – clarification on "university education" and finances to "living during university education" (cultural issue)	
28	Swedish higher education is free (there are no tuition fees). Changed "How do you meet your university expenses (e.g. books, living expenses)?"	"How do you meet your university expenses?"
29	Revision "practicing" to "working" (language / cultural issue)	
30	Revision "practicing" to "working" (language / cultural issue)	
31	Revision "intern" to "intern (praktikant)" (cultural / language issue)	

32	Revision – clarification on "preparing for class" to "preparing for courses" and "spouse" to "partner" (language / cultural issue)	
33	Changed to "university"	"collegiate"
34	Unchanged	
35	Unchanged	
36	Unchanged	
37	Unchanged	
38	Unchanged	
39	Unchanged	
40	Revision – "practicing" to "working" (language / culture issue) Revision – clarification on "global" and "societal contexts" to "global" and "societal context issues" (culture / language issues)	
41	Unchanged	
42	Deleted. Inappropriate in Swedish context	"Please indicate your ethnic background: (Mark all that apply) • White/Caucasian • African American/Black • American Indian/Alaska Native • Asian American/Asian • Native Hawaiian/Pacific Islander • Mexican American/Chicano • Puerto Rican • Other Latino • Other"
43	Changed: • Swedish native • Swedish citizen • Permanent resident (permanent uppehållstillstånd) • International student from ____ (added) • None of the above Revision – "Citizenship status" to "status" Major cultural issues regarding designations that would be important foci of study. High level of international students.	• U.S. Resident • Permanent resident (Green card) • Neither
44	Revision – clarification on "siblings" to "brother(s) or sister(s)" (language issue)	

45	Changed to equivalent Swedish educational levels. There is no equivalent for "Associate Degree" so item 38678 deleted. • Did not finish gymnasiet • Graduated from gymnasiet (tog studenten) • Attended högskola/universitet but did not complete degree • Completed a kandidatexamen • Completed a magisterexamen • Completed a civilingenjörexamen (described as most Pre-Phd level) • Completed a doktorsexamen	• Did not finish high school • Graduated from high school • Attended university but did not complete degree • Completed an Associate's degree (A.A., A.S., etc.) • Completed a Bachelor's degree (B.A., B.S., etc.) • Completed a Master's degree (M.A., M.S., etc.) • Completed a Professional degree (J.D., M.D., etc.) • Completed a Doctoral degree (Ph.D., Ed.D
46	As question 45, above	
47	US dollars converted to Swedish Kroner, and then based on monthly salary vs yearly (cultural issue). Roughly this worked out to dividing the original numbers by 10 so that the values were whole numbers.	