Awareness Seeds for more Gender Diversity in Computer Science Education

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Computer Science is still not a very diverse field, it is mainly male-dominated. The picture in Computer Science Education is not much better. In the Netherlands, only 4-5% of the CS students are female. We believe that one of the first steps required for changing this situation is to create a higher level of awareness of this status quo and its implications. In this paper we propose five patterns that help lecturers to create such awareness as a first step towards a more gender-diverse student population.

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1. INTRODUCTION

Computer Science (CS) is still a male-dominated field. A similar situation can be observed in Computer Science Education. In the Netherlands, only 4-5% of the CS students are female. Much research has been conducted and many different reasons why so few women participate in CS were identified (see e.g. [Barker and Aspray 2006; Cohoon and Aspray 2008; Hill et al. 2009; Ashcraft and Blithe 2009; Lagesen 2011]).

For example, the social context in a country influences the career choices of women and men. A hetero-norm visualization contributes to perpetuate the status quo [Rommes 2010; Sörensen et al. 2011], because people behave conform to gender roles in order to belong to the society. Girls compare their ideas of who they are to their stereotypes of Computer Science and decide they won't fit in. The representation of women as a hetero-normalized and homogeneous group gives little option to develop talent on individual preferences.

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In the Netherlands, results of the *Program for International Student Assessment* (PISA) show that in general Dutch 15-year-old boys perform better in natural science and mathematics than girls [Booy et al. 2011]. One explanation is the low self-perception of Dutch girls regarding their skills in mathematics. This affects the girls' performance in mathematics [Meelissen and Luyten 2008], which is seen by people as one of the skills needed to become a good computer scientist. In consequence it therefore negatively affects the self-assessment of the girls with respect to a study in computer science too. Initiatives like the *Girls Day* in the Netherlands have been initialized to change the situation, but without any measurable large-scale and long-lasting effect: the numbers of female CS students remain very low.

That this imbalance is an issue has been discussed and recognized, main reasons being an appreciated diversity and higher creativity in the workforce and including females in the production of what is also used by females. Diversity is good for business and the society can't ignore the talent and the perspective of half of the population [Corbett and Hill 2015]. Information technology is seen as a crucial increasing actor for the economy in the Netherlands, a lack of professionals would be threatening the economy [Rijksoverheid 2015]. Besides that, offering all members of society the same chances and possibilities including equal payment should be a matter of course in 2015.

However, even though these results are publicly available, it seems that not many people are aware of them and the consequences they imply. Increasing the awareness of these issues more broadly would in our opinion be an important step towards changing the undesired situation in long terms. We believe that it is hereby more valuable to look for the positive aspects of working approaches instead of continuing with identifying the causes of the imbalance. Patterns as introduced by Christopher Alexander and his colleagues [Alexander et al. 1977] are a proven way of describing such knowledge, as they focus on what works and understanding why and when it works.

In previous work we proposed a first set of patterns that was intended to help educators improving the enrollment and retention of female students in CS education [Köppe and Bartilla 2014b]. One important aspect not addressed in these patterns is how to increase the awareness of all involved people in CS education on this issue. This awareness forms in our view an important aspect for successfully addressing the issue of gender imbalance in CS education.

In this paper we propose five patterns that are intended for people at institutions with computer science programs who are involved in addressing the diversity imbalance of their student population. An overview of these patterns is given in Table I. The pattern AWARENESS SEEDS serves as high-level entry pattern and starting point. The other patterns describe various ways of implementing it.

Pattern Name	Summary
AWARENESS SEEDS	Plant seeds that create awareness of why gender diversity in the student population is desired so that people come to action.
SEEDING CONTINUITY	Don't stop after initial activities, continue with planting awareness seeds on a regular and reoccurring base.
FEMALE CS ROLE MODELS	Expose everyone to females computer scientists as role models so that the image of the discipline can change.
QUICK SUPPORTERS	Start with recruiting supporters from the group which is already aware of the undesired gender imbalance and the issues related to it.
SHARING MINORITY EXPERIENCE WITH MAJORITY GROUP	Let majority members experience or learn about what it means to belong to the minority.

Table I. : Proposed Patterns

This work is part of a larger project at the Rotterdam University of Applied Sciences in the Netherlands on increasing the number of female students in a time frame of five years.These patterns are intended as useful support in this project, but also a means to share the knowledge with other educators who want to address the gender imbalance in their own institutions. We are aware that of course there are more diversity issues than the male-female imbalance in Computer Science, be it other underrepresented groups or other male-(or female) dominated fields. In this work we want to focus on this issue first, but also think that most of the patterns could be generalized to address the underrepresentation of other groups in CS education as well.

The presented patterns are of course no silver bullets and address only one small part of the gender imbalance issue. They therefore should be combined with other activities. Describing such other activities as patterns remains part of future work.

The background information in the following section provides support from research for the proposed patterns. The patterns and a short conclusion are then presented in sections 3 and 4 respectively.

2. BACKGROUND

Even though most people recognize that there is a strong imbalance with respect to diversity (it's plain obvious when one is looking at CS student cohorts and can easily spot the few female students), many of these people don't experience this as an issue that needs to be addressed. Results of research on how lecturers and students perceive Computer Science regarding gender specifics gave interesting and important insights [Bartilla 2014]. When asked directly, people state that the discipline is open for everyone and everybody can become a CS professional. However, interviews and observations revealed that most participants in the study unconsciously have a bias towards male students as being more eligible for CS than females. Implications of these hidden implicit perceptions are subject to stereotype threat and can be seen as one of the factors that contribute to the persistence of the status quo.

Some people claim that it is "natural" for females to not choose for CS. This claim is counter-exampled by reports on countries where there is a much more diverse student population in CS, such as Malaysia with about 50% female CS students [Othman and Latih 2006] or countries like Mexico, Brazil and Guyana with a percentage between 34% and 50% female students in CS [Galpin 2002]. One conclusion of this research is that there is no lack of female role models in these countries, which helps with shaping the perception of Computer Science as being a diverse discipline [Othman and Latih 2006]. This leads to a higher percentage of female students.

Role models are a good way of learning about what a career in CS can mean. Especially female role models show girls and young women that they also "can make it", which increases their (often lacking) self-confidence [Alvarado and Judson 2014]. Dryburgh considers the lack of role models and "the fact that the beliefs of male peers about "who does computing" are stronger than those of females" ([Dryburgh 2000], summarized in [Barker and Aspray 2006]) as conclusively related to underrepresentation of girls. Following this line, Google is sponsoring a program to make women more visible in technology. In 2015 the conference *Women Techmakers* increased the participation of women at the annual conference for developers and technologists to 23% (up from 20% in 2014 and 8% in 2013)[1].

Companies like Facebook and LinkedIn started with initiatives to help women in tech [Mendoza 2015], and also in CS education many activities and institutions exist that have the goal of increasing the diversity in computing and IT related fields. For example, there is the *Hour of Code*, a one-hour introduction to computer science taking place around the world. It is designed to demystify coding and to show that anybody can learn the basics of programming[2]. This event stands open for both genders, but clearly addresses girls too.

In the Netherlands the *Code Event* takes place. During these Code Events, girls aged 8 to 18 years learn programming from female IT students and professionals. The girls discover the many possibilities of programming in various workshops, such as creating a website, an app, or a game. Girls are active users of ICT applications. Such programming events, organized by the Dutch organization VHTO[3], are encouraging the girls to become 'creators' themselves[4].

Research by National Center for Women & Information Technology (NCWIT) addresses the role males play in promoting gender diversity in technology workplace [Ashcraft et al. 2013]. They offer a variety of tips and strategies, where creating awareness of the several implications which the under-representation of females in IT-related jobs have is the central theme. Creating (or "seeding") this awareness and raising it in a continuous and sustainable manner is one of

[1] https://www.womentechmakers.com
[2] https://code.org
[3] http://www.vhto.nl
[4] see for an example http://digivita.nl/digivita-code-events-tijdens-codeweek-2015/

the basic strategies they describe. Even though their work focuses on the work force, we believe that the strategies are partly also applicable in academic institutions and CS education.

The Norway University of Science en Technology (NTNU) in Trondheim increased the number of female students in computer science up from 6% in 1996 to 38% in 1997 [Lagesen 2011]. The NTNU hereby used different visible actions like advertisements, promoting arguments such as career prospects and job opportunities, and the quota for woman.

3. THE PATTERNS

The pattern descriptions use an adapted version of the format used by Alexander et al. [Alexander et al. 1977]. Each pattern starts with a short description of the context, followed by three diamonds as a section separator. In the second part, the problem (in bold) and the forces, which shape the problem and explain why it is hard to solve, are described, followed by another three diamonds. The third part offers the solution (again in bold) and advices for the implementation of the solution, followed by positive and negative consequences of the pattern application. As last part, one or more examples of the pattern application are given, highlighted in *italics*. References to related patterns are made explicit by writing the names of these patterns in SMALL CAPS.

PATTERN: AWARENESS SEEDS

There is an imbalance in the CS student population and only a minority of the employees seem to see this as an undesired situation. You want to change this.

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People are often not aware of the various advantages of diversity. This makes it hard for them to understand why the prevalent uniformity is undesired.

People only come to action when they really see a problem or are convinced of a new desired situation.

People belonging to the minority have different needs and problems than the majority members. Recognizing these needs and problems does not happen automatically, majority members therefore often are not aware of them.

Having prejudices is normal. However, that doesn't mean that they are true. Prejudices can be corrected, where becoming aware of them is an important first step.

Mindsets and views are formed by experiences and the environment one is surrounded with. If not exposed to diversity, one is likely to not see the issues related to a not-diverse environment.

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Therefore: Plant a variety of seeds that create awareness of why gender diversity in the student population is desired. These seeds should communicate why things have to change and how they can be changed.

A seed is "the beginning of something which continues to develop or grow"[5]. The variety of seeds can cover different areas, such as simply providing sources of information on the topic (see examples section for some references), stimulating thought triggers to look beyond one's horizon, or specific activities that create a higher awareness of the undesired situation.

This pattern is a specialized version of PLANT THE SEEDS [Manns and Rising 2005]. Implement it by regularly communicating the subject, e.g. in discussions, mails, news-letters etc., but also directly to other people. Start with what you have: communicate about the status quo and why it should be changed. There are enough research results that can be used for this part, so share information over publications on this topic or invitations to specific conferences and events. Create this awareness as part of other professional practices and activities, not as something special. Make sure to not make this a one-off event, but that there's a SEEDING CONTINUITY.

[5] http://www.merriam-webster.com/dictionary/seed

Invite FEMALE CS ROLE MODELS for presentations and guest lectures to change the picture both lecturers and students have of people who are in the workforce of the Computing discipline.

Include male advocates in all your activities and actions where possible, ideally with QUICK SUPPORTERS. Be prepared for discussions with arguments based on research findings.

Let members of the majority gain valuable experiences as minorities with SHARING MINORITY EXPERIENCE WITH MAJORITY GROUP.

Creating awareness of why not having a diverse student population is an undesired situation is an important step towards changing this situation, as people will get new insights, experience their environment differently, and also might start correcting their prejudices.

There is a chance that if this pattern is over-applied, the addressed people will get the feeling that this is the most important issue. This might lead to unnecessary resistance to this subject. This pattern therefore needs to be applied in balance with all other activities and projects that are of relevance for the involved department(s).

In the newsletter of the Informatics and Communication Academy at the HAN University of Applied Sciences, information on events and projects that address the subject of increasing the percentage of female students in computer science are included on a regular base.

Activities such as the Girls Days in Germany[6] and the Netherlands[7] or female-only coding events such as organized by the Rails Girls[8] or the PyLadies[9] are also good awareness seeds.

At Carnegie Mellon, the Women@SCS Advisory Council presented an afternoon forum called "Girls, Technology, and Education" in 2001, which was explicitly open for male teachers and students too. At this forum, issues such as girl-friendly classroom strategies, software game development and others were discussed, and by focusing on girls and technology in education and entertainment several aspects were addressed that certainly supported a higher awareness of the issues related to these aspects.

Some good books with lots of background information that can be used for identifying seeds are Women and Information Technology [Cohoon and Aspray 2008] and Technologies of Inclusion: Gender in the Information Society [Sörensen et al. 2011].

The card deck "Notable Women in Computing" offers playing cards with 54 notable women in computing that include their names, affiliations, achievements, and what they are known for [10]. Sharing these cards creates a higher awareness of the fact that women too contributed largely and in various ways to the computing discipline.

You are reading an awareness seed at this very moment! Working on this topic and sharing the results with direct colleagues and other interested parties is certainly a strong seed.

PATTERN: SEEDING CONTINUITY

aka: CHAIN OF ACTIONS

You created some AWARENESS SEEDS and the first leaves start to grow.

As daily tasks will continue and other issues will arise, awareness of the diversity situation will fade away and be replaced by other relevant issues. This will be of negative influence on the effect of your activities to change the situation towards a more diverse one.

[6] http://www.girls-day.de
[7] http://www.vhto.nl/projecten/girlsday/
[8] http://railsgirls.com
[9] http://www.pyladies.com
[10] http://www.notabletechnicalwomen.org/product/notable-women-in-computing-playing-cards/

The gender imbalance won't change by a single intervention. The priorities of people change often and are mainly determined by short-term goals and the tasks at hand.

However, there's often not much time to spend for actions that (re)create the awareness on the topic.

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Therefore: Continue with planting awareness seeds on a small but regular and reoccurring base. Remember: constant dripping wears the stone.

Identify opportunities for planting the next awareness seeds or refreshing old ones. Plan ahead the activities that are required for realizing them and make sure that all involved people are up-to-date too. However, it needs to be clear that these activities should be naturally seen as part of the normal work and not as additional tasks.

Continuity shows that there really is a long-term issue which cannot be handled through one-time activities. Furthermore, creating the awareness on a continuous manner costs less energy (compared to the overall results of the activities) than doing it occasionally, but in larger terms.

The more people continuously are aware of the topic, the higher is the chance that they also will participate in—or support—change actions.

It can be frustrating if the first activities do not lead to an observable change and one could become less motivated to continue with awareness seeds. Still, it is important to continue with them. However, if it shows that no change is happening because the awareness seeds do not trigger interest or awareness in some people, then one should think about other ways of planting the seeds.

SEEDING CONTINUITY is a more specific version of SUSTAINED MOMENTUM [Manns and Rising 2005]. A kind of task force or active support group—including both men and women and ideally also members of varying organizational hierarchy levels such as supporting staff and management—can help with ensuring and facilitating the SEEDING CONTINUITY.

At the Norwegian University of Science and Technology (NTNU) in Trondheim, they were able to increase the percentage of female students in only one year from 6% to 30% because of a broad change of the perception of computer science in Norway (see [Lagesen 2011]). However, after they stopped the campaign (assuming that the critical mass has been reached and therefore the problem has been solved), the percentage immediately dropped again. It became clear that a one-off intervention is not sufficient in changing the situation, so a long-term inclusion project was initiated (the "Women and Computing Initiative") and numbers increased again and became stable.

PATTERN: FEMALE CS ROLE MODELS

You want to show a part of what computer science is by showing who computer scientists are.

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People often have the image of computer scientists being male. This fosters gender stereotypes which can perpetuate and become a kind of self-fulfilling prophecy.

Role models shape the image of a discipline, as they represent the people working in that discipline. If only people are shown that represent the majority in the discipline, then likely the image of it won't change. However, exposing the role models to only that part of the population which feels connected to the role model, such as female CS students to female computer scientists or female software developers, does not help too with changing the overall image of the discipline.

People often are aware of the gender imbalance in computer science (it is plain obvious), but there is little awareness of the gender stereotypes that are related to this imbalance. Research suggests "that stereotypes are activated for women more frequently when men significantly outnumber women" [Corbett and Hill 2015].

However, many advertising campaigns already reflect a diversity in the shown pictures in publications such as flyers or websites. But these pictures do not connect deeply enough to the people so that they really change their image of computer scientists in general.

Furthermore, if women are visible then often not as computer scientists, but in a communication or representation role, which reinforces the gender stereotypes even more.

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Therefore: Invite female computer scientists to become role models and make them visible to *all* students and employees.

Increasing the visibility of female role models is possible through inviting female professionals—programmers, software engineers, software architects, CS researchers—for events like a kick-off of a Computer Science project for students. One can also have female speakers who represent the Computer Science study at introductory events.

Another strategy is to consciously increase the number of female lecturers in Computer Science subjects like programming. In this manner it is possible that the visibility of female role models could be increased and stereotypes could be overcome that Computer Science fits on the basis of a persons' gender.

If women who work in CS-related jobs are more visible, then the image of CS as male-dominated is not predominant anymore, which is one of the first steps for changing this image. Another advantage of having female role models is that they are likely to help with increasing the self-confidence of the female students ("She made it, so I can do it too!"). It also communicates that it is normal to be female *and* a computer scientist.

Increasing the visibility of female role models also will address the visibility/invisibility-paradox: females in CS are visible as females and invisible as CS experts [Lagesen 2011]. The prevalence of stereotype threat can be reduced when the number of women in the workplace at all levels of management is increased [Corbett and Hill 2015].

However, the number of female role models should not be unrealistically high compared to male role models, as this will create a too unrealistic image of the discipline and might be experienced as implausible.

The Dutch organization for Computer Science Education at Universities of Applied Sciences in the Netherlands (HBO-I[11]*) organizes lecturer's days once a year. The goal is to exchange knowledge and ideas and to develop strategies on how to improve CS education in the Netherlands. At these days also keynotes are given. At the lecturer's day 2014, two keynotes were given, one by a female and one by a male professional, hereby giving a diverse representation of the field.*

The Dutch organization VHTO[12] *(knowledge center for girls and women in technical engineering disciplines) maintains a list with potential female role models and regularly organizes guest lectures for them at primary and secondary schools in order to promote a more diverse image of the technical disciplines, including computer science.*

Activities initiated by the Women@SCS Advisory Council included an "Invited Speaker Series", where female speakers from academia, business, and industry were invited to present technical talks, share their stories and experiences and also discussing gender and work issues [Frieze and Blum 2002]. These presentations were open to both women and men.

PATTERN: QUICK SUPPORTERS

aka: START WITH PEOPLE WHO STAND OPEN

You want to create AWARENESS SEEDS and you need more people who support you.

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[11] http://www.hbo-i.nl/portaal

[12] http://www.vhto.nl

It costs a lot of energy and time and might still be unsuccessful in the end if you try to convince people of something they don't believe in or don't see value in in first place.

Changing a situation always comprises a trade-off between available time and energy and the maximum possible goal that can be reached.

It is demotivating to be the lone wolf in the struggle for more diversity.

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Therefore: Start to involve the people in your activities who already stand open for changing the situation and/or are aware of the issues related to it.

Start with identifying the people who stand open, e.g. through observing how they act during discussions on the topic or how they talk about male and female students. Then, when you plan activities that involve a group of people or when you need some support in other ways, approach these people first.

This will help you to create the broadest possible support (in manpower) with the least necessary effort and is a specialization of EARLY MAJORITY [Manns and Rising 2005]. These people can then function as BRIDGE BUILDERS [Manns and Rising 2005] and communicate the issues related to a not-diverse student population and the necessity of changing this situation to other people.

By convincing people in a quick and easy way to support the change you'll broaden the participation fast, you're not the lone wolf anymore and can celebrate SMALL SUCCESSES [Manns and Rising 2005], which is motivating and encouraging.

However, getting support of the people who already are aware of the issue does mainly include your manpower. The other people still need to become aware of the issues, which certainly requires more activities.

At Rotterdam University of Applied Sciences, a Code Event was organized where female CS students gave programming workshops to schoolgirls. The goal was to give these schoolgirls a good impression of what computer science is and to do that in a safe setting (meaning that there was no competition with boys involved). They also can ask questions to the present female students over how they experienced being a female CS student themselves, the students were therefore also FEMALE CS ROLE MODELS*. At this event, also lecturers had to be present, but there weren't enough female lecturers available. The organizers therefore asked some male colleagues which they knew stood open for this event (and the general idea behind it) to help during the day. Most of them agreed to help, as they saw the benefits of this event.*

PATTERN: SHARING MINORITY EXPERIENCE WITH MAJORITY GROUP

You planted AWARENESS SEEDS, but some members of the majority group only superficially agree that really something needs to be changed.

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It is hard for people to really understand what belonging to a minority or underrepresented group—like females in computer science—really means. In consequence, their intrinsic motivation to help with the change is low.

Usually, the majority group represents the norms and highly influences the general norms and beliefs. People belonging to this group don't have to fight for their rights, as they are conform with these norms and beliefs. They aren't aware of what it means to belong to a minority that is different from the norm and has to fight for its own rights and place.

Minority groups have different needs than majority groups, but this is hard to see and understand if one belongs to the majority.

The mechanism *homosocial cooptation* [Meuser 2004] means that members of a social group are orientating between themselves and choosing in first place themselves and not outsiders of the group. Homosocial networks in education are important for students [Cohoon 2006]. If the feature of the group is to be a man, then people are outsiders because they are a woman. It is hard to become part of this group and you have to adopt to the norm and rules of the group. Members of the homosocial network are the majority and it is hard to understand people outside of the network.

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Therefore: let members of the majority—students and teachers—experience or hear what it means to belong to the minority, e.g. by sharing minority stories or having them make a minority experience firsthand.

If there is communication about the topic, you can share stories. This makes it possible to inform others (majority members) about how minority members experience the field. In computer science education, men often don't know what it means to be a female computer science student or a female employee in a computing company, surrounded by mainly male colleagues.

Knowing about how that feels, e.g. by hearing shared stories or making such an experience firsthand, can create a better understanding of the minority position. This understanding is a good step towards changing one's views and perceptions of the minority and in consequence changing the behavior towards them. It also might make the need for changing the situation to a more diverse one more obvious. However, it is much harder to create such an experience compared to sharing stories about it, even though this experience will have a much stronger effect. The most important aspect is to make people aware of that it is different when one belongs to the minority and therefore can't take the same things for granted as the majority. Simply being one of the few males in a larger group of women while sharing a common interest (such as computer science education) can already make some deep impression, as it shows how it feels to in first instance being recognized as a male and not as an expert.

One important aspect of applying this pattern is that it also requires at least a minimum of reflection on the experience made or heard about. If a real experience has been made, then the simple question "How did it feel?" might be sufficient to trigger that reflection. If stories were shared, then questions such as "What do you think about this?" or "What would you do if you were in such situation?" might help.

It is good to take into account that over-applying this pattern or forcing people to make such experience might be counter-productive and might create resistance against further activities.

According to [Ashcraft et al. 2013], men who attended the Grace Hopper Celebration for Women in Computing[13] *(GHC) reported that experiencing a minority feeling there themselves has changed their view (the majority of GHC participants is female). A quote demonstrates this: "I think Hopper was a big jolt. When I stood up after an hour of it...and said, 'You know, an hour ago, I would have argued very strongly, differently; now I know nothing.'...I mean that was a revelation...so Hopper was a big kick in the pants."*

Some earlier work of the authors [Köppe and Bartilla 2014a] was presented as a poster at the 2nd Gender&STEM conference in Berlin, Germany. The majority of conference participants was female, so the 2nd author of this work made a first-hand experience as minority member at this conference, being mainly visible (and directly addressed in the beginning of a presentation) as male and not as researcher in the field. This made it quite obvious how it feels to get the special attention of others only because of a different gender.

In the Netherlands, all students get support from mentoring staff at the universities of applied sciences. This support ranges from helping them organizing their study, but also offering initial help with personal problems or problems with other students or teaching staff. Regularly, female students tell these mentors about things they experienced. These stories range from how they have to especially prove that they are competent in technical areas to how some teachers approach them differently from the other (male) students. If these stories are shared, then some people will think more

[13] http://anitaborg.org/initiatives/ghc/

about how to approach female students in a more appropriate way (as CS students and not as females). It also helps them to think about how they can support the female students with lessening the necessity of having to prove their proficiency more than the male students.

4. CONCLUSION

One important step in changing the gender imbalance in computer science education (CSE) is to create awareness of the situation and why it is undesired. In this paper we presented five patterns that can help with making such step in a sustainable way. They are part of larger work on patterns that address all relevant aspects of increasing the gender diversity in CSE and, in consequence, the computing workforce too.

During the work on the presented patterns we identified two more patterns which will be further elaborated in future work. These patterns candidates are:

—ACTIVE SUPPORT GROUP - Ensure support by a group and not only individuals and keep them alive.

—MALE SUPPORT - Involve males in all activities intended for increasing the gender diversity in order to prevent that it becomes a "women-only issue" which repels males unnecessarily.

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