Preliminary findings of a gender and diversity screening at a technical university: impressions of the project "IGaDtools4MINT"

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Abstract: In the paper at hand the project design of "IGaDtools4MINT", a research project aiming to promote gender and diversity aspects as well as an opening of the faculty culture of computer science, is introduced. A first approximation on the reasons why women tend to study computer science and other MINT/STEM-subjects far less often than men will be given. Moreover, results of an initial survey of first semester students of computer science and impressions of a qualitative participant observation of different introductory courses of computer science at RWTH Aachen University are interpreted and discussed. The results of the evaluation allow for the assumption that efforts for the creation of a gender and diversity friendly environment which is a basic factor for the attraction of non-traditional, diverse students are visible but that these efforts to a large extent lack a coherent strategy and gender and diversity sensitivity to contribute to a sustainable structural and cultural change process within the department of computer science.

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1 Introduction

In order to attract diverse people German universities have been realising measures of gender and diversity management within the last years. Up to now many different measures are carried out in order to increase the diversity of participants in scientific culture.

At German universities the amount of women studying MINT-subjects (German abbreviation for mathematics, computer science, natural science and technology; equivalent to STEM) is very low compared to other countries [Sc07]. Surprisingly, the numbers remain low despite the increasing efforts to change this imbalance. Introduced measures primarily focus on increasing the percentage of women in STEM-fields as well as lowering their drop-out rates. Despite the efforts of pilot programmes and support measures the numbers remain largely unchanged. What are the reasons and why is the status quo problematic?

If the development of technology is carried out only by a specific group of people this technology will naturally represent the assumptions, views but also the blind spots of that group. This cannot only become an economical disadvantage, but also result in a misbalance regarding such technologies in general [Sc03]. Furthermore, if such a large segment of society such as women and other hitherto neglected diversity categories are left out we have to assume that a large waste of human resources is taking place since these groups would be able to contribute alternative views, perspectives and focus on technological problems as well as developments. Particularly in the face of the looming shortage of skilled labour due to demographic change in Germany women as a resource for technical talent can no longer be ignored [LW07] [Le11].

The reasons for the comparatively low participation of women and other groups in STEM-subjects in Germany are manifold. The faculty cultures, for instance, are largely coined by male values and assumptions. These male preferences are reflected (often unconsciously) in the didactics of the respective subject making it a rather unattractive choice of field of study for women [Mü02] [Ja09]. Moreover, the lacking connection of theory and practical use and respectively professional life seem to be factors that are criticised particularly by women [Sc07]. Likewise false perceptions about the contents of the subjects and requirements needed to study the subjects prevent more women from enroling in technological fields [WDW09] [MW06]. In the case of computer science we are dealing with a certain image of a typical student of this subject which is strongly connected with the “hacker” and “nerd” cultures [FM02]. Regardless if this is the case or not it nonetheless prevents the access of certain groups to computer science.

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In order to discuss the possible reasons identified in the literature for the case of technical universities in Germany and perhaps to identify "specialties" of the single organisations as well as to develop sustainable and effective measures a gender and diversity screening was developed. The screening process will exemplary be conducted at the department of computer science at RWTH Aachen within the framework of the project "IGaDtools4MINT"[1].

2 Background

In the domain of science, technology, engineering and mathematics (STEM) women are highly underrepresented. To increase the portion of women working in this domain it is necessary to increase their enrollment and their persistence in STEM study programs in absolute and relative numbers. The project IGaDtools4MINT focuses especially on computer science as an important part of the STEM fields. Within this field the number of new enrolments in Germany shows that women are underrepresented by far. In Germany in the winter term 2009/2010 only 15% of the new students in computer science were female. This is the same share as at RWTH Aachen University, where 47 of 319 new enrolments in winter semester 2010/2011 were female (~15%). [HF11]. Surveys about the status quo of computer science at RWTH Aachen University have shown that the overall local count of all female students in computer science is even less. From 2007 to 2011 only 11 to 13% of the students were female (WS 2007/08: *13%*, WS 2008/09: *12%*, WS 2009/10: *12%*, WS 2010/11: *11%*). This is far below the overall average of RWTH Aachen University, which is at 32% in 2010 [HF10].

Albeit very few women decide to study computer science, women seem to be more successful than men. The share of graduating women is consistently higher (2007: *16%*, 2008: *18%*, 2009: *19%*, 2010: *20%*) than the share of women currently studying. It can be inferred that it is especially important to encourage women to decide for a computer science related course of studies in the first place. So what are the reasons for the lack of interest in computer science?

2.1 Exploring the gender and diversity gap

As already mentioned a lot of measures have been developed and implemented in order to attract more diverse people. But still, the intended results have not been reached so far not only to attract more diverse people but also to retain them in the academic field.

[1] The project "IGaDtools4MINT" is funded by the German Federal Ministry of Education and Research and the European Social Fund for Germany (ESF) and has a duration of three years between 2011 and 2014. The acronym stands for "Integration of Gender and Diversity in MINT-Subjects at Universities".

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Especially for the low participation of women in computer science several reasons were discussed in several studies [Sc03] [FM02] [Ja09]. One criterion was the different computer usage of boys and girls. While there is not much of a temporal difference, the two groups can be distinguished by how they use the computer: Girls tend to use computers as tools to fulfill tasks while boys rather use them to play or experiment with them. Because of the skills acquired by this different usage boys often feel more competent whereas girls get the feeling to be less competent by comparison. Already at the age of 11 a significant difference in the technological self-concept of female and male students can be observed. The self-concept of girls is much lower than the self-concept of the boys [Br10] [Leo11]. Teachers often seem to be over-challenged with this situation and fail to take countermeasures.

Coeducation is another point influencing the self-concept of boys and girls by intensifying the mentioned sexual stereotyping. Girls in coeducational environments experience computer science as more challenging and less interesting than girls in mono-educational environments. In addition to that there is a lack of visible, famous female computer scientists or female computer science teachers that could act as a role model for girls.

While these are factors within the education system, the big gap in prior knowledge is another very important criterion. Its influence can be observed during school classes as well as during the first semesters at university [PMO09] where it has negative impact on women. Of the first year computer science students at ETH Zürich (2003 to 2008) almost 50% of the women had no prior experience in programming at all, whereas only 10-20% of the men had no prior experience. Interestingly an almost equal share of female and male students had some basic programming knowledge, but without knowledge of more advanced concepts like object-oriented programming.

In response to these findings several changes for teaching were discussed to address the different, highly heterogenic groups of students. New content should be connected to prior knowledge to increase success in learning and special courses could help novices to catch up with their fellow students. Additionally the use of an inverted curriculum, represented by a given software system, is proposed. A conventional programming course is taught “bottom-up”, i.e. the course starts with the most fundamental programming concepts like if-statements, variables and loops. An inverted curriculum is the inverse approach that is the topics are taught top-down starting on the level of the applications architecture down to its individual components. This offers advanced students the possibility to explore a richer environment with more complex libraries, whereas novices can make use of libraries’ APIs to learn programming in an easily comprehensible system.

Overall it has to be kept in mind that the computer itself is often seen as an obstacle. While other technological toys encourage creating and crafting, the computer is often simply used as it is. The urgent question is: How to motivate students of both sexes to go further than mere usage and get them interested in computer science?

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2.2 Successful initiatives

The project IGaDtools4MINT is oriented towards a project of the CMU (Carnegie Mellon University) which is described in "Unlocking the Clubhouse" [FM02]. This project raised the count of female first year students in computer science from 7% in 1995 to 42% in 2000. Various interesting ideas for educational reforms are described and numerous interventions for raising the number of women and other under-represented groups in computer science are identified. The measures can be grouped as follows:

- Profound knowledge of the present starting conditions has to be provided.
- The reforms have to be supported by an experienced, competent and approved team.
- Students must be integrated in the process and their experiences have to be considered.
- Weaknesses must be analyzed and focused upon.
- Initiatives to support the networking of women have to be developed.
- The disciplinary culture has to be opened up and enhanced.
- Activities for prospective computer science students have to be developed and deployed.
- Subject-specific and social changes of the surroundings have to be continuously integrated.
- The pedagogical diversity has to be promoted.

Based on these recommendations six crucial action fields can be identified:

1. Teaching and course of studies: The curriculum can be analyzed and improved and university courses can be redesigned to use new pedagogical approaches. Additionally, the teaching can be improved by enhancing it with interdisciplinary elements or concepts like team-teaching. Overall a pedagogical concept for gender-sensitive teaching has to be developed.
2. Research and transfer: To ensure sustainability more women are needed in research positions and gender issues need to be established as a topic in research questions.
3. Organisation: Introduction courses for prospective computer science students have to be improved as well as the organisation of the course of studies itself.
4. Expertise and key competences: By promoting mentoring programs the transfer of know-how and important key competences can be focused and encouraged.

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5. Disciplinary cultures: The disciplinary culture has to be rethought to break with old, obstructive habits. Possible initiatives could be peer-tutoring and –training and specific workshops for lectures.

6. Social basic conditions: Last but not least an early first contact with computer science is desired for students during school. This way they can already be introduced to these topics before deciding for a course of studies.

In [KWS09] several successful activities and changes for attracting women to computing are described as well. These changes concern school career (K-12), tertiary education and promotion of careers in research and industry. Especially for girls positive role models within school are important and it is regarded as crucial to break with common myths and stereotypes about computer science. Wrong perceptions of multipliers, like parents and teachers, have a negative influence on students. Therefore, when discussing actions, these multipliers have to be considered as well. One possible action to enthuse girls for computer science in school is to introduce hands-on approaches for technological topics. This was for example done by teaching programming with mobile phones [HP10]. To ease the transition from school to university as the next step, summer schools for girls are suggested and universities and schools should intensify their contacts and work together. At university an introduction course for computer science is recommended to motivate students right in the beginning to study computer science.

Other changes did not turn out to be successful, like splitting student group according to their prior knowledge in “high performer” and “low performer” groups [Co07]. This allows optimised teaching for the specific group, but the separation seemed to have negative influence on the self-concept of the students. Instead the introduction course was redesigned with positive effect on the drop-out rate. One important change was the use of gender- and diversity-sensitive examples, like instant messaging instead of bank software. These examples were identified with help of a survey.

The gap in prior knowledge of computer science, already mentioned before, was identified as a huge pedagogical challenge [BH10]. At TU Munich an introduction course was designed to narrow this gap down as good as possible. In this course the students develop their own object-oriented program within 2.5 days. During this task they work self-directed, only supported by other students, acting as tutors. The course aims at lowering the fear of self-directed software development. An evaluation of this concept was positive.

Besides changing the way of teaching by introducing self-directing working and choosing gender- and diversity-sensitive examples, the choice of tools can be reconsidered. The use of a visual programming language (Alice) to learn object-oriented programming was positively evaluated [MLC04]. The cognitive load for learning object-oriented programming is reduced especially for students without prior knowledge, as the jigsaw-metaphor of visual programming prevents syntax errors. Thus the students can concentrate on the concept of object-orientation.

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3 Project design

Based on the previously described concepts and findings the project IGaDtools4MINT aims for gender- and diversity-sensitive teaching and to open up disciplinary cultures. A concept to raise the number of women in computer science and to lower the drop-out rates is being developed. The findings will be aggregated to build a gender- and diversity-toolkit, which will be deployed at TU Berlin. The toolkit will contain recommendations for actions and initiatives to raise the count of women and other, under-represented groups significantly.

The central issues for research in IGaDtools4MINT are:

- How can the STEM-field, especially computer science, be made more attractive for diverse groups of students?
- Which levels and participants have to be considered and with which instruments and methods?
- How to ensure the sustainability of gender-sensitive structures?
- How to deploy these structures efficiently in other universities and other institutions of higher education?

IGaDtools4MINT is based on a diversity approach that understands the variety of people as an indication for equitable opportunities for participation in social production processes and as potential and incentive for economic and social innovation. Within this approach, the groups of women and men are not seen as homogenous. Instead, it is considered that the diversity of all students is represented by additional diversity categories, such as social background and ethnic identities.

The project started with an evaluation of the introductory programming lecture for computer science. The preliminary findings are discussed in the next section. Currently, in June 2011, a new concept for a gender- and diversity-sensitive and interdisciplinary introduction course for computer science is being developed and first changes on the existing course will be deployed with the beginning of the next winter semester.

4 Preliminary findings

A lot of measures have been developed and implemented in order to attract more diverse, non-traditional students for STEM subjects and to finally achieve an opening of the respective faculty cultures which is an essential prerequisite. But still, the intended results have not been reached so far to such an extent that it could have a sustainable effect on the image of STEM subjects and the attitudes of future students, students and staff and therefore on the different faculty cultures.

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But why did those actions not have a larger effect? To find answers to this question the instrument of a gender and diversity screening could offer valuable insights into actual processes at universities. It is supposed to shed some light on the question to what extent the integration of gender and diversity aspects for securing equal opportunities in higher education has progressed in a specific institution. How well do the processes keep on track? Do certain measures integrate research from the field of gender and diversity and where might further action be necessary? Are measures and actions integrated in a coherent strategy?

4.1 Summary of survey results[2]

In the screening process of the computer science department the question was raised how the group of computer science students at RWTH Aachen University actually looks like. Is the group as homogeneous as previous studies showed [Wo03] [TW09]? What backgrounds do they have and what are their motives for choosing computer science? How do they rate their prior knowledge? Therefore, a questionnaire covering these questions was designed and handed out in a compulsory first year bachelor class of computer science in winter term 2010/2011. In this section the important results of the survey are briefly summarised.

319 students enroled in a bachelor degree of computer science in this respective term. [HF11]. The collected questionnaires added up to a total of 227, showing that a large amount of first year bachelor students participated in this survey.

The evaluation shows that the group largely consists of male students (86,3%) and is between 19 and 21 years old (74,5%). The majority chose mathematics as an advanced course at high school (72,6%) followed by physics (25,5%) and computer science (10,6%).[3]

Regarding the countries origin of the interrogated students a range of 22 different nationalities were named. A share of 79,7% were German followed by 2,2% with a Turkish, 1,8% with a Russian and 1,7% with a Luxembourgish citizenship. With regard to the political discourse in Germany on equal opportunities in higher education for people with migration background, the additional question was asked which language was spoken at home. The answers for this item were consistent with the results regarding nationality meaning that one fifth does not have a German family or language background.

In conclusion, the findings of our survey match the results of previous studies in this field saying that the group of computer science students recruits itself from a relatively homogeneous group [Wo03] [TW09].

[2] For a detailed overview of the survey with a description of the methodological approach and a discussion of results see [ALW11].
[3] For a further distinction between the choices of advanced courses of male and female students see [ALW11].

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The students' expectations in regard to what they expect to encounter during their time at the university offered interesting insights, especially in the students' perception or expectation of their own performance. In general, about 70% of the whole group of respondents said they "strongly agree" or "agree" to the statement "I will graduate successfully" as figure 1 shows below.

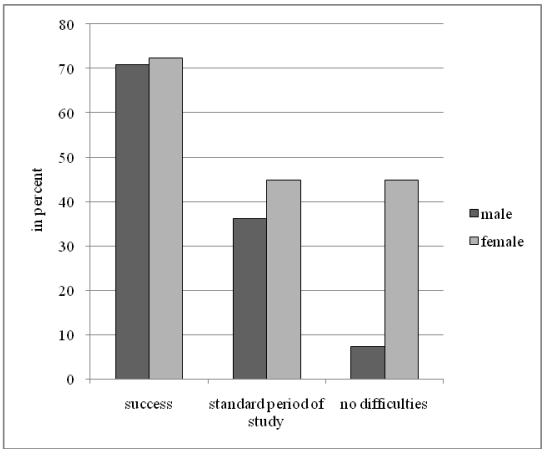

Fig. 1: Students' expectations. Source: own survey and illustration.

Remarkable results were observed when the answers to the statements "I will graduate within the standard period of study" and "I won't have any difficulties in studying computer science" were evaluated and displayed separately for female and male students. As figure 1 indicates, the female students showed a much stronger tendency to agree with these statements than their male colleagues. 36,1% of the male students expect not to study longer than the usual number of semesters compared to 44,8% of the women in this sample. The same amount of female students (44,8%) do not expect difficulties while studying computer science. This is a very large share as a comparison to the male students' answers shows: only 7,2% agree with this statement.

The female students in our survey seem to be much more self-confident and therefore our survey might be a sign for a change of attitudes. This finding is interesting and needs to be explored further, as other studies as mentioned before rather found the opposite situation [Sc99]. Thus, the reasons for these results have to be discussed. The easiest explanation would be to discuss the results as not being representative due to the small size of the group. But if the results could be confirmed by a second group, cultural aspects of the university would have to be taken into consideration, i.e. as RWTH Aachen University being a traditional technical university, it could be assumed that the female students deciding to study there are bound and determined in doing so.

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A further indication for a change process was observed when asking the students about their prior knowledge of programming languages. The male and female students of our survey have equal levels of programming skills. Fig. 2 shows that the differences between the male and female students of our sample rather refer to the specific programming language.

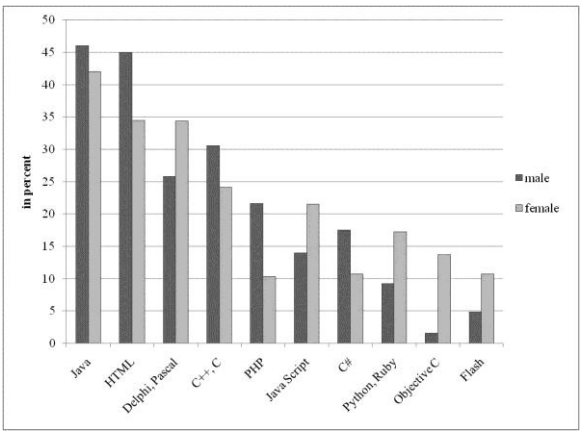

Fig. 2: Level of confidence in selected programming languages. Source: [AWL11].

This might refer to the context the language was learned in (e.g. in high school which is determined by the respective curriculum) but maybe also to a different interests as those languages are used for different purposes. This finding hints at an interesting change process going on which needs to be looked at more deeply in the future.

All in all, there are no differences by looking at the homogeneous composition of the student group in Aachen compared to previous surveys. But male and female students partly have different priorities regarding the reasons for the choice of the study subject which has to be considered. And it is remarkable that female students of computer science at RWTH Aachen University have a high level of self-confidence and trust in their abilities which could point at a change process regarding their attitudes and they have the same level of prior programming knowledge but in other languages.

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4.2 Screening impressions of computer science courses at RWTH Aachen University

In the framework of IGaDtools4MINT a participant observation was carried out in selected courses of the subject computer science at RWTH Aachen University in winter term 2010/2011. The courses were preparatory courses for bachelor and master students as well as an information session for higher semesters. Methodologically based on the approach of Münst a survey sheet was designed in order to record relevant data [Mü02]. The guideline used contained aspects such as "use of gender-neutral language", "type of media used", "references regarding occupational choices", "references regarding everyday application of study content", "interactive atmosphere" or "examples used". In the following section some impressions of the courses named above will be described.

An informational session for more advanced students was held with the help of an interesting didactical approach in order to present the contents of the seminars and lectures taking place in the upcoming semester. Every lecturer was given exactly two minutes and a laptop with beamer to present his course. The obvious advantage of such a strategy is that the students get to know their lecturers beforehand. Furthermore, the contents are presented in a lively way and concrete application examples are given. The result is less anonymity between students and lecturers and a better conjunction of theory and practice. Points of criticism are that most of the chosen examples entail typical male connotations like sports cars, car racing computer games and action movies. In addition, it must be stated that with more than 100 PowerPoint slides in 1,5 hours the retentiveness of most of the audience should have been overused.

Concerning the use of gender-neutral language it is not possible to make a final statement as the major part of the courses was held in English which in contrast to German has no female and male variations for most terms. Nevertheless, it was obvious that some of the lecturers made an effort to address both genders.

One of the basic findings of this qualitative approach is that the lecturers indicated the importance of math while naming autonomous learning and teamwork as necessary requirements for studying computer science. One of the lecturers addressed the issue that the meaning of some of the learning contents of the first semesters can only be accessed at a later time. Concerning a professional career many links were given particularly in relation to the occupational outlook of bachelor/master degrees. Different statements recorded in preparatory courses for first semester students suggested that the teaching staff assumes that most of the first semester students already have experience in computer programming.

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Moreover, the use of language during the sessions was inconsistent. For no apparent reason the working language in various information sessions was switched between English and German several times. Even in novice informational sessionstechnical abbreviations and acronyms are frequently used by the teaching staff. Such a use of technical terminology in front of beginners presumably without elaborate prior technical understanding can cause intimidation and lead to a feeling of not being prepared sufficiently. The use of "computer talk" in these introductory courses can thus promote feelings of insecurity and isolation.

The advice to sign up for a mailing list which will be essential for receiving information about examination dates etc. was given in a side note by a colleague of the presenter sitting in the audience. This observation leads to three questions: Is it really essential to register, as there are also other lines of communication distributing such information? Why was this (if at all) vital information distributed in such a careless fashion? What happens to people who did not visit this particular course? It must be feared that social mechanisms of exclusion are enhanced if not induced at this point as students who are not visiting this specific course are disadvantaged compared to those that seek social integration.

One of the lecturers informed the attendees about an offer of psychological consultation for students which was combined with a remark that surely he is hoping that none of his students will need to make use of this offer. Such a remark questions the meaning and seriousness of such an offer and is clearly aimed at creating a humorous response from the audience. Thereby the impression is created that people who engage in psychological consultation deviate from the norm to a great extent and are thus marginalised.

These examples from real situations observed in some computer science classes at RWTH Aachen University show that there are many visible attempts to implement gender and diversity aspects in various ways to create and ensure a gender and diversity friendly atmosphere. Yet, those attempts mostly remain on a superficial level and need to be improved by further sensitising different stakeholders to contribute to a coherent strategy which leads to the sustainable creation of a gender and diversity sensitive environment.

Conclusion

The first results of our survey have shown that students of computer science at RWTH Aachen University have relatively homogeneous backgrounds and rather represent the traditional image of computer science students. The interrogated women have a high level of self-confidence which could be a sign for a change of attitudes but has to be focused on in more detail.

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But apart from this finding, it is still true that non-traditional students do not study computer science in Aachen. For the design of gender and diversity inclusive measures it is important to acknowledge that at RWTH Aachen University computer science is extremely closed to non-traditional students. Therefore, it can be affirmed that existing measures so far have not lead to the attraction of diverse students because such measures had no impact on the intended structural and cultural change of the department of computer science.

This conclusion is further supported by the impressions gathered in introductory classes for new bachelor and master students of computer science. It could be observed that in various ways aspects of gender and diversity equitable teaching are being implemented. In some areas those efforts for instance contribute to a welcoming atmosphere and support the establishment of a bond between the students and the teaching staff which is an important factor especially for female students to feel comfortable. [FM02]. But other examples have also shown that certain measures (e.g. course starts in English but is continued in German) are insufficiently implemented.

All in all, there is an increased awareness on considering gender and diversity aspects within computer science classes but the competence of the different stakeholders has not developed to the level to be fully gender and diversity sensitive so far. The department could benefit from a coherent strategy contributing to a sustainable change process as it would not only facilitate a change of the students' attitudes but also of the whole department with its different stakeholders. This intended change process is crucial for the success of measures in this field and will be the focus of the gender and diversity toolkit.

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