USING PERSONAS TO GUIDE EDUCATION NEEDS ANALYSIS AND PROGRAM DESIGN

Anna Yström*

Lena Peterson

Björn von Sydow

Johan Malmqvist

*corresponding author
Chalmers University of Technology
Gothenburg, Sweden

ABSTRACT

The undergraduate programs within electrical engineering, computer science and engineering and software engineering at Chalmers are currently under revision. Some notable problems for these programs are the long-term trends of diminishing number of applications and a low share of female students.

This paper first describes the stakeholder's needs analysis phases of the project, where current occupational roles for these types of engineers were mapped out in order to find out what knowledge skills and attributes that are necessary to work as an engineer in this field. These occupational roles were then used to guide the program concept design phase of the project.

As the number of occupational roles is large, a persona methodology was used to gather all the necessary information into a graspable format. Personas have for a long time been used in e.g. software development for describing users/customers. We adapted this methodology to describe the future professional roles of engineering graduates. The personas were based on information gathered through workshops with Chalmers staff and representatives from the local business sector, alumni surveys and observational journals from working engineers as well as documentation from different organizations on the future demands on engineers.

The paper then describes the program concept design phase of the project, where the personas were used as reminders for the design team that the roles for engineers at work are broad and contain many tasks and aspects that are traditionally not covered in engineering education. These many tasks need to be considered in the curriculum. In particular, the personas were helpful in the work of designing new and more diverse profiles at the bachelor level. In addition, the personas work, which was performed rather broadly across the departments involved in these five programs, has served as a basis for making the premises for the succeeding revision well known across the organization.

KEYWORDS

Engineering, personas, occupational roles, workshops.

INTRODUCTION

The undergraduate programs within electrical engineering, computer engineering and software engineering at Chalmers University of Technology (Chalmers) are currently under revision. Some notable problems for these programs are the long-term trends of diminishing number of applications and a low share of female students. This is not only a problem for Chalmers, since there is a strong need in society for engineers within these areas. Swedish universities can presently not meet this need, as witnessed recently in particular in the electric power and IT industries.

Five programs were considered in the revision: Two three-year programs leading to a "Högskoleingenjör" degree (Bachelor of Science in Engineering) and three five-year programs leading to a "Civilingenjör" degree (Master of Science in Engineering). The basic premise was to create, from these five programs, two new ones, structured in a three-plus-two–year format. Students would thus be able to finish their studies after three years with a "Högskoleingenjör" degree and to go out in industry or to continue for two more years and obtain a "Civilingenjör" degree, at Chalmers or at another university. This would address fundamental aims of the Bologna structure, i.e. to support employability and mobility.

The process of changing these engineering programs has been inspired by the CDIO initiative [5]. Instead of making only minor changes, it was decided to take a holistic approach and not to choose the easy solutions over the best. The revision project started in the autumn of 2008 with a general analysis, collecting and analysing data from many sources regarding labour market trends, demography and university application trends, as well as with an analysis of our existing programs. The next step was an analysis of professional roles for engineers. We foresaw that an overwhelming number of disparate and similar roles would be proposed and decided to approach the problem using the method of personas as a means to condense information. Personas have for a long time been an accepted mediating tool in e.g. software development [2][3], in particular for describing users/customers. In this project, we collected information from Chalmers faculty and alumni, industry representatives, work journals and various task classifications and distilled these into nine personas. The personas were then used in the program design phase of the projects as guides for elaborating role-specific course packages ("profiles"), but also for identifying professional skills that should be included in the compulsory parts of the programs.

The aim of this paper is to demonstrate how personas can be used as a tool for capturing education needs and for guiding program design. Specifically, we address these questions:

- How can personas be used to condense and structure information about a large set of potential occupation roles into a manageable set of personas, thus facilitating the communication of said information?
- What is a suitable process for developing personas corresponding to potential occupational roles for graduates from a particular program?
- How can personas be used in the program concept design phase?
- What are the effects of using personas in the needs analysis and program design phases?

The rest of this paper is organized as follows: In the next section, we introduce personas as a method and the particular process we used. The following section discusses the resulting personas. We then show how the personas were used in the program concept design phase, using the three-year part of the EE program as our example. The final section offers some conclusions.

PERSONAS AS A METHOD

Educational development process

The main phases of educational development processes include identifying stakeholder's needs, developing the program idea and structure, designing courses and learning environments, as well as developing faculty competence. In a successful development process, these tasks are tightly interwoven, and there is an evident trace from stakeholder needs to learning experiences [5].

The outcome of the first phase – identifying stakeholder's needs – is the statement of a set of program learning outcomes (PLO). The PLOs typically include 20-40 high-level statements of the knowledge, skills and attributes that the graduate should possess upon graduation. The PLOs are used to guide the development of the program idea, structure and courses.

A "good" set of PLO:s is firmly grounded in the professional activities of the graduate, covers all knowledge, skills and attributes that the graduate should possess, is specific enough to be a helpful tool in the course design phase, is solution-independent, and is well anchored with external stakeholder such as industrial and government, with faculty and with the students [5].

However, engineering programs educate students towards many different professional roles including researcher, project manager, operations manager and business developer. It may be difficult to merge and trace the specific competencies of these professions in a summary kind of document like a PLO statement. Due to their comprehensive and general character, PLO statements may also be difficult to interpret for faculty who are unfamiliar with the particular kind of language used. This might create a barrier for faculty to contribute with their insights to the PLOs. The risks also include lack of understanding and commitment towards the PLO statement.

The premise of this paper is that a stronger sense of commitment towards and understanding of the PLOs can be obtained if faculty are actively involved from the very beginning of the stakeholder needs analysis, and that "personas" are a suitable tool for facilitating this involvement.

Why personas in educational development?

When we need a way to organize and communicate information, personas become a tool to "package" a great deal of information in a relatively brief and graspable format. This was the case with the occupational roles, of which there surely are several hundred for engineers in this field, and that information would not be possible to handle and consider without a method or a strategy. Personas are also useful because they give us something concrete to refer to and discuss. Through a persona, it is possible to explore new thoughts and possibilities, a way to free your mind from what has previously been obvious [9]. The probability of a good result is greater if you choose to design the product to the needs of one single user, rather than consider all potential users [4]. The difficulty lies within the prioritization – which users should be chosen to be represented by the persona? In this project, that was not an easy question, as there were many opinions about "what the typical engineering role should be, or is today". We needed to select a few roles that could represent the entire group, without being inconsiderate to the needs and requirements from the rest of the group, as they still probably need to be able to get a qualifying education at Chalmers. It should be noted that the primary reason for not reaching the desired result with the personas, is that they are only partially implemented, not communicated well enough, or there is a lack of understanding of how the personas could be used in a beneficial way [6].

It may be tempting to use stereotypes about certain professions or persons, especially, if you know that a clear, common perception about a certain role or category of students etc already exists. As this project strives to break this type of behaviour (as described in [8]), the creation of the personas must to a large extent be based on real, current information rather than preconceived opinions.

However, it is a goal that the revised programs should be more appealing to female students, and since the personas should lead the way to this change, it is important to include women among the personas. This makes it even more important that the persona is not based on assumptions about what career goals women have or how they make their choices. However, this will not be easy, as the available sample of female students in this area is quite small.

The work process

The process used to create personas in this project was based on an established model [1][7][9], which suggests the use of extensive qualitative and quantitative data, e.g. from interviews or questionnaires. In this project, it was necessary to have a somewhat different approach, as there was no possibility to retrieve that amount of material in the short time available. Instead, the main data was collected through workshops with Chalmers staff and industry representatives.

To complement these data, we also had access to current documentation on the topic, an alumni survey from a few years back and journals from a number of working engineers. It is always important to validate the personas after they have been created, and that also applied to this project, where a validation workshop was held at the end of the project phase. The process of how the occupational roles were generated and then gradually refined and reduced is described in Fig. 1.

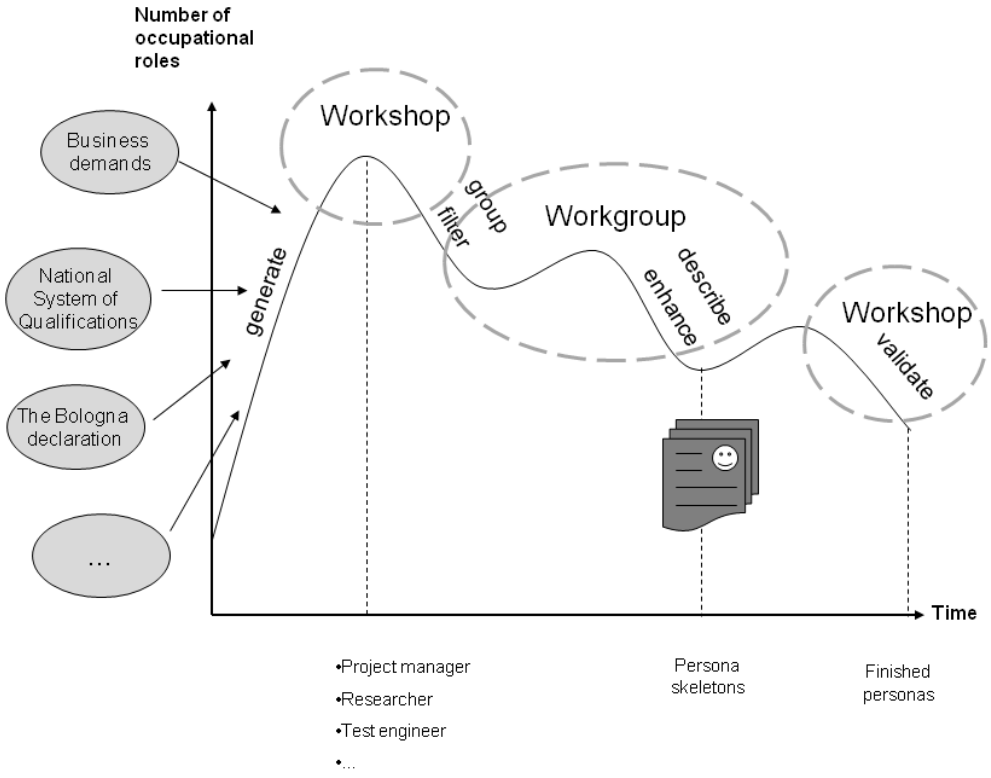


Figure 1.The process of creating the personas

Current marketing materials from universities and companies

The project started with an overview of what possible occupational roles the Master's programs and the engineering programs at Chalmers mentioned in their marketing towards prospective students. The result was very clear; the number one occupational role mentioned was PhD student/researcher. It was followed by project manager and scientific or technical expert. Few mentioned more "common" roles e.g. development engineer, support engineer, or test & verification engineer.

Engineering education at other universities in Sweden, Europe and the U.S. were also briefly reviewed. It appeared as though Sweden in particular focused on more academic, expert-oriented roles, as opposed to more general competences or engineering skills. It was also noted that many of the prestige universities in Europe and the U.S provided little information regarding the labour market opportunities; perhaps a degree from those universities in many cases is enough to get a job, no other specific qualifications are needed?

The internet was also scanned for information from large engineer employers regarding what jobs they offered and what tasks these jobs included. This information was valuable when giving accurate descriptions of the personas' jobs.

The alumni survey contained information regarding current type of work and industry, main tasks and opinions about relevance of the education for their work. As the questions were not written with this project in mind, only some of the information proved to be useful.

Workshops

In total, four workshops were held. Three during the project and one as a follow up at the end of this project phase. Of the first, two were directed at Chalmers staff and student representatives, and one was designated for representatives from the local business sector, especially, those who are major employers of Chalmers alumni. The largest workshops had about 60 participants, the smallest around 15. The aim of the workshops was to generate as many occupational roles as possible for engineers, and, preferably, in electric, computer and information technology engineering. After a short introduction, the workshops were divided into three main groups. In the first, the participants were given five minutes alone to brainstorm on the subject of what kind of work an engineer does, just to get the mind going in the right direction. Thereafter, the participants were divided into groups of five to eight persons, and given about half an hour to discuss what they each had come up with. They were provided with big pieces of paper, pens and post-it notes, and they were to write down their results on the notes e.g. teacher, test engineer, researcher. The third and last phase aimed at adding more descriptive information to these occupational roles, competences, skills or knowledge that were important for each role. New post-it notes were distributed, and the participants were also asked to physically group roles that they found to be similar.

After the workshops, each sheet of paper with post-it notes was transferred to an electronic mind map structure. When all mind maps had been transferred, they were merged into one large mind map. However, much information from the groups was the same, which indicated that the perception of what an engineer does is quite clear. If that perception reflects reality is another issue. It could also be noted that the industry representatives were better at providing detailed and descriptive information than the Chalmers staff and students were.

The roles were categorized into six main groups; research, education, development, marketing and communication, economics and administration and, finally, management and leadership, as illustrated in Fig. 2. The information from the workshops was mainly used to

select which occupational roles that would be suitable for the personas. This decision was based on what roles that appeared to be common in e.g. the alumni surveys, and which roles that appeared to be common in many workshop groups. Of course, the overall group of personas had to represent a large field of engineers, and they should, therefore, be able to represent parts of this field in some way.

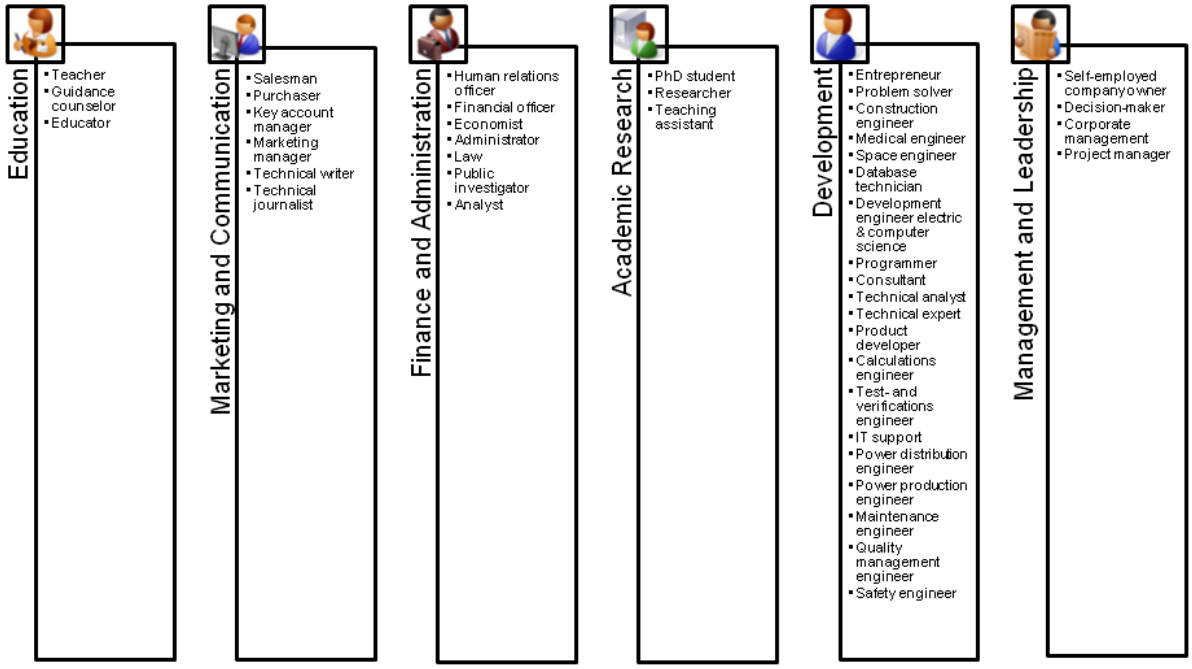


Figure 2. Categorization of occupational roles from the workshops

Journals from working engineers

As a large part of the creation of personas is about creating believable reflections of reality, it was decided that the information about engineers provided "in second hand" through the workshops would not be sufficient to create the type of personas that was desired. To give the personas more life, more current and qualitative information was needed on career goals, job descriptions and tasks. About 100 working Chalmers alumni in the requested fields, residing in the Gothenburg area were contacted via e-mail and asked to participate in the study and offered a symbolic compensation. Their task would be to fill out a pre-formatted journal over three days, where they described what they did and how much time they spent doing it. They also had to answer some more general questions about their working experience, career goals etc. In total, about 20 journals were submitted. The low number of respondents could be explained by the short time frame which limited the possibilities to send reminders. Despite this, the information provided in the journals proved to be very important to be able to create realistic personas.

RESULTS – THE PERSONAS

Assembling the information – from skeletons to personas

When the necessary information had been gathered, the workgroup assembled and chose a number of roles that were developed into skeletons, i.e. not complete personas, but still with main characteristics determined. When the skeletons had been created and reviewed in the

work group, eight of them were selected to become full personas.

A persona can contain different kinds of information depending on the purpose. It was decided that our focus would be to describe the occupational role, what the most common tasks are, career goals, something about education or skills and a short personal note. The personas would be described in plain text on no more than a standard A4 page, and have a picture. Both the picture and the personal note help to make the character more realistic. This was the only part of the persona that had no connection to the qualitative and quantitative data collected.

Validation

All previous participants of the workshops were invited to the validation workshop, which also discussed the future phases of the project. During the validation workshop, the participants were divided into groups of about five persons, and they were given five minutes to mingle around and meet each persona, which was printed on big posters and put up on the walls. Beside each persona were red and green post-it notes, which were used to write positive comments or tips for improvements. After this session, the groups sat down and discussed the overall picture of the field, which the personas hopefully reflected. Comments were made on post-its on big pieces of paper. All in all, about two hours was spent on this validation exercise.

After the validation workshop, the comments were reviewed in the work group and some were valid enough for us to change certain details, other we disregarded because they were too detailed, brought on by misunderstandings, or contradictory to other comments or information. Some comments were about the female personas having unrealistic workloads and that working under such pressure will lead to sickness (cf the example in Fig. 4). The male personas with similar “leading” positions received no such comments. However, some comments regarding one specific area led to the creation of a ninth persona, to better represent the competences needed in that particular area.

THE PERSONAS

About 100 different occupational roles were identified and clustered into six groups; research, education, development, marketing and communication, economics and administration, and, finally, management and leadership. From these groups, in total nine personas were created, two women and seven men. Their occupational roles ranged from PhD student, network administrator, project manager, entrepreneur, IT solution architect, microwave specialist, test engineer, component engineer to technical writer. They portrayed engineers, who had been working for some time after graduation, and a few of them had reached leading positions in the companies. Their educational level ranged from three years to five years technical education, except for the PhD student, who was still in the educational system. Their workplaces ranged from very large companies to very small, with only a few employees. An overview of the characteristic features of the personas can be found in Fig. 3, i.e. the depth and breadth of knowledge they possess in relation to their years of education. The placement on the timeline also implies that for many positions, it has taken some time for the personas after graduation and to get there.

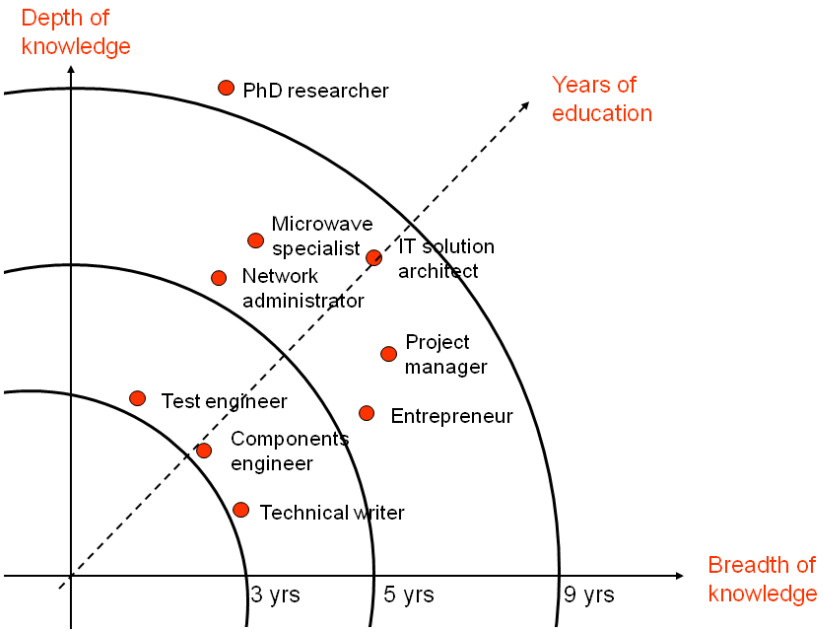
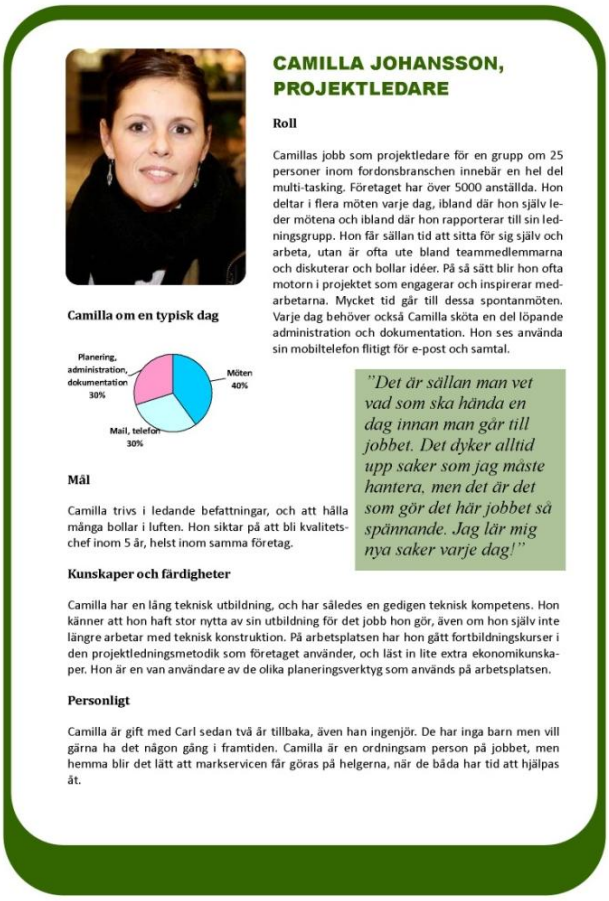


Figure 3. Overview of some of the characteristics of the personas



CAMILLA JOHANSSON, PROJEKTLEDARE

Roll

Camillas jobb som projektledare för en grupp om 25 personer inom fordonsbranschen innebär en hel del multi-tasking. Företaget har över 5000 anställda. Hon deltar i flera möten varje dag, ibland där hon själv leder mötena och ibland där hon rapporterar till sin ledningsgrupp. Hon får sällan tid att sitta för sig själv och arbeta, utan är ofta ute bland teammedlemmarna och diskuterar och bollar idéer. På så sätt blir hon ofta motorn i projektet som engagerar och inspirerar medarbetarna. Mycket tid går till dessa spontanmöten. Varje dag behöver också Camilla sköta en del löpande administration och dokumentation. Hon ses använda sin mobiltelefon flitigt för e-post och samtal.

Camilla om en typisk dag

"Det är sällan man vet vad som ska hända en dag innan man går till jobbet. Det dyker alltid upp saker som jag måste hantera, men det är det som gör det här jobbet så spännande. Jag lär mig nya saker varje dag!"

Mål

Camilla trivs i ledande befattningar, och att hålla många bollar i luften. Hon siktar på att bli kvalitetschef inom 5 år, helst inom samma företag.

Kunskaper och färdigheter

Camilla har en läng teknisk utbildning, och har således en gedigen teknisk kompetens. Hon känner att hon haft stor nytta av sin utbildning för det jobb hon gör, även om hon själv inte längre arbetar med teknisk konstruktion. På arbetsplatsen har hon gått fortbildningskurser i den projektledningsmetodik som företaget använder, och läst in lite extra ekonomikunskaper. Hon är en van användare av de olika planeringsverktyg som används på arbetsplatsen.

Personligt

Camilla är gift med Carl sedan två år tillbaka, även han ingenjör. De har inga barn men vill gärna ha det någon gång i framtiden. Camilla är en ordningsam person på jobbet, men hemma blir det lätt att markservicen får göras på helgerna, när de båda har tid att hjälpas åt.

Figure 4. Example of one of the personas

PERSONAS IN USE

After the personas phase, in the spring 2009, the revision of the programs was continued in a program concept design phase. Two main teams were formed; one for a combined CE + SE program, one for the EE program. Also, two supporting teams that addressed student-recruitment issues and mathematics were added. Each of the main teams was led by one the heads the existing programs; the teams also comprised teachers, both from areas within the main fields of study and from supporting fields, study counsellors, students from the existing programs and from the student union, and career-service officers. The duration of this phase was merely ten weeks. At Chalmers the five-year programs already have a three-plus-two–year structure since 2007 when the Bologna structure was implemented at the master's level. For this reason, and due to the short duration of this phase of the project, the main teams decided to focus their efforts on designing the three-year part of the programs.

The result of this phase was a final report in the style of a compilation thesis with the summarizing introduction written by the main project leader and with the reports from the main teams as the "papers". This final report has been sent out for comments both within Chalmers and to student organizations, other universities, industry, trade organizations and relevant union organization. Around fifty comments were received. Currently, these are being reviewed and the decision on how to proceed will be taken by the president of Chalmers presently.

Example Electrical Engineering

Traditionally, the role as a design engineer is the focus of both the three-year and the five-year EE program. The personas served to illuminate the need for broader scope within the concept three-year program. These additional roles were modelled on the personas, with the addition of the operations engineer, who was not among the nine personas.

In the Swedish (and European) credit system one year of full-time studies corresponds to 60 higher-education credits (hec). A three-year program is thus 180 hec. In the EE program concept structure the common core is 90 – 120 hec, the "persona/role" package is (max) 30 hec, and the compulsory bachelor thesis is 15 hec. The remaining 15 - 45 hec is to be used for electives. Students aiming at continuing in a master's program have to prepare by electing the appropriate theoretical base for the desired master's program.

The table below summarizes some of the results relating to the roles in the three-year concept program. All these details were not in the final report of the EE team.

Table 1. 3-year roles in the EE program concept proposal.

Persona/ professional role	**Specific Goals / Intended learning outcomes The graduate should be able to…**	**Examples of courses in persona/role package**
Test engineer (digital hardware, RF)	use and program test equipment communicate with design engineers determine testability during product development create test plans from product requirements assess risks related to product fabrication and operation	Machine-oriented programming Electrical measurements Requirements management Embedded microcontrollers / RF design

Component engineer	communicate with vendors and design engineers assess risks related to electrical components during manufacturing and in operation assess compliance to regulations read and condense data from vendor component documentation	Production Electrical Components and modelling
Technical writer / Information officer	write text intended for users of EE-related products and components, such as instructions, manuals produce and maintain internal documentation for EE-related projects make internal and communication plans	Professional communication Project management
Operations engineer (electric power)	operate and maintain production plant including managing labor detect and correct faults in equipment make technical requirements specifications and prepare documents for procurement of equipment and services plan for maintenance and reinvestments communicate with vendors, subordinates and management	Electric power systems analysis and operation Applied control theory and process control Utility asset management Work organization
Project manager (junior)	prepare project plans assess and manage risks communicate with design and test engineers and management	Project management Project economy and risk management Work organization Leadership and ethics
Design engineer (digital hardware, electric power etc)	conceive and design product communicate with customer (internal or external), marketing, project leader analyze and assess technical solutions according to requirements including economical	Product design Production Hardware description language / electric power engineering
Preparation for master's program	communicate with experts and researchers in intended field formulate and solve theoretical problems related to intended field	Mathematics/physics Field-specific courses Individual project

Design consequences

If the concept EE program is implemented, it will probably, at least from the start, have fewer admitted students than do the two combined existing programs, due to the unknown effects on recruitment of students. Thus, it would most likely, for economical reasons, not be possible to offer a large set of elective courses. During the development of the concept program the aim has been to find some courses (or parts of courses) that can be reused among the personas packages, but also among other programs at Chalmers. This part of the work has not yet been carried out in detail, due to the limit time for concept phase. However, it is clear that the courses for the more generic personas/roles, such as project leader and technical writer must be shared among programs to gather enough students.

Each course package, in the concept program, has to be designed to fulfil the learning

outcomes for the intended role/persona. Each student taking the program will also have to fulfil the degree requirements for the three-year engineering degree as specified in the national system of qualifications. It may require complicated syllabus rules to ensure that both these sets of requirements are fulfilled.

In the concept program the compulsory part is smaller than in the existing programs to allow for a broader array of possible roles after three years. This new compulsory core is more geared towards the engineering fundamentals and role, which all students have to have, whether or not they are aiming for a three- or a five-year exam. Even for students aiming for a five-year exam, the traditional base of math and physics will be spread out over the five years and theoretical, deeper math and physics courses are pushed to the non-compulsory parts. This implies that the existing master programs may have to be modified to include more of the theoretical base, which is currently assumed to be in their prerequisites.

CONCLUSIONS

The number of potential occupational roles for graduates from an engineering program is very large, 100+ in the case we studied. This amount is impossible to overview and to design for. To condense the information we collect roles into role groups, but a group is a generalization that does not highlight the tasks of individuals. Personas are helpful in identifying and concretizing the key work tasks for the roles in a group. Personas used for analyzing educational needs should further highlight the goals for a person occupying such a role and the educational learning outcomes that prepare for working in the role.

A process for developing personas for the occupational roles for graduates of an engineering education needs to have two main elements: One, similar to conventional personas processes, has an external focus and includes searching for information including studies of practicing engineers, national regulations and statistics. The other one, however, which is more specific for education planning applications of personas, has an internal focus. This internal process needs to be carefully designed as well; many faculty have a limited understanding of practising engineers' actual tasks, and it takes time for them to become so acquainted with the personas materials that they can take ownerships of them and use them as inputs to the design process. Here, we used a process with multiple workshops, which seems to have been successful: it has involved a large group of Chalmers staff, and even though many were sceptical in the beginning, at least some have been pleasantly surprised by the results.

The personas helped structuring the concept programs by identifying typical occupational roles that graduates who choose to go out in industry after three and five years, respectively, could take on. Suitable course packages could then be designed.

Amongst the insights gained from the personas work can be mentioned the structured overview of occupational roles. Further, many faculty were further surprised by the amount of non-technical work than many engineers perform, and need to be prepared to do. It has also been indicated that personas might be useful in other types of development work, for example student recruitment, by explaining future professional roles to potential applicants. Personas for prospective students could also be helpful for the university to understand attitudes of potential applicants.

REFERENCES

[1] Cohn, M. User Stories Applied: For Agile Software Development, Boston, Addison Wesley, 2004.

[2] Cooper, A. The Inmates are Running the Asylum, Indianapolis, SAMS, 1999.

[3] Cooper, A. "The Origin of Personas", Cooper Journal, August 1, 2003, accessed as an electronic resource at [http://www.cooper.com/journal/2003/08/the_origin_of_personas.html] 09-04-08,

[4] Cooper, A. "Using Personas to Create User Documentation", Cooper Journal, December 2, 2004, accessed as an electronic resource at [http://www.cooper.com/journal/2004/12/using_personas_to_create_user_documentation.html] 09-04-08.

[5] Crawley, E, Malmqvist, J, Östlund, S. and Brodeur, D. Rethinking Engineering Education: The CDIO Approach, New York, Springer, 2007.

[6] Grudin, J and Pruitt, J. "Designing for User Experiences", Proceedings of the 2003 conference on Designing for user experiences, ACM Press, 2003.

[7] Mulder, S and Yaar, Z. The User is always right: A Practical Guide to Creating and Using Personas for the Web, Berkeley, New Riders, 2007.

[8] Ottemo, A. Delrapport: Rekryteringsarbete och genusmönster i rekryteringen till Chalmers utbildningar på EDITZ-området (Recruitment Work and Gender Patterns in Recruitment to Chalmers' EE and IT educations), Chalmers University of Technology, Gothenburg, unpublished, 2008.

[9] Pruitt, J and Adlin, T. The Persona Lifecycle: Keeping people in mind through Product Design, Amsterdam Boston, Morgan Kaufmann Publishers, an imprint of Elsevier, 2006, accessed as an electronic resource at Books24x7 - ITPro & BusinessPro (e-book collection) through Chalmers Library.

Biographical information

Anna Yström (corresponding author) is a PhD student at the Department of Technology Management and Economics at Chalmers University of Technology, Gothenburg, Sweden, and holds an MSc in Industrial Design Engineering. She participated in this study as a facilitator in the process of creating the personas prior to her PhD studies. Her PhD project concerns managing and organizing creativity in open innovation arenas.

Lena Peterson is an associate professor at the department of Computer Science and Engineering and a Dean of Education at Chalmers University of Technology, Gothenburg, Sweden. She was previously Head of Program for the five-year electrical engineering program and participated in the electrical-engineering team in the project. Her research focuses on design methodologies for analog circuits.

Björn von Sydow is an associate professor at the department of Computer Science and Engineering at Chalmers University of Technology, Gothenburg, Sweden. He was previously a Dean of Education and participated in the project as the project leader.

Johan Malmqvist is a professor in Product Development and Dean of Education at Chalmers University of Technology, Gothenburg, Sweden. His current research focuses on information management in the product development process (PLM) and on curriculum development methodology.

Corresponding author
Anna Yström
Chalmers University of Technology
Vera Sandbergs Allé 8
SE-412 96 Gothenburg, SWEDEN
+46 (31) 772 8247
anna.ystrom@chalmers.se