Gender biases in assignments for Computer Organization and Reasoning and Logic at the TU Delft

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Abstract

The field of Computer Science is male-dominated. This means that there is a large lack of female representation. This causes women to be less interested in CS and have a lower sense of belonging. This lower sense of belonging does not only increase the already existing gender gap, it also has an impact on women's performances in CS. A lack of women in education causes a lack of women in the professional field. Education therefore plays an important part in decreasing the gender gap. This study aims to investigate potential gender biases in assignments of first-year courses for *Computer Science and Engineering* at the TU Delft. This study analyzes assignments from two courses based on four heuristics: The gender of characters and the way they are portrayed, gender-neutral pronouns, Whether assignments relate to People or Things, and The opportunities for collaboration and competitiveness. This paper shows that both courses suffer from a lack of story-based assignments. This lack of story-based assignments causes a lack of social relevance as well as a lack of characters and personal pronouns. Both courses allow for collaboration. Despite allowing collaboration, *Computer Organization* also has competitive elements in its assignments. This paper recommends that Computer Science courses use more story-based assignments.

1 Introduction

The existing gender gap in CS is a known problem. In 2022 17% of first-year *Computer Science and Engineering* students were female [1]. Filling this gender gap gives social and economic advantages because attracting more women to the field of CS can help fill the lack of professionals and make the field of CS a fairer working environment. Due to the lack of female representation, female students have a lower sense of belonging in CS than male students [10]. Female students also have lower self-efficacy than their male counterparts. A lower sense of belonging and self-efficacy results in lower motivation for CS.

Education can be important in attracting and retaining more women in CS because the existence of biases can influence female students to drop out of a CS major or to refrain from starting [4]. Considerable research has been done on the biases female CS students experience [8–10]. An example of a bias female students face is how they are not taken seriously by their male peers. To my knowledge, Medel and Pournaghshband are the only ones presenting specific examples of gender biases in education material [7]. This paper aims to investigate potential gender biases in the assignments of first-year courses in *Computer Science and Engineering* at the TU Delft. The research questions therefore are:
RQ: To what extent do the assignments from first-year courses of the bachelor *Computer science and Engineering* follow good practices for gender inclusivity?

I answer the research question by analyzing the assignments from both courses based on four heuristics found in literature: The gender and portrayal of characters, gender-neutral pronouns, Whether assignments relate to people or things, and collaboration and competitiveness [3, 5–7, 10].

By answering the research question, this paper aims to support TU Delft in improving the experiences of female students in the Computer Science and Engineering Bachelors.

2 Background

Different factors cause the gender gap in CS. I consider four such factors present in assignments:

- The sex of characters and whether they are portrayed positively or negatively
- The usage of the generic *he*
- Whether assignments relate to *People* or *Things*
- The Opportunities for Collaboration and the Competitiveness

The male stereotype gets enforced when characters are mostly male or when female characters are negatively represented. Another factor enforcing the stereotype that CS students are male is the usage of the generic *he*. The generic *he* means the usage of the *he* pronoun as a gender-neutral pronoun. One alternative is the usage of pronouns like *he or she*, however, Medel and Pournaghshband have also shown that men will more likely envision men when these pronouns are used and women envision both men and women equally. A gender equitable alternative for the generic *he* is the singular *they* [7].

Marcher et al. have shown that assignments relating to *People* appeal more to female students than assignments relating to *Things*. Men are often indifferent about this. This means that to increase the overall enjoyment and satisfaction of assignments, it is optimal for assignments to relate to *People* [6].

By accommodating student interactions, women's sense of belonging will increase [10]. One way to accommodate student interactions is by allowing students to collaborate on assignments. This increases women's sense of belonging, and could challenge the stereotype of CS students as asocial and that CS is a competitive field [3, 5]. When assignments have competitive elements, the stereotype of competitiveness gets reinforced.

3 Methodology

3.1 Materials

To answer the research questions I evaluate the assignments for *Reasoning and Logic* (R&L) and for *Computer Organization* (CO) from 2023.

For R&L I evaluate the *Tantalizing TA checks* and the project. The Tantalizing TA checks are weekly homework assignments to practice with the theory. The assignments

get checked by TAs and students get feedback on them. The project consists of four small assignments on Prolog. The assignments explain how to use the theory from lectures in practice using Prolog. To analyze the collaboration and competitiveness, I look at the previously mentioned materials, the course information page on Brightspace, and the slides from the first lecture.

For CO I evaluate the Assembly assignments. Specifically, I evaluate the lab manual and the lab assignments manual. The Assembly assignments consist of three mandatory parts and eight optional parts for bonus points. In these assignments, students must program in Assembly using a lab manual explaining the Assembly language. Students can sign off each part with TAs, who also give feedback when the solution is insufficient. To analyze the collaboration and competitiveness, I look at the previously mentioned materials, the course information page on Brightspace, and the slides from the first lecture.

I analyze these courses and assignments because I want to evaluate both large project-like assignments and smaller homework assignments. I analyze the assignments based on the Brightspace and Weblab pages from 2023, the educational platforms used for courses. I analyze seven TA assignments, the R&L project consisting of four parts, and eleven Assembly assignments.

3.2 Analysis

I examine the assignment on the previously mentioned five criteria.

Characters

I examine the characters present in assignments based on sex and how positively they are portrayed. I use a similar method as Medel and Pournaghshband [7]. This means that for each named and human character, I manually annotate their gender, limited to male, female, and unknown, and how they are portrayed, positively or negatively. I label the characters based on the activities they are doing. For example, when a character gets a high grade, that is positive. When a character needs help, they are negatively represented. When Characters are described neutrally, I count them as positive. When a name appears multiple times in the same assignment, I consider it to be one character. If one name appears in multiple assignments, I count each assignment separately. I exclude historical characters being explained in assignments and real people, like professors, since those are not made up nor are their actions. After that, I compare the amount of women and men as well as the percentage of negatively portrayed women and negatively portrayed men.

Pronouns

The second heuristic I analyze is the usage of gender-neutral pronouns to refer to people. To examine pronoun usage, I consider the generic *he*, the singular *they*, and other general pronouns like *he or she* or *(s)he*. For both pronouns, I count how often they appear in the assignments. I only count the frequency of the *he* pronoun used as a gender-neutral pronoun, not when it is used to refer to male characters. I

compare the frequencies of the singular *they* and the gender-neutral *he*. Ideally, the generic *he* never gets used, but for this research, I consider the ratio between the generic *he*, the singular *they*, and other gender-neutral pronouns.

People vs Things

To analyze the assignments based on *People vs Things*, I first manually label each part of the assignments. The possible labels are

- People: When the assignments relate to people
- Things: When the assignment relates to things
- Neither: When the assignment does not relate to people or things, for example, questions about theory or animals.
- Both: When the assignment relates to both people and things.

If sub-parts of an assignment part are assigned to different labels, I split that part of the assignment into its sub-parts and label those. After that, I count the frequency of each label. To analyse the data I look at the frequency of People and the frequency of Things and I compare those.

Collaboration and competitiveness

Because collaboration and competitiveness are closely related, this section covers both heuristics.

To examine the opportunities for collaboration in both courses, I first manually annotate for each assignment whether collaboration is mandatory, allowed, or prohibited. I annotate the assignments based on the assignment descriptions and the course information. For both courses, I compare the frequency of encouraged, allowed, and prohibited.

To examine the competitiveness of assignments, I manually annotate each assignment whether it has a competitive element. An assignment has a competitive element, if there is competition or when solutions from different students are compared to each other to evaluate the results. Although collaboration can help challenge the stereotype of Computer science being a competitive field, it does not mean that when there is an opportunity for collaboration, the assignment cannot have a competitive element. For example, when groups are competing against each other, there is an opportunity for collaboration but there is also a competitive element. This means that the assignments will be annotated on their competitiveness independent of how the assignments are annotated on collaboration.

4 Results

In this section, the results of the research for each course are presented, split on the criteria.

4.1 Reasoning and Logic

Characters

In total, the assignments of R&L contain 18 characters. Figure 1 shows the gender of these characters and how they were represented. As shown in the plot, The majority of characters are male, 7 out of the 18. A vast majority of the male characters were represented positively or neutrally. The amount of

female characters is less than half the amount of male characters. For the female characters, the division of positively and negatively represented characters is equal, whereas for male characters the frequency of positively represented characters is more than three times as high as that of negatively represented characters. For characters with an unknown gender, the difference between the frequencies of positively and negatively represented characters is similar to that of the female character, the same goes for the amount of characters with an unknown gender.
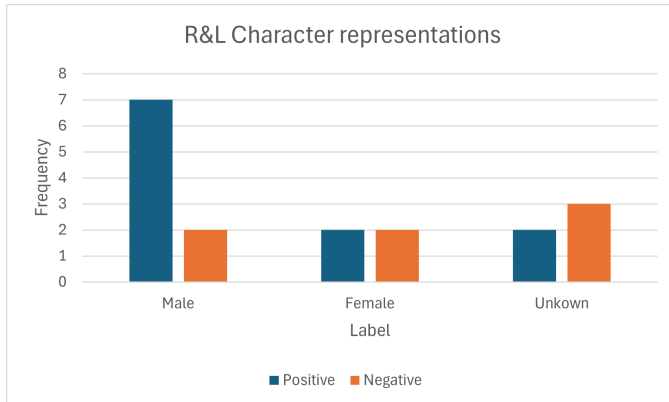

Figure 1: Number of male, female, and unknown characters represented positively or negatively.

Pronouns

As mentioned previously, not many of the assignments of R&L are related to people. This means that personal pronouns are not often needed. Therefore there are 8 gender-neutral pronouns used throughout the assignments of R&L. Figure 2 shows how often each gender-neutral pronoun is used. The generic *he* is never used in any of the assignments. Instead, the singular *they* is almost always used, seven times. Notably, five out of these seven times was caused by the fact that almost every *Tantalizing TA check* had the same final question, which included the singular *they*. Once an assignment included a different gender-neutral pronoun to refer to a person, namely *(s)he*.

People vs Things

The first criterion I look at is *People vs Things*. In total, there are 40 assignment parts. Figure 3 shows the frequencies of each label, People, Things, Neither, and Both. A majority of these parts are not related to *People* or *Things*, 31 out of the 40. R&L is a theory-based course. This means that most questions are theoretical questions, and therefore not related to people or things. The R&L course also uses examples with animals in some assignments. These assignments were all labeled as neither *People* nor *Things*. There are more than twice as many assignment parts related to *People* than to *Things*. There are 5 assignments related to *People*, where there are only 2 related to *Things*. There are also two questions related to both *People* and *Things*. One of them is because some variables in the logical statement are things and some of the variables are people. The other question is a question where
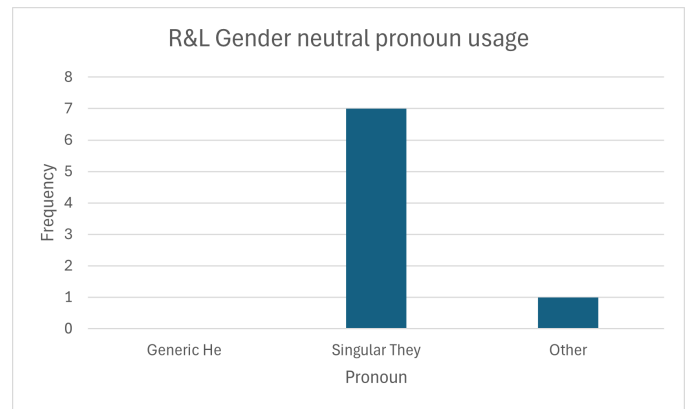

Figure 2: This graph shows how often each gender-neutral pronoun is used to refer to a person.

students need to design a logical puzzle. This means that students can decide for themselves whether the puzzle they design relates to *People* or to *Things*.
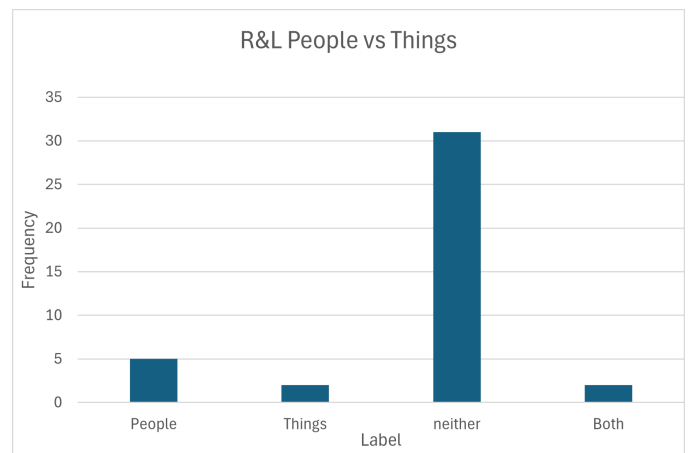

Figure 3: This graph shows how many assignment parts related to *People*, *Things*, *Neither* or *Both*

Collaboration and Competitiveness

Reasoning and Logic is a course that encourages collaboration. In the course information they say: "We strongly recommend you travel together and seek out each other's help during the lab hours". The course information also says: "The only activities we must insist you do alone are the tests in 5, and 10. These are meant to gauge your progress (week 5) and mark you (week 10)." This means that collaboration is allowed for all assignments. R&L encourages students to work with each other instead of against each other. This means that this course has no leaderboards or other competitive elements in its assignments. Slide 14 of lecture 0 says: "Within our course there is no competition, no leaderboard."

4.2 Computer Organization

Characters

Despite having three assignments related to people, the assignments from CO only have one character in them. This

character is present in the fourth bonus assignment. In the example output of this assignment, the following sentence is present: "My name is Piet. I think I'll get a 10 for my exam." Here Piet is a positively represented male character. Apart from Piet, there are no other characters in the Assembly assignments or the lab manual. This does not make it possible to compare the representation of male characters to that of female characters. The reason why the *People* related assignments do not have characters in them, is because these three assignments are about a group of archaeologists. They are always mentioned as archaeologists. They do not have names and therefore I excluded them.

Pronouns
Because there is only one character mentioned once and the only assignment related to people is about a group of people, there are no singular personal pronouns used. This means that there are also no singular gender-neutral pronouns used to refer to people. It is therefore not possible to compare the generic *he* and the singular *they*, because neither was used.

People vs Things
The *Computer Organization* course has eleven Assembly assignments. Figure 4 shows how many of these assignments are related to *People*, *Things*, neither or both. Most of the assignments, both mandatory, 2 assignments, and Bonus assignments, 5 assignments, are not related to *People* or *Things*. This is because the assignments are to implement a concept in Computer Organization. These assignments are not story-based and therefore do not have a story relating to *People* or *Things*. The assignments that are story-based are all related to *People*, three assignments in total. These assignments are all based on the same story about archaeologists, who want to decode ancient scripts. There is one bonus assignment that is related to both *People* and *Things*. In this assignment, students have to create their own game. This means that students can decide for themselves whether this game is related to people or things based on their preferences.
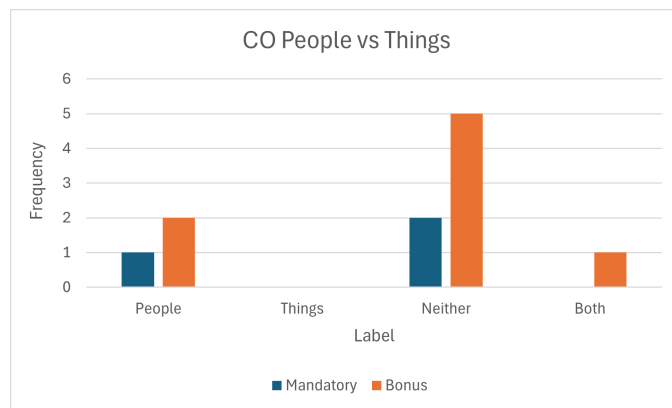

Figure 4: This graph shows how often assignments from CO are related to People or Things

Collaboration and Competitiveness
All Assembly assignments are to be done in pairs. The mandatory assignments need to be done in the same pair,

while the bonus assignments can be done in different pairs or even alone. Collaboration between pairs is allowed, but sharing code is not. The assignments lab manual says the following:
"The following are some of the cases that are considered fraud:
• Sending your code to other groups. The motivation of "I sent it for them to find some inspiration" does not work."

The fact that collaboration is mandatory in the Assembly assignments, does not mean there is no competitiveness. The seventh bonus assignment is an assignment where students have to make an interpreter for the Brainfuck language. This assignment also has a competition, where students have to make their interpreter as fast as possible. The students with the fastest interpreter get extra points on this assignment. The overview of all assignments also says that in the last assignment, extra points can be scored, in the past this was by another competition. However, the assignment description of bonus assignment eight does not mention these extra points. It is therefore unclear from the assignments lab manual whether the last bonus assignment has a competitive element.

5 Responsible Research

As mentioned in the materials section, I analyze the course assignments from 2023 according to the Brightspace and Weblab pages. When the assignments or the curriculum changes, these pages will remain untouched. This means this research will be reproducible, even when the courses change. By specifically describing which pronouns and characters I consider and which materials I use, I make sure this research can be reproduced in the future with the same pronouns, characters, and materials. The figures in the paper show how the courses perform on the heuristics, however, I do not note down how specific assignments perform on the heuristics. This means that if reproducing this research yields different results, it is not possible to trace back which assignment was labeled differently. However, this paper focuses on the gender inclusivity of the courses, not on the inclusivity of individual assignments.

I have taken these courses myself and therefore I have done the assignments. I have personal opinions on the assignments. This creates a risk that my opinions bias the results of this research. All six heuristics are based on gender biases presented in literature to mitigate the risk of this bias.

6 Discussion

This section interprets the results presented in the last section. It also gives recommendations to improve the assignments for R&L and CO. This section also explains the limitations of this research.

6.1 Recommendations

Reasoning and Logic has some example-based assignments, but most are about abstract concepts. While most example-based assignments are about People and not Things, improvements should be made to the amount of non-example-based assignments. Women prefer educational content with social

relevance [2]. This means that women prefer assignments that relate the content to its social relevance. Because most assignments in R&L are questions about abstract concepts asked in a vacuum, there is no link to the social relevance. One way to improve the R&L assignments is to add more story-based questions to the assignments.

The risk of story-based assignments is the unconscious gender biases that are present in the characters. This is already a slight issue in R&L. Most of the characters in the assignments are male and positively portrayed. Female characters are less often positively portrayed. The assignments of R&L sometimes already use ways to mitigate these biases. One example of this is the use of animals as characters [7].

CO only has three story-based assignments. All the other assignments are assignments where students must implement a function or algorithm without context. This means that for CO the lack of social relevance is more apparent.

While the Assembly assignments are done in pairs, CO has a strict anti-fraud policy. Strict anti-fraud policies could make students afraid to ask peers for help [5]. This reinforces the stereotype that there is little collaboration in CS.

Another aspect the CO assignments can improve in is competitiveness. There is a competitive element in the assignment about making a *Brainfuck* interpreter. It is possible to challenge students to improve their interpreter to be as fast as possible without comparing students to each other. One way to do this would be to give students points based on the speed of their interpreter. When a student's interpreter runs in X time, a student gets A points. When the interpreter runs in Y time, they get B points. This way students compete against the clock instead of each other.

6.2 Limitations

The limitations of this research need to be taken into account. I only look at whether assignments relate to people or things, while things can be learned from assignments relating to neither people nor things.

Another limitation is that I exclude all historical people and professors from the list of characters. I exclude them because I am interested in all made-up characters. However, the fact that all the lecturers and most historical people in the field of CS are male, inflicts biases I did not consider in this research.

I only analyze two courses from the first year of the *Computer Science and Engineering* bachelor. These two courses are not representative of the full first year of the bachelor.

Reasoning and Logic and *Computer Organization* are two different courses with completely different assignments. This means that the results from R&L and CO are not comparable with each other. The goal of this paper is therefore not to compare the two courses, but to present biases in both courses and give recommendations specified to the course.

7 Conclusions

Gender biases that are present in education material, cause women to have a lower sense of belonging, lower self-efficacy, and even lower performance. This paper analyzes the Assignments of first-year courses, specifically the *Reasoning and Logic* and *Computer Organization* courses, given

at the TU Delft to present these gender biases, that are present in the assignments. This paper analyzes these courses based on five heuristics:

- The sex of characters and whether they are portrayed positively or negatively
- The usage of the generic *he*
- Whether assignments relate to *People* or *Things*
- The opportunities for Collaboration
- Competitiveness

The majority of assignments are not related to People or Things. These assignments are often about theoretical concepts, or assignments without context. Both courses do have more assignments related to People than to Things. *Reasoning and Logic* has a majority of male and positively represented characters. Female characters are more often represented negatively. *Computer Organization* only has one character in its assignments. Therefore comparing male and female characters is impossible. The assignments of *Computer Organization* do not contain singular, gender-neutral personal pronouns. The assignments of *Reasoning and Logic* do. *Reasoning and Logic* never uses *he* as a gender neutral pronoun, only *they*. This paper presents recommendations based on these results. The main recommendation is to add more context and social relevance to the assignments. This can be done by adding stories to the assignments or questions.

To further analyze the assignments of the courses in the first year of *Computer Science and Engineering* at the TU Delft, the assignments of *Reasoning and Logic* and *Computer Organization* need to be analyzed together with the rest of the course. The course influences the assignments. This means that looking at the assignments in a vacuum does not represent the full course. To improve first-year bachelor courses, the other courses in the first year also need to be analyzed. To improve the experience of female students, the next step would be to research the experiences of female students taking first-year courses. Doing this creates insights into how the biases presented in this paper influence students' experiences and performances.

This paper should give the TU Delft some basic insights to improve the gender inclusivity of the *Reasoning and Logic* and *Computer Organization* courses.

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