Understanding Students' Experience and Perception of Gender Bias in a Software Engineering Education Environment

Tanjila Kanij
Dept. of Computing Technologies
Swinburne University of Technology
Melbourne, Australia
tkanij@swin.edu.au

Jonny Low, John Grundy
Dept. of Software Systems and Cybersecurity
Monash University
Melbourne, Australia
jonny.low@monash.edu, john.grundy@monash.edu

***Abstract*—The Software Engineering (SE) workforce is still man-dominated, and there are still fewer women students graduating from Computer Science/Software Engineering (CS/SE) courses in most countries. Two major reasons are fewer women enrolling in CS/SE courses and a lower percentage of those women who enrolled completing courses. We wanted to investigate the second reason - the experiences of students within the CS/SE education environment to identify key issues that need improvement to increase women student recruitment and completion. We interviewed 18 CS/SE students to explore their experiences. We requested they review selected SE education content to understand the perception of gender diversity within the SE education environment. Our findings indicate that many women students feel excluded by several behavioural aspects of their fellow men students, as well as by some teachers. We found that gender-biased language and stereotypical images make women students feel more excluded. From the experiences and opinions of our participants, we propose recommendations for higher education CS/SE teachers, universities and researchers to improve gender inclusion in SE teaching environments.**

***Index Terms*—Gender Bias, Teaching and learning, Assessments**

I. Introduction

The SE workforce – despite many different efforts over many years – still exhibits considerable gender under-representation from those not identifying as men. Three key reasons exist: there are many more men SE graduates, many more men enroll in SE courses, and there is much lower retention of women and others not identifying as men in SE courses. To date, much research and practical interventions have been carried out to try and address these issues, as well as retention issues within the SE workforce itself [1]–[3].

Many studies have examined young womens' attitudes to SE careers and courses in high school and issues in recruitment into SE courses [4]. Studies have examined perceptions of SE careers, including gender bias in job advertisements, bias in recruitment processes, and workforce retention and promotion issues [5]–[7]. Some studies have examined issues within the SE higher education context around gender bias, including teaching staff, attitudes, and content [8]–[12]. To date, many studies have produced somewhat generic recommendations and have had limited input from SE higher education students about their experiences, issues and perceived solutions.

Studies in SE higher education and job contexts have shown a persistent stereotype of SE being a highly technical, men-oriented subject [13]–[15]. The SE higher education student population is in most countries still highly men dominated, as is the SE workforce and research community [16]–[18]. Very limited work has been done to examine teaching approaches, content, delivery, assessment, policies and practices, and other SE higher education factors that might positively or negatively impact perceptions of gender bias, and thus negatively impact non-men student retention and achievement. We wanted to learn from the lived experiences of SE higher education students and get their feedback on their perceptions of gender bias in SE higher education contexts, including but not limited to teaching workforce representation and attitudes, teaching materials and assessment practices, policies and procedures, and any other factors that positively or negative impact perceptions of gender bias. We wanted to answer the following key Research Questions:

- RQ1. To what extent do Software Engineering (SE) students experience gender bias within SE education?
- RQ2. How do SE students perceive different types of gender bias within their teaching and learning content?
- RQ3. What practical suggestions do students have to address negative issues and reinforce positive issues around gender bias in SE higher education courses?

Our findings aid academics in designing SE teaching and learning content, assessment, and policies to combat negative student experiences of gender bias in SE education contexts. This will help universities to identify key areas that need attention to advance gender inclusiveness. Section II presents some background research relevant to this study. Section III describes the overall methodology followed for our interview study, and Section IV summarizes our key findings. Section V summarises our key recommendations, Section VI gives some threats that may invalidate findings, and Section VII concludes the paper.

II. Related Work

Software Engineering (SE) is a major study area within Computer Science (CS) education. Research on gender inclusiveness in CS does not always specify software engineering education. The majority of the research is conducted in a CS context which may or may not include software engineers as a particular student body. As such we review research related to Computer Science/Software Engineering (CS/SE) education in this section. Since perceived gender bias is the focus of this study, we start by reviewing some taxonomies of gender bias. We then review some relevant research on gender diversity within CS/SE education.

A. Defining Gender Bias

Doughman et al. [19] proposed a taxonomy of gender bias in the text as " *being an exclusionary, implicitly prejudicial, or generalized representation of a specific gender as a function of various societal stereotypes*", According to this taxonomy, there are five major types of gender bias noticeable in the text: "generic pronouns" - (pronounces used without specifying sex), "sexism" - (forms of sexist language), "occupational bias"- (generalization of occupation or role/duty onto a specific gender), "exclusionary bias" - (word or order of words excluding sex) and "semantics" - (implicit meaning deepening existing bias). These types were further divided into sub-types illustrated in Table I. Hitti et al [20] propose a similar taxonomy of gender bias within the text - with two major types, "structural bias" and "contextual bias". Structural bias can be traced down from the grammatical structure, for example, use of gendered pronouns or words in gender-neutral settings. The contextual bias, on the other hand, cannot be directly traced down from grammatical syntax, it is dependent on the context, for example "*senators need support from their wives*" – assuming the senator to be a man.

TABLE I
Gender Bias Taxonomy adopted from [19]

Type	Sub Type	Example
Doughman Taxonomy [19]		
Generic Pronoun	Generic He	The client should receive his invoice in two weeks
	Generic She	A nurse should ensure that she gets adequate rest
	Gendered Generic Man	A Good teachers know how to man the classroom
Sexism	Hostile Sexism	Women are incompetent at work.
	Benevolent Sexism	They're probably surprised at how smart you are, for a girl.
Occupational Bias	Gendered Division of Labor	Professors are men and elementary teachers are women.
	Gendered Roles & Duties	I'll have my girl get you a cup of coffee.
Exclusionary Bias	Explicit Marking of Sex	Chairman, Businessman,Manpower, Cameraman...
	Gender-based Neologisms	Man-bread, Man-sip...
	Gendered Word Ordering	"Men and Women", "Brothers and Sisters"...
Semantics	Metaphors	"Cookie": lovely woman.
	Gendered Attributes	An unmarried male (bachelor) is a "personal choice". An unmarried woman (spinster) is derogatorily an "old maid".
	Old Sayings	A woman's tongue three inches long can kill a man six feet high.
Hitti Taxonomy [20]		
Structural Bias	Gender Generalization	"A programmer must always carry his laptop with him."
	Explicit Marking of Sex	"Policemen work hard to protect our city."
Contextual Bias	Social Stereotype	"Senators need their wives to support them throughout their campaign."
	Behavioural Stereotype	"All boys are aggressive."

B. Studies of Gender Diversity in CS/SE Workforce

A gender-diverse workforce ensures solutions and services are developed from a variety of perspectives and also increases creativity and productivity [21], [22]. Despite this, many industries, including Engineering and Information Technology, suffer from significant gender imbalance in their workforce. According to Sanz [15], the majority of Information Technology (IT) professionals are men. As a subdomain of IT, software engineering (SE) is no different. A report based on 40,000 respondents on payscale.com found that 84.5% of software engineers were men and 15.1% were women [23].

A number of studies have investigated issues with lack of gender diversity and gender bias in CS/SE workforce. Reviews of GitHub, Open Source Software projects and Large Language Models have found that bias is evident across all platforms. Imtiaz et al. [24] investigated gender bias related effects observed in physical workplaces, such as "prove it again", "tightrope", "maternal wall" and "tug of war" on GitHub. They found that women have a lower acceptance rate when they are identifiable as women [25]. Hannák et al. [26] reviewed ratings and reviews given to workers in two freelancing platforms and found that they are influenced by the perceived gender and race of the workers, with women receiving fewer reviews. Sultana et al. reviewed the influence of gender on pull request acceptance, code review interval, and code review participation in the context of Free and Open Source Software development, and found bias exists with women having significantly longer delays for code review [27].

Reviewing the software engineering hiring process, Campero found that women are more likely to be segregated toward software quality assurance jobs [28]. MurCiano-Goroff reviewed a large data set from an online job platform and found that women are less likely to self-report prior programming experiences than men [29]. Wynn and Correl [2] attended 84 recruiting sessions conducted by technology companies who were hunting for talent. They observed that these sessions are often "chilly" to women candidates due to exclusion of women in presentations and discussion, pervasive gender stereotyping, imposing extreme technicality, and references to masculine "geek" culture.

Use of language that is biased towards a gender demonstrates stereotypical views about certain jobs and unfortunately increases the likelihood of gender imbalance in the workplace. It also raises the possibility of losing more competent candidates when language is biased towards the one gender over another. Kanij et al. [30] developed a set of personas informed by the GenderMag approach [31]. The personas indicate that women applicants are interested in information such as type

of the job and prefer to read job advertisements in full. On the other hand, men applicants look for information such as the location of the job and read job advertisements selectively. The personas were then used in a cognitive walkthrough process to analyze SE job advertisements for gender bias, highlighting aspects of SE job advertisements that may be biased towards facets of one gender.

C. Studies of Gender Diversity in CS/SE Education

The majority of research conducted on gender diversity within CS/SE education has focused on investigating causes of bias, and deriving recommendations and proposing solutions to mitigate the bias. There is also a body of research on the impact of gender bias and the interplay of gender diversity within SE student teams. We summarize the relevant research under these themes in the following subsections.

Much research has focused on investigating the presence of gender bias within CS/SE education and most of the time has confirmed that [8], [32]–[35]. Identification of several forms of gender discrimination, such as language used in teaching and learning content, including content in textbooks [8], use of specific gender pronouns [9], and even perceptions of what a Computer Scientist should look like [10]. Medel and Pournaghshband [8] found evidence of CS curricula with a gendered representation of characters presented in the examples used for security, women images used for image processing concepts, and use of gendered pronouns. Some of the identified issues could be easily addressed, such as replacing gender pronouns with gender-neutral ones. Investigating gender bias in Greek textbooks, Papadakis [9] found that some professions e.g. programmer had inherent man connotations. Stereotypical man bias within education content was also found in Swedish and English language [11].

Metaxa-Kakavouli revealed that a stereotypical masculine presentation of the introductory CS course web page resulted in lower confidence, less sense of belonging, and reduced intention to enroll in the course [36]. The influence of gender within SE student teams has been studied in the context of role assignment, leadership and openness [37]–[40]. In pair programming context same and mixed-gender pairs are compared to find the impact on the quality of outcome, confidence, and compatibility [41]–[44]. Results suggest women participate in more project management and requirements engineering work compared to architecture design and Scrum methods, tending more towards lightweight programming tasks over complex ones [37]. In large-scale SE projects, a similar phenomenon was observed where women students assigned themselves to less technical tasks and received lower peer reviews as a consequence of lower contribution [39]. Experimenting with leadership within SE teams, Al-Taharwa found that women-led teams followed better engineering practices, however, achieved lower prediction models [38]. Wolz et al [40] found that women are likely to feel more comfortable presenting their ideas in the team while working with other women.

In a pair programming setting there was no significant difference found in the quality of programming between same and mixed-gender pairs [41]. However, same-gender pairs performed better in terms of communication and compatibility. A similar finding was made in terms of the quality of programming measured with lines of codes produced in a given time [42]. Women feel more confident when they pair program with women [44]. Investigating the influence of the gender of the partner, Jarrat et al. found that having a woman partner was associated with higher confidence in the outcome. However, women students themselves perceived they had lower competence than their partners [43]. Unconscious bias from teachers has also been reported in the literature, with examples of women students considered as less competent [45] and not considered for leadership roles [46].

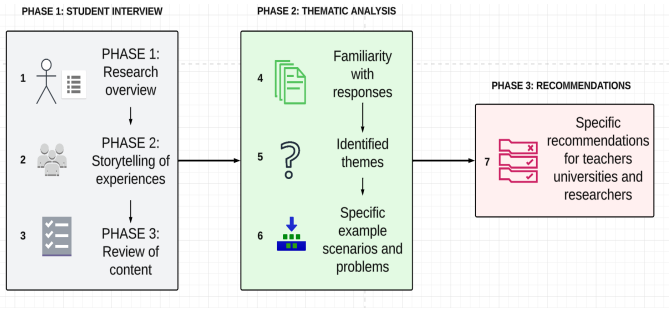

Fig. 1. Our overall Research Process

III. Method

To answer our research questions, we wanted to interview SE students from different universities in *anonymous location*. One major risk of an interview study on a sensitive topic such as gender bias is social desirability bias. This refers to participants providing responses that are socially desirable but not always reflective of their judgment or feeling [47]. To mitigate this risk, we designed the interview protocol inspired by "Interpretative Phenomenological Analysis (IPA)". The IPA is a qualitative research method that is designed to understand phenomena [48], [49]. While the IPA method suggests studying a phenomenon over a period of time, this was not suitable for our research. As such our study was not an IPA study, but drawing inspiration of the IPA method, we designed our interview protocol in a way to study participants "experiences" instead of their perceptions. For example, instead of referring to gender bias directly, we asked "Have you ever felt excluded/lonely/deprived or faced challenges in a CS environment due to any of your characteristics?". The overall process of this study is shown in Figure 1. Our study was approved by the Monash University Human Subject Ethics Committee #38816.

A. Recruitment

Invitation to participants was distributed through social media, student clubs and societies in one university and leaflets were distributed in two universities in *¡anonymous location¿*. We adopted "convenience sampling" which refers to recruitment more guided by participant availability and

interest [50]. While convenience sampling may reduce the generalizability of the findings to some extent by attracting participants who have "interest" in the topic [51], this approach was deemed more suitable given the qualitative nature of the study. We also employed "snowball sampling" by requesting the participants to nominate potential more participants [50].

B. Data Collection

We conducted one-to-one in-depth interviews to understand the perspectives of our SE students on gender bias within their SE education environment. The interview was divided into three phases. In the first phase, we gave the participants a brief overview of our research and motivation and collected their consent and demographic information. Questions included the motivation behind studying for an SE degree. In the second phase, we asked about their experience in SE classrooms, interaction with other students, their teachers, and so on. In the last phase, we presented them with some selected SE education content to review and comment on for perceived gender bias (or no bias). Interviews lasted from 45 to 60 minutes and were recorded and auto-transcribed with the consent of the participants. Participants were offered a small gift voucher as an acknowledgment of their participation.

C. Interview Protocol

The interview followed a "storytelling" format, instead of being driven by a specific set of questions. Our goal was to understand the experiences of the students and then to identify if there was any gender discrimination-related experience reported. The interview started with a brief description of the research motivation, an introduction to the research team, and collecting some demographic information. We moved to "ice breaking" discussions with triggers such as "what made them study the particular SE course" or "how they found interest in *[something they said in the demographics]*". The discussion then slowly moved toward their experience in the classroom, labs, teamwork and so on. Finally, we asked our participants whether they were aware of university initiatives/policies for gender inclusion and the reporting channel/support available if there was a case of "harassment" or any other incident.

D. Example Course Content Selection

We wanted to collect feedback from SE students on example SE course content (lecture slides, assignments, feedback) potentially containing some form of gender bias. The aim was to give us a specific idea of how they perceive gender bias embedded in SE teaching and learning content. The authors of this article have between five to over thirty years of experience in teaching SE subjects. We reviewed a significant body of SE teaching and learning content that they have taught and identified some content potentially having gender bias. We reviewed this gender bias with respect to the taxonomy described by [19] and [20] and included five content types for the analysis. Four of those were lecture slides and the remaining one was assessment material. The five contents were selected from a huge set of teaching and learning content

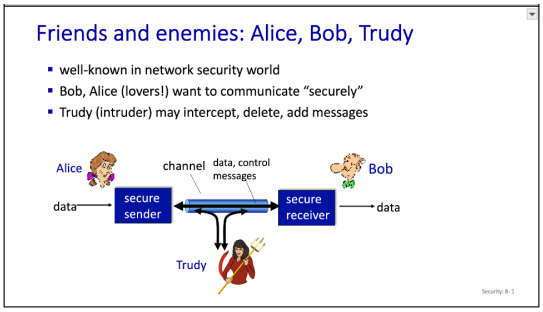

Fig. 2. Test material 1 (TC1)

since we could confirm multiple forms of gender bias in those according to [19] and [20] taxonomy.

The selected SE teaching content was then presented to two expert academics in the higher education context (one of them being the Dean of Diversity, Equity and Inclusion within our Faculty) to review the content and give feedback on potential perceived or actual gender bias. When these materials were presented to our study participants in their interviews, we made no explicit reference to gender bias or types of gender bias. Instead, participants were instructed to review and report any "non-technical" issues found in the content. Due to time constraints, not all participants were presented with all five material examples. They were presented with the selected random content and they could decide how many of those they wanted to review. The contents are described in the following subsections.

Test material 1 (TC1): The first example SE course content was a lecture slide on "Intruder attack", extracted from the Data Communications and Security unit. The slide contains a scenario illustrated with gendered names and images. A woman's image and name "Trudy" has been used to indicate an intruder. The slides originated from one of the most popular books on fundamental network concepts "Computer Networking: A Top Down Approach" [52], which has been criticized in the literature [8]. In researchers' opinion, the slide presents a negative portrayal of a woman character, and presents subtype "hostile sexism" gender bias according to [19] and "contextual bias" according to [20]. The experts indicated similar thoughts on the content and regarded that as "*gender non-inclusive*". One of the experts said: "*white, binary, heterosexual stereotypes. Trudy positioned as an "evil" mistress. Seems to perpetuate gender stereotypes/ topes of good and bad women*". Figure III-D shows this slide.

Test material 2 (TC2): The second test material was a lecture slide on "Firewall", taken from Operating Systems unit. The slide contains a diagram with non-human elements, however, adopted from the famous book "Operating System Concepts" [53], the slide contains images of dinosaurs near the title and the footer. One of the experts concluded that the slide was alright, however, the other expert complained about using the images of dinosaurs which can sometimes be considered as "*stereotypical 'boys' toy*". According to the Doughman taxonomy [19] this is "Metaphor" bias and according to Hitti

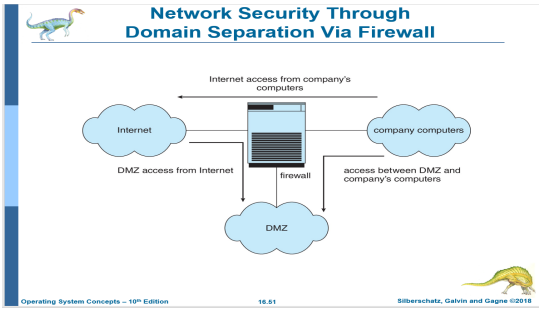

Fig. 3. Test material 2 (TC2)

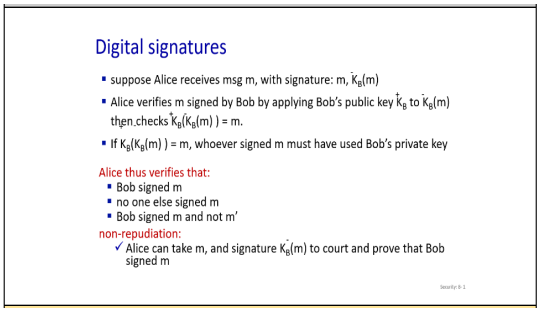

Fig. 4. Test material 3 (TC3)

taxonomy [20], this is an example of 'contextual bias". Figure 6 shows this test material.

Test material 3 (TC3): The third example was a lecture slide on "public-private key encryption" taken from "data communication and security" unit. The slide contains text only, however uses gendered names "Bob" and "Alice" to illustrate an example scenario. This example closely matches with the "Generic Pronoun" category from the Doghman taxonomy [19], however, instead of using pronouns, uses gendered names. Similarly, this is also analogous to "Structural Bias" from the Hitti taxonomy [20]. None of the experts raised any issue with this content.

Test material 4 (TC4): This material was a snippet of study content extracted from the "Software Project Management" unit, that contains a description of Scrum roles such as product owner, scrum master and scrum team and a diagram illustrating the concept. It contains names of scrum roles such as "scrum master" and both gendered pronouns such as "he or she". According to both Doughman and Hitti taxonomy [19], [20] using the terminology "scrum master" is an example of "explicit marking of sex". Although the ordering of pronouns ("he" used before "she") does not belong to any type in either taxonomy. We think that this may also be a form of gender bias. One of the experts also suggested the same: "*He is always listed first*". The expert also said using he and she indicates binary gender, whereas gender is no longer considered as binary. The expert also pointed out the usage of gendered language with "scrum master". The other expert commented that using of neutral pronouns is better: "*I personally like gender neutral pronouns e.g., They instead of he+she - where you are likely to get it wrong at some point. Gender neutral symbols are good*".

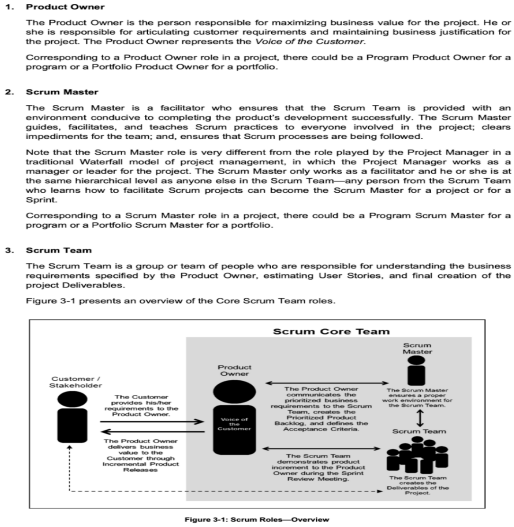

Fig. 5. Test material 4 (TC4)

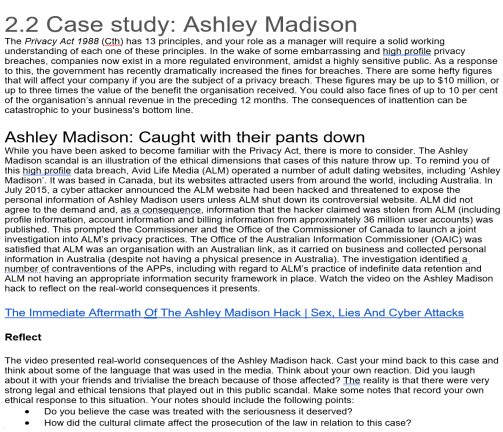

Fig. 6. Test material 5 (TC5)

Test material 5 (TC5): Our final test SE course material was assessment instructions. The assessment instruction contains a description of data breach scenario on the Ashley Madison adult dating website as a case study. The case study is a report with the title "Caught with pants down", supported with a YouTube video link. Both our experts commented that the title was "*problematic*" since it used "*gendered/ sexualised reference*". We conclude that this example closely matches with "Metaphor" from the Doughman taxonomy [19] and "Behavioral stereotype" from Hitti taxonomy [20].

E. Data Analysis

Except for demographic information, all of the data collected in our study was qualitative in nature. We applied a top-down thematic analysis following the steps: (1) reading the responses many times to familiarize ourselves with the data; (2) identifying high-level themes from each response;

TABLE II
SNIPPET OF THEMATIC ANALYSIS

Dimensions	Themes	Example quote	Matching responses
Motivation to study SE	Motivation from school	*...in 11-12 I started doing computer science and while doing computer science I also, you know, watched a lot of workshops, watch a lot of courses on cress, on on Udemy. And then I stumbled upon the topic data science. So that was my key moment that I knew that I wanted to.* (P14)	P1, P5, P9, P10, P14-P17
	Desire to acquire technical knowledge	*...I realized if I use some advanced tech skills something uh coding. So I can do the job better. That's like more than many years ago. And yeah, when after in the COVID during the COVID, I felt like the technology is like growing fast and yeah. So I thought it's amazing* (P2)	P2, P4, P7, P18
	Passion for technology	*I think it was more so the fact back when I was a a teenager, I got I grew inspired with app development and that really gave me the the inspiration to wanting to explore down the path of it.* (P6)	P3, P6, P13
	University	*...the only unit that I like was the intro, the Java unit. So I just decided to change my course* (P8)	P8, P11
	Parents' choice	*My parents actually, they forced me to study computer science*. (P12)	P12
Experience of Gender Discrimination	pro-activeness from men students'/ignoring women students	*...they didn't share it in real time. So it was like if I met them in class, then it was like, oh, can you send me then they'll be like, OK, OK. Yeah, we'll.* (P18)	P14, P18
	Marking women students down	*For the marking, some rumor or some like exist, like not probably different tutors with different criterias and sometimes we just need to like appeal or just like to see anything. Sometimes we can, like, improve ourselves from the communication, from the remarking we learn some something.* (P2)	P2, P3
	Behavioural issues of men students	*One instance with someone and even myself as well, where they've been some like obsessive people like they, I don't know, feels like out of interest or something, but like they wouldn't leave us alone. Both me and like my female peer.* (P14)	P14

(3) reviewing the themes to group similar ones together or to divide one theme to multiple; and (4) particular responses under the themes were reviewed to identify and list unique example scenarios and problems reported in those. A snippet of the thematic analysis is presented in Table II. Demographic information is reported with descriptive statistics and the qualitative analysis results are reported with the themes.

IV. RESULTS

We interviewed eighteen (18) participants studying different SE courses and subjects in two well-known universities in Melbourne, Australia. The demographic details of the participants are summarised in Table III. There were eight (8) woman participants and the rest identified as men. The majority of participants were between 18 to 27 years of age, with three elder participants (38, 45 and 62 years). Participants studied in a variety of Bachelors or Masters courses. 11 had a major SE focus (BE(SE), BIT, BCompSci, BCompSci(Hons)). The other 7 had AI or Business focus, but included SE subjects (programming, project management, business analysis/requirements). We asked them to indicate their ethnicity (the shared cultural heritage or identity); however, the majority of the participants (except P1, P3, P15 and P18) indicated their nationality (the country of origin or citizenship). We report this as "Ethnicity/Nationality" in Table III.

TABLE III
TAXONOMY ADOPTED FROM [19]

Participant	Age	Degree	Year	Gender	Ethnicity/ Nationality
P1	21	BcompSci	Second	Man	Pakistan, Islam
P2	45	Master in Data Science	-	Woman	
P3	38	Master In AI	-	Woman	Southeast Asia
P4	62	Master in AI	-	Woman	Australian
P5	19	BcompScience	Second	Woman	Asian
P6	21	BInfoTech/BSc	Third	Man	UK
P7	23	BBus/BInfoTech		Man	Australian and New Caledonian
P8	21	BCompSci	Second	Woman	Chinese
P9	20	BCompScAdv(Hons)	Third	Man	Chinese
P10	22	BCompScAdv(Hons)	Fifth	Man	Filipino
P11	21	BE(Hons)	Third	Man	Chinese
P12	21	BBus/ BCompSci	Second	Man	Bangladesh
P13	18	BCompSci	First	Man	Australian Canadian
P14	20	BInfoTech/BA	Third	Woman	Filipino, Born in New Zealand
P15	18	BCompSci	First	Man	Indian, Hindu
P16	25	BinfoTech & Cybersecurity	Third	Woman	Srilanka
P17	19	BCompSci	Second	Man	India
P18	27	Master's in Business Information Systems	First	Woman	India, Hindu

A note on terminology used – we use 'man' or 'men' and 'woman' or 'women' gender terms. Many participants used 'male' and 'female', which we preserve in their quotes, though these are technically biological sex terms. We have not used non-binary or other different gender terms unless they were specifically identified by participants. We acknowledge that this is a weakness in the wider gender inclusivity of this work.

A. Motivation to Study IT

Eight participants (P1, P5, P9, P10, P14-P17) specifically mentioned that they were motivated to study SE/computers/programming/technology from school. One participant (P15) said they developed a "passion for technology" from grade six. P10 started elf learning, P15 started Python programming and P16 started gaming from grades 11-12. P14 said she had a curiosity for technology and the "all girls" school she attended, encouraged a lot for science and maths, however, not that much for technology. Four other participants said their motivation was to acquire knowledge such as: "advanced tech skill" (P2), "Quest for Knowledge" (P4), "know business and technology perspective" (P18) and "Interest for digital asset and blockchain" (P7). Three other participants

also mentioned their interest/passion for computers (P13), app development (P6), and mathematics (P3) brought them to CS, however, they did not mention school. Two participants said this was not their first choice, however, one started liking Java programming in an Engineering degree so migrated to SE (P8) and one decided after coming to university (P11). P12 said they studied CS as a result of "Parents' choice". P18 said they expect a better work-life balance in professional life.

B. Experience of Gender Discrimination in SE Courses

Since each interview followed a free-form storytelling format, participants shared many different experiences in their classroom. From those, we report the experiences that were related to gender dynamics. Three distinct themes were identified from the experiences: "pro-activeness from men students', "marking women students down" and "behavioural issues of men students". There were also some examples of "contribution in a teamwork", however, those could not be strongly linked to gender dynamics.

Two women participants shared their experience when the "*proactive attitude*" of men students made them feel excluded. P14 said some men students talking about "*coding accomplishments outside of uni*" made her "*gravitate towards female students*". P18 reported an experience of working with men students in a team project, where documents were not shared even after requests. She also noted that she waited to be assigned to some work. However, all other students proactively self-assigned themselves and nobody assigned any work to her.

Two participants (P2, P3) shared another experience that was: "*rumours of marking women down*". P2 and P3 said they had heard about this happening (P2 on a specific instance, P3 heard it at a conference). One woman participant (P14) described several experiences where she felt "*uncomfortable*", including: "*male students not leaving the women students alone*", "*male students not respecting personal space*", "*male students sitting too close to female students*", and "*male students inviting for dates*". She said this does not happen among friends, however during the initial time, women students experience these: "*I remember during first year like that was like a really weird experience that like me and my friends all went through at*". She also mentioned that coming from a girls' school, this was a new experience, and she eventually stopped attending the classes where this happened: "*just because I've never, you know, like I went to an all girl school I had no that's never something I went to before and especially because lectures were all online. All I did was just remove myself from the situation and I did fine because all the content is just replicated online*".

One man participant (P1) shared an experience of teamwork where he found a woman student putting in *"extra effort"* despite challenging circumstances. Another counter-example was shared by a woman participant (P8) who said a woman student was not responding and eventually disappeared from the team: "*So just went missing and not replying...*".

C. Awareness of Support

Almost all the participants were aware of available support in case of emergency or any severe incident (except P3 and P4 did not provide any clear indication). The majority of the participants were aware of different "inclusion advancement" initiatives taken by their universities. They mentioned different "diversity clubs" (P1, P5-P7, P9, P12-P18). One participant (P14), showed her frustration with the "diversity clubs" and questioned whether university efforts to advance inclusion were genuine. The following comment is an example of this: "*I think the most recent thing I can think of was on like ... the third week of UNI, the IT faculty decided to do like a little showcase of all the IT clubs and things like that as well and had their designated area 2 tables ... which are the like, the faculty initiative clubs for like diversity and stuff would put into a corner in not even a table. It was like a little circle thing. I think that just really showed that they don't really care that much and it's kind of just like a name thing...*".

RQ1. Experience of Gender Bias: No man participants reported any instances when they felt "excluded". However, two women participants reported some experiences where they felt excluded due to the particular behaviour of men students. Two participants reported rumours about marking women students down. Any bias reported by our participants was against women, and there were no instances when any bias was reported against men students. These findings are no different than the existing body of research reporting on the presence of gender bias against women in CS/SE education [8], [32]–[35]. The two major causes of feeling "excluded" or "uncomfortable" by the women participants were the "behavioural aspects of man students" and "discrimination in assessment by the teacher". The proactive approaches or particular behaviour of men students resulting in "exclusion" for women students have not been reported in the literature. Discriminatory approaches from teachers got some attention from the research community [12], [45], [46]. Instances of direct discrimination such as "marking down" were not found in the studied literature.

D. Review of Example SE Teaching materials

Our example materials were selected randomly before presenting to the participants, and not all participants provided feedback on all contents that were presented to them. We thus obtained different amounts of feedback on each example course teaching material. Some form of gender bias was reported by our participants in four of the test materials (TC1, TC2, TC4 and TC5). Figure 7 shows the number of feedback we received on each test material. Table IV summarizes the feedback of the participants vs the expert reviews.

Feedback on TC1: Eight (P1, P2, P5, P7, P8, P11, P12, P15) participants provided feedback for TC1. The majority (P1, P2, P5, P7, P11, P15) indicated concern about gender roles assigned to the images used. The following example comment indicates this sentiment: "*giving an example where one gender looks wrong, with a devil stick and tail, doesn(')t seem right. but it is interactive and grabs the attention* " (P1). Two (P5, P15) of them said image of "Trudy" holding a

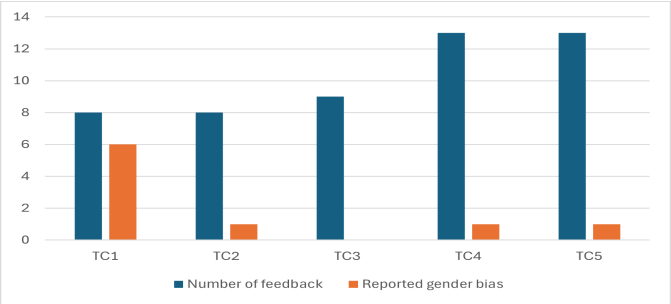

Fig. 7. Summary of feedback received on the test materials

TABLE IV
SUMMARY OF TEST MATERIAL

Identifier	Type of bias	Expert Review	Participant Feedback
TC1	Hostile sexixm [19], contextual bias [20]	Gender stereotyping with the example	Gender stereotyping, inappropriate example
TC2	Metaphor [19], contextual bias [20]	Use of gender stereotypical images	Use of stereotypical image and colour
TC3	Generic Pronoun [19], Structural Bias [20].	No comments	Comment on format and content, nothing specific to gender
TC4	Explicit marking of sex [19], [20]	Use of gendered language, pronouns indicate binary gender	Suggested improvements to the content and the image, binary gender used, "scrum master" image is perceived as "man"
TC5	Metaphor [19], Behavioral streotype [20].	Use of gendered/sexualized language	Use of gendered language, feedback on the content

"*weapon*" (P15) is not "*appropriate*". One of them said apart from gender bias this can also offend people of certain beliefs: "*The devil character could offend someone if they have a certain religious belief*" (P7). Two (P7, P11) of the participants thought "Bob" and "Alice" referred to as "lovers" in the example is inappropriate, one of them said: "*Alice and Bob being 'lovers' may not be appropriate for the classroom as it depicts a heterosexual relationship which is not inclusive of all students*" (P7). Two (P5, P15) of the participants specifically suggested how the images could be improved, one of them suggested using "stick images" (P5) and the other participant suggested using: "*a mischief emoji or an image with two hands rubbing each other, etc*" (P15).

Feedback on TC2: Test material 2 (TC2) was reviewed by eight (P1, P2, P6, P7, P8, P11, P12, P15) participants. Three (P7, P11, P15) questioned the use of the "dinosaur" image. One of them said the image is a stereotypical image: "*...use colours and pictures (blue and dinosaurs) that when I was growing up were stereotypical interests of a 'boy'*" (P7). Two (P2, P6) explicitly appraised the content as "gender-inclusive". Two (P8, P12) participants said "more information" should have been presented in the content. One participant said content was "*clearer, more simple*" (P8). Another participant said the content was "*Less interactive*" (P1).

Feedback on TC3: We received nine (P3, P4, P9, P10, P13, P14, P16, P17, P18) responses on TC3. Four (P4, P10, P13, P14) liked the content, expressed with various sentiments: "*better use of spacing and colour*" (P13), "*spaced out sections*" (P10), "*red underlines are gone in the mathematical expressions*" (P10), "*make their points very clear*" (P14) and "*better cognitive load*" (P4). However, four (P9, P14, P16, P18) complained about the fonts, formatting, and overall layout of the content: "*The text is very slim in comparison to the given space - could've utilized more of the space (width)*" (P14). One said pictures would have been more helpful: "*...hard to understand only with words, pictorial representation of a digital signature will be eye-catching and easier to understand I feel*" (P18). One (P17) said there were no issues with this content. Another (P3) said the content was somewhat confusing since this is talking about public and private keys in the same slide. None of the participants indicated anything related to gender bias in this content.

Feedback on TC4: Thirteen (P1, P2, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P16) participants provided their feedback for TC4. The majority (P1, P2, P6, P8, P9, P10, P13, P14, P15) provided a positive review about the content: "*Very well structured, does not feel intimidating*" (P6), "*small topics, easier to read and make sense of*" (P8), "*All the information is well laid out*" (P13), " *The inclusion of the image sums up one of the points and is better than reading a paragraph or watching a video*" (P13) and so on. Two participants complained about the size of the text in the content: "*the less reading the better*" (P11) and "*May not be easy for people who do not like reading large chunks of writing*" (P6).

Two participants said there was a lot of text within the diagram itself: "*The visual provided has too much writing and put me off from reading it after a few seconds*" (P6) and "*It would've been better if they wrote less within the figure to simplify it further*" (P14). One also suggested the following simplification in the diagram: "*...possibly by having a title of the person they are representing and then a small sentence following*" (P14). One participant picked the pronouns used and indicated those were binary: "*only uses 'he or she' pronouns which could be offensive to people who use other pronouns*" (P7). They said the scrum master image can be perceived as "male" - "*Scrum master image only contains characters that society has typically perceived as a 'male'*".

Feedback on TC5: Thirteen (P1, P2, P5, P7, P8, P9, P10, P11, P12, P13, P14, P15, P16) participants reviewed this test material and twelve (except P2) provided their feedback. Some (P8, P9, P10, P13, P14, P16) had concerns about the presentation. One thought the case was not treated with due "*seriousness*" (P2). Two (P1, P12) gave positive feedback about the content, including "*interactive*" (P1) and "*real world case*" (P12). Three (P7, P11, P15) mentioned the title was inappropriate. One of them explicitly specified this can introduce gender-related bias -"*...seems to have sexual connotations in 2 instances 'caught with their pants down' and the title of the youtube video. People who are struggling with their gender identity may find this offensive when other terminology could have been used*" (P7).

RQ2. Perception of Gender Bias within SE Teaching and

Learning Content: Participants identified several perceived instances of gender bias in the example course content, and proposed several improvements to address these. Gender-related issues identified were: "use of stereotypical examples", "use of stereotypical images and colours", "use of gendered languages" and "use of binary gender". The use of stereotypical examples and images (women portraying negative roles) has been identified in the literature [8]. However stereotypical images (mostly icons), such as "dinosaurs" and "scrum master" icons in the content are new findings. Avoiding gendered pronouns, or using gender-neutral pronouns was suggested by Papadakis [9], however, our example content had "he or she" - that raised the issue of using binary gender language only. The fact that the icon used for scrum master in one of the example contents could be perceived as a man reflects the perceptions of what a Computer Scientist looks like [10].

E. Participant Recommendations

While discussing their experiences students proposed several suggestions for their universities. These include suggestions related to improved experience (quick response time (P6, P11), improved disability service (P6)), better engagement (icebreaker games (P10), better interaction (P9, P10), and so on. Since the focus of the research is gender inclusiveness, we present the suggestion related to that in detail in this section. Two participants (P2, P4) emphasized on having more "female teachers". P4 encouraged to have more women teachers in technical units, so that: "people start to take her as an inspiration to do better". P2 said "*...And yeah, because I feel very comfortable to, like, communicate to the woman coordinator. I can, yeah. So luckily*". Four participants (P7, P14-P16) suggested that universities should promote diversity. P7 said: "*Encourage women to STEM*", P15 said: " *encourage girls at the school to take up coding or CS*" and P16 said "*maybe like a scholarship scheme for Aboriginal women and non-binary people, something like that*". P14 however, suggested that the diversity and inclusion clubs should be given more priority.

RQ3. Suggestions for Improvement: Our participants made three major recommendations to improve gender diversity within SE education. Increase the number of women teachers so that they can be role models/inspiration for others, and that women students may feel more comfortable in communicating with women teachers. Encourage young women into SE, including by providing scholarships to non-binary students and First Nations young women. They suggested giving priority to diversity-related clubs and initiatives. Participants made several recommendations to make SE teaching and learning content more gender inclusive: replacing images of humans/avatars with stick images or emojis, avoiding stereotypical images and colours and using gender-neutral or plural icons.

V. Recommendations

We summarise key recommendations for SE teaching environments drawing from the suggestions made by the participants where possible. Figure 8 presents a mapping of our the recommendations for each scenario and problem and some general suggestions made by our participants.

SE classroom and teamwork environment: Four scenarios were identified under classroom and teamwork contexts. In the classroom the problematic issues were the "proactive approach of men students" demonstrated through talking about project accomplishments outside of study and not respecting others' personal space. In teamwork settings, men students not sharing documents and self-assigning tasks to themselves were the issues. In both cases, nothing specific was proposed by the participants to overcome the scenarios. We believe that these issues are related to behavioural aspects of the men students, that most of the time could be unintentional. As a consequence, men students may not be aware that some of these behaviors make women or other minority groups feel "excluded". We recommend that during orientation or the first few days of study, men students could be given a small information booklet or interactive brief training to develop awareness about this.

Assessment: One scenario found was a perception of "marking women students down". The stereotypical thinking that men are more capable (especially within STEM subjects) resulted in this scenario. We need to educate teachers to believe in the competencies of women or other minor gender students. We also propose that assessments be marked by multiple teachers when possible to alleviate unconscious bias.

Teaching and learning content: When presented with specific example course content, participants identified problems in many and in some cases, suggested improvements. The major theme was using ***stereotypical images, icons and colours***. The suggestions from the participants were very helpful, such as replacing images with stick images and emojis. They even provided some examples as well: "*you could have used a mischief emoji or an image with two hands rubbing each other, etc.*" (P15). The use of blue colour and a man-looking icon for scrum master were some other problems identified by our participants. We suggest that these stereotypical colours and icons be avoided wherever possible. If icons need to be used, those should be gender-neutral or used in the plural to indicate multiple genders. Use of ***gendered language*** included case study title indicating gender and the use of binary pronouns excluding other genders. We suggest avoiding SE case studies or content with any gender reference and using gendered pronouns. Use of ***non-inclusive language or relationships*** included a participant indicating that "Bob loving Alice" in one example could be disliked by people with heterosexual relationships. We suggest that references to human relationships should be avoided as examples. The use of "Scrum Master" both suggested man gender and has become unacceptable as a reminder of slavery [54]. We recommend the agile development community rethink the title of this role and if possible rename it to something more gender-neutral. We recommend review of all non-inclusive terms used in SE roles and practices [54].

Universities advancement of gender diversity: Our participants suggested that more women teachers would be helpful,

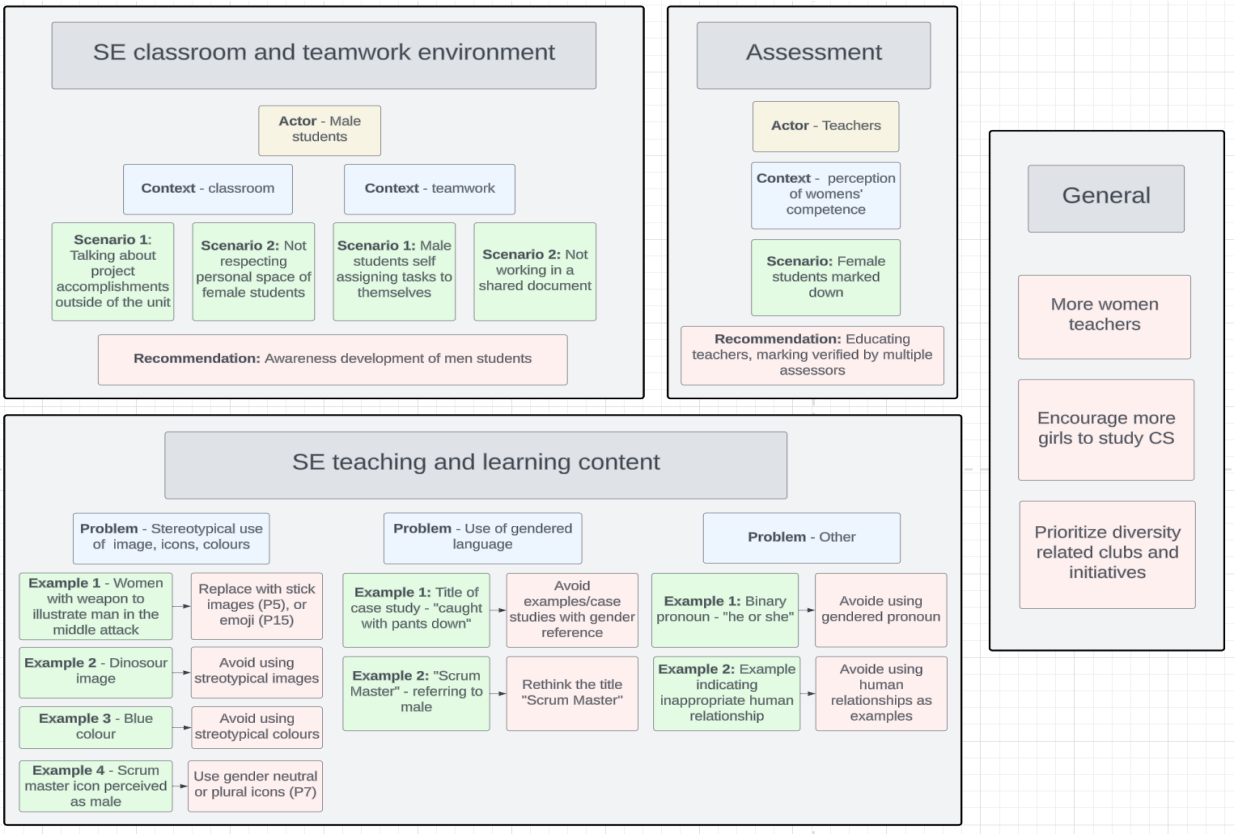

Fig. 8. Recommendations from analysis of our interview data.

especially in technical SE units. They said young women could be encouraged from school to study SE, and that diversity-related and student-lead SE clubs and other initiatives should be given priority to support by universities. These include educating SE teachers to overcome unconscious bias related to minority gender student's competency in SE subjects.

Recommendations for researchers: Our study suggests several directions, including a rethink on SE terms like the title of the Scrum role "Scrum Master". More research on awareness development to improve behavioural aspects of men students in SE courses, and further research on identifying efficient ways of educating SE teachers to avoid unconscious bias would be helpful. Finally, development of automated tools for assessing teaching and learning contents based on some our recommendations would aid teachers in ensuring inclusiveness of their teaching and assessment content.

VI. Limitations

A common threat to validity of research on sensitive topics such as "gender discrimination" is "social desirability" bias. To try and avoid such bias we designed the interviews inspired by the IPA method and followed a simple storytelling format. Participants shared their lived experiences as well as experiences they had heard of or seen from others. A potential threat is participant responses biased towards the topic of research. At the beginning of the interview, participants were given a detailed description of the research motivation, researchers' interest and a brief state-of-the-art research on gender inclusiveness. This information can bias the participants to focus (or even exaggerate) on gender-related issues. However, the diverse responses we received indicate that this was not the case. Our study participants discussed their experiences, without focusing on gender dynamics at every instance. Our study was limited to 18 participants from a range of different IT courses, some with more SE content than others, and limited to two Universities in a single country. Further studies with greater numbers, more diverse students, a greater number of SE courses and subjects, and other countries are needed.

VII. Summary

Software engineering education and workforce have been dominated by people identified as men. We aimed to better understand specific gender bias scenarios and experiences from the lived experience of SE students. We identified five gender bias scenarios within the SE education environment and eight specific problems within SE education contents. We propose a set of recommendations for universities, teachers, and researchers, drawn from lived experiences and perceptions of these students. We plan to confirm the findings by replicating the study on a larger scale. We plan to address a major limitation of not having any non-binary gender participants, to find scenarios and issues specific to their challenges.

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