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Gender perspectives on a flipped classroom environment

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Abstract: The present paper investigates the gender perspective of flipped classroom. In particular, it considers how the collaborative setting of in-class group-work affect the female population of students. The paper draws on an in-depth analysis of the interview with one such student. The focus of this interview was on interactional collaboration between peers during group work activities in a mathematics course. Such work is vital in a flipped classroom arrangement. The student, called Sofia, highlighted arguments of value for a deeper investigation. The analysis draws on Bjerrum Nielsen's framework with four different gender perspectives (2003). Our analysis illuminates a number of arguments about interactions and interpretations of gender and challenges when collaborating in groups in a flipped classroom setting. Arguments informs both context and individual levels of the setting. What is realised in the case of Sofia is that there are dualistic viewpoints raised within all gender perspectives, sometimes conflicting each other. Result is that guidance from a teacher in formation of groups is necessary but will need careful considerations.

Subjects: Educational Research; Higher Education; Gender & Sexuality

Keywords: Gender; engineering students; flipped classroom; collaboration in groups; mathematics

Introduction

According to World Economic Forum, Norway is third best in the world to gender equality, having closed nearly 85% of the gender gap (WEForum, 2021). The gender gap measures differences between genders in health, education, work and politics, and shows that Norway has reached far when it comes to equality between genders—also in education levels. However, there are differences between professions, and the percentage of female students in engineering educations is rather low; 20,7% in (DBH, 2021 (DBH)). If looking particularly at computer science engineering educations the number is even lower; 15,9% female students. Thus, female students are underrepresented in this field, and their views and reflections ought to be taken

ABOUT THE AUTHORS

Ragnhild Johanne Rensaa is professor of mathematics at The Arctic University of Norway. Her PhD from the Norwegian University of Science and Technology is in mathematics and her research interests are in mathematics teaching and learning of engineering students. She has a particular focus on teaching and learning of linear algebra, which is an important branch of mathematics and an important subject for engineering students.

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into consideration to facilitate the education. Discussing what such reflections may inform about is a main aim of the present paper, drawing on feedback from an investigation on computer science engineering students in their first year of studies at a university in Norway. In a class of 25 students, four were women and among these were student Sofia. In an interview she gave some reflective views on her relation to male students in a flipped classroom (FC) setting. Since FC is a teaching format increasing in use, it is valuable to lift forward gender issues to raise the awareness about more gender-friendly organization of such classrooms. This is what the present paper is about, drawing on the analysis of the in-depth interview with Sofia.

Expecting students to prepare before coming to class has been done within the academic tradition for decades, thus it represent an old academic activity (Wan, 2015). Earlier this presumed reading of some designated texts in advance, while lately it is more about utilizing digital medias like teaching videos and computer algebra systems. The running of the in-class part of FC, however, is rather new. It is a teaching approach where students are expected to take responsibility and drive the problem-solving activities, with the instructor as facilitator and guide (Stephan, 2014). In a mathematics course, from which the present investigation is taken, students work in groups with mathematical tasks. In such activities, the interactions between members of a group are important. Interactions presumes activity with students taking part and contributing to the scientific discussions. This activity, however, may vary from student to student, based on each individual's interpretation of the setting but also view of self and of own capacity in this setting. It is related to self-evaluation, which is not only a question about obtained grades but also about apprehensions in relation to a context (Devos & Banaji, 2003). In this perspective, gender issues may play an important role since research has reported that boys more often rank themselves as better than girls (Fredricks & Eccles, 2002).

The present paper explores the intersection between the above issues as it focuses on interactivity in a gender perspective, interpreted in the context of a FC arrangement in a class of computer science engineering students. By analysing the interview with Sofia, drawing on Bjerrum Nielsen's four gender perspectives (Bjerrum Nielsen, 2003), we let a female student's voice clarify what challenges there may be in in-class group-work where males are overrepresented. By this we seek to illuminate what gender challenges there may be in an FC design and suggest what could be done to meet these challenges. The following research question: Based on perspectives of a female computer science engineering student, how may the social construction of gender illuminate the collaboration during group work in a flipped classroom environment in mathematics?

We start by relating the investigation to literature and give the methodology, both utilizing four different gender perspectives described by Harriet Bjerrum Nielsen (Bjerrum Nielsen, 2003—to be presented); structural, symbolic, personal and interactional gender. Then, results of the analysis are presented, raising arguments for a discussion on what challenges there are and how these may be met.

1. Literature and conceptual framework of the study

The literature rests on three parts. On the general level, the research takes place in a mathematics classroom in a computer science engineering class, which sets the frame for the investigation. On the specific level, the focus is on gender in a flipped classroom and both gender perspectives and flipped classroom arrangements need to be elucidated. Before doing this, a clarification is needed. The notion of *gender* is taken to be more than a biological sex. It has sociological aspects involving socially constructed differences between women and men, including what they do and how they interact (Acker, 2006; West & Zimmerman, 1987). This is in line with the historic transition in use of the gender terminology in debates (Wedege, 2007).

Engineering educations in general have an underrepresentation of female students, in most programs even a strong underrepresentation (Powell et al., 2012). This is by researchers referred to as the "woman problem" (Lagesen, 2005). It points to the exclusion of women in both science and engineering, despite the fact that in most academic settings female students are in majority. This

overrepresentation in academia is clearly not transmitted to science and engineering, which is found strange by researchers (Lagesen, 2005; Quinn, 2003). It is particularly problematic for information technology in which lack of women in western countries is eminent (Mellström, 2009). Sax and colleagues draw on US national data on incoming college students over a period of 40 years to conclude that while engineering programs have become more popular, men's interest rise faster than women's (Kanny et al., 2014; Sax et al., 2016). The researchers' focus on students' intentions to major in engineering and trends reflect a longstanding and substantial underrepresentation of females in engineering. This unequal division between genders is especially current in information technology studies (Mellström, 2009). Explanations may be that these learning environments are not women friendly (Henwood, 1998; Siann, 1997), stereotype threats may influence performance (Corbett & Hill, 2015), but also females' persistent underestimating of own mathematics abilities (Sax, 2008). The situation in Norway shows a similar minority of female students in engineering educations with even smaller numbers of females in computer science education (DBH). There are trends pointing towards a shift as female's traditional reasons for not pursuing an engineering degree including low math confidence, less theoretical orientation and greater commitment to social activism loose traction (Sax et al., 2016). Still, this varies across fields, and gender gaps in computer science engineering is still large.

When discussing a female student's interpretation of the collaboration during group work, gender aspects may be important. This is illuminated for instance, by Connell (2006). She points to gender as the positioning of women and men in social relations in which they negotiate the cultural meanings of being women or men. This view of gender as a social construction forms the theoretical frame of the present study. It draws on Bjerrum Nielsen's four different gender perspectives (Bjerrum Nielsen, 2003), derived through her studies of gender in scouting. Her framework, which we name the BN-framework, includes both interactions and interpretations of gender, thus suitable when focusing on the collaboration during group work in a flipped classroom teaching format.

The first gender perspective described by Bjerrum Nielsen is structural gender. In this perspective, gender is interpreted in relation to the social structure that the women and men are working in. In the present case, this is a computer science education environment. Such environments seem to have achieved equality and accessibility to all who choose this career path, but at the same time a so-called masculine work environment persists (Powell et al., 2012). This is supported by Logel and colleagues' study of female engineering students' perception of the field, showing that these students experienced social identity treats as minorities in the field. This made them perform lower on engineering tests as a result of interactions with sexist colleagues (Logel et al., 2009). Some researchers problematize the fact that women in STEM-educations (Science, Technology, Engineering and Mathematics) more often leave the STEM pipeline than male peers. This happens at all levels of their education (Ellis et al., 2016). In the Ellis' study, a lack of mathematical confidence among the female students is suggested to be a reason why the odds of women to leave their study after a mainstream calculus course—which is part of any engineering education—is 1.5 times greater than for men (Ellis et al., 2016).

The second gender perspective in the BN-framework (Bjerrum Nielsen, 2003) is symbolic gender. It refers to structures like symbols and symbolic discourses that tell what is normal in a society. This develops in time as structures are set over a longer period. A masculine work environment (Powell et al., 2012) may in due time establish what is normal in the society, with technology associated with masculine values (Mellström, 2009). Lagesen (2005) problematize the lasting idea of a comprehensive masculine culture within science and engineering, a culture prevailing time and space. A stereotyping of engineering and technology implies that women that enter these studies have to be able to resist cultural norms on an individual level. In computer science engineering educations the masculinity may be even more standing than for engineering educations in general since computers are more likely to be regarded as "boy-toys" with masculinity associated with passion for technology (Ivančević et al., 2013; Ottemo, 2016). However, in her

study of conception of gender at secondary school level, Sumpter (2012) found that there is a gap between what is gender stereotyped beliefs, downgrading female students' abilities of reasoning in mathematics, and beliefs from an individual perspective where female students hold such stereotypes to be false (Sumpter, 2012). Thus, social and individual perspectives may differ, underlining the importance of considering both.

A third perspective, personal gender, is about how each individual see gender as a personal matter. Individuals shape their lives within the structures and cultural norms that they live in, a dynamic and ongoing process. It is about how we fit—or not fit—into symbolic models of gender (Bjerrum Nielsen, 2003). A female student's choice of education may be due to her gendered identity (this is something I have in me to do) and it may be her gendered subjectivity (this is something that is meaningful to me, this is who I am). Weber's research on perceived personal capacity among 556 middle- and high school students (Weber, 2012) shows that the female students indicated lower levels of personal capacity in technology- and engineering-related activities despite taking part in technology and engineering courses. It indicates a missing identity with engineering activities, thus with the profession. Most female students in Weber's study did not want to study to become engineers based on their view of engineering activities, often stereotyped to be masculine (Weber, 2012). Adding to this, the Ellis-study referred above shows that among US females who actually enter a STEM-education, the dropout rates are larger by female students than by male students (Ellis et al., 2016). Ellis and colleagues compare mathematical abilities and preparedness between male and female students, and conclude that reasons for the high dropout rate among female students were lack of mathematical confidence more than lack of mathematical ability. In a Nordic perspective, investigations of first-year engineering students' task performance in mathematics show that female students have higher demands on learning goals for themselves than their male peers (Tossavainen et al., 2021). In UK, Solomon's study reveals that the perception of oneself as a successful learner in a community may make a student unworried about lack of own participation in mathematics (Solomon, 2007). This type of identity is noticeably gendered as the male students in Solomon's study held this view. The female students, to the contrary, tempered with an identity of marginalisation (Solomon, 2007). This is about how these students see themselves and judge their own capacity by self-evaluation (Devos & Banaji, 2003). It is not only about grades, merely about how they perceive themselves related to the context of which they are a part. Confidence in own abilities is also a part of the results obtained by Pelch (2018) in his investigation of academic emotions among students interested in STEM degrees. The three categories that were reported most frequently in female students' statements were aligned with personal interaction, high student anxiety and negative self-image. Male students, on their side, contributed most frequently with statements about active learning and group studying, but also about satisfaction with own course performance (Pelch, 2018). An explanation may be that male students avoid discussions about emotions while female students bring such themes to the fore and—according to Pelch—females more often express themselves in negative words about their feelings .

The fourth and final gender perspective given by Bjerrum Nielsen is interactional gender (Bjerrum Nielsen, 2003). This is about interaction between individuals, viewing gender in terms of actions and what we do rather than what we are. It is something that develops through negotiations between individuals. In Pelch's study (Pelch, 2018) on academic emotions of male and female STEM majors, statements about the importance of personal interaction were highly emphasized and came almost exclusively from the female students. Particularly for engineering students, Sahin (2010) argues that team work is important since social skills in the workplace of an engineer is vital. He lifts forward problem-based learning as a rewarding pedagogical design to encompass both group working skills and a variety of other abilities like being able to communicate and readiness to self-direct the learning. Sahin concludes that a problem-based working method gives significant higher conceptual learning gains with freshmen engineering students (Sahin, 2010). In a flipped classroom arrangement, interactional work with peers during group-work activities is a vital part of the educational design. A gender perspective on interactions in FC adds to this as the social interaction between

members in the group work is about negotiating each member's action and role in the group-work (Wedege, 2007). An example of such negotiations taken from engineering educations is given by Tonso (2006) in her study of the culture on a US campus. The engineering students' positions, be it nerdy, hardworking, sporty or slack, were carried into students' group work activities and did thereby play an important role for the students' emerging identities as engineers (Tonso, 2006). In group work interactions it may also be challenging when male students' belief in themselves as learners make them relaxed towards lack of own participation in mathematics (Solomon, 2007). Contribution levels between male and female student may then be different.

In her presented framework of "doing gender", Wedege draws on Bjerrum Nielsen's work and illuminates the structural, symbolic, personal and interactional perspectives by results in Danish and Norwegian papers given at Nordic gender/women and mathematics conferences (Wedege, 2007). Wedege emphasizes that the four perspectives are not separate and pointing to different situations, they represent different points of view to look at the same situation. The Flipped Classroom (FC) teaching format is designed as a combination of students preparing before coming to class and in-class activities aiming to facilitate for students to explore topics in greater depth by interacting with each other (Bergmann & Sams, 2012). However, as pointed to by Fredriksen and Hadjerrouit (2020), most research perspectives on FC are put on students' attitudes and performances rather than on pedagogical and didactical strategies (ibid. p. 20). In particular, attention to in-class activities seem to be of vital importance for a successful implementation of FC. Hamdan and colleagues (Hamdan et al., 2013) point to the shift in "Learning Culture" as one of the pillars of Flipped Learning. This shift consists of moving away from a teacher-centred model, where the "teacher is the main source of information" or the "sage on the stage", towards a collaborative learning arena, "where in-class time is meant for exploring topics in greater depth and creating richer learning opportunities" (Hamdan et al., 2013, p. 5). In most cases, the teacher seeks to implement the collaborative learning through various forms of group work. As have been highlighted earlier, gender may be an issue in such settings. Since the social interplay between peers in the FC in-class learning arena is of vital importance for the success of this pedagogic framework, a focus on gender is thus important.

2. Method

2.1. The origin of the data

The data of the present study originates from a study by the second author, having focus on dialectical contradictions, students' participatory qualities of learning, in-class tasks and affordances/constraints in a flipped classroom setting (Fredriksen, 2020). A variety of data was collected in this project, including interviews with some of the students in class. When these were analysed, it became clear that one respondent brought forward reflected thoughts related to gender. Since gender issues were out of range for the study by Fredriksen, the second author shared the data with the first author, knowing that gender issues had shown interest to her earlier (Grevholm & Rensaa, 2017). She took these data further. This underlines that the questions asked during interviews were not aimed at gender issues and the topic was introduced unmotivated by the interviewee. Details about the interview design and FC arrangement may be found in (Fredriksen, 2020). A part of this work identifies students' participation in mathematical problem-solving during class attendance, a vital focus when asking what makes FC efficient or not. Gender aspects are indisputable a part of this, and the present discussion addresses this issue.

2.2. Research setting and method

The cohort of students from which the present interview is taken was following a mandatory 10 ECTS mathematics course in calculus with a small linear algebra part. Four out of 25 were female students. The second author of the paper was teaching this class. In line with the principles of FC, the teaching was split in an out-of-class part where students were required to prepare for the teaching in-class through videos and quizzes (Bergmann & Sams, 2012). For the in-class part, a rule imposed was group-work where students were told to form groups. These groups were sometimes on a voluntarily

basis, other times selected by the teacher, and students were supposed to collaborate on given tasks. Additionally, a shorter plenary discussion bringing up common mathematical problems would take place, orchestrated by the teacher. However, flipped classroom teaching is meant to off-load the direct instruction part in class, freeing time for deeper exploration and with increased interaction (Bergmann & Sams, 2012). There were in-depth semi-structured interviews (Bryman, 2008) with nine students, striving to obtain rich information about attitude, behaviour and perceptions of the students' views about FC teaching and learning. Sofia was the only female student being interviewed but also a student performing well and completing the mathematics course. She was the female student that most easily interacted with the male students in class, also a person with great social skills. She had a high attendance in class but had not always watched the out-of-class videos for preparation, expressing a bit bad consciousness about this. As such, she was the type of person always trying to behave in a good manner. The interview was taking place towards the end of the course. At this stage, Sofia was the only female student attending class as the other three had disappeared from regular teaching. She was also the only female that completed the mathematics course as the other females did not return to class. The interviewer was not the same person as the teacher in class to encourage honesty. The interview was done in the native language of the students, thus explanations from Sofia have been translated to English by the authors. As the interview was kept in an informal tone, translated statements from Sofia are not always in formal English. This is since they are directly translated in order not to change the meaning of the content.

Sofia's arguments have been analysed by using the four perspectives of gender that Bjerrum Nielsen introduced; structural, symbolic, personal and interactional gender (Bjerrum Nielsen, 2003). The four perspectives represent different viewpoints and different lenses to analyse the same situation (Wedege, 2007). The perspectives complement each other to add valuable information in answering the research question on how social constructions of gender may elucidate the collaboration during group work in FC.

2.3. Limitations

A luminous limitation of the present study is that only one student's voice is being analysed. This voice, however, is used as source of information to raise a highly important discussion about the role of gender in group-work. It cultivates the uniqueness of the case (Yin, 2012). By no means Sofia's arguments are claimed to be generalizable, merely taken as arguments to picture the situation. The present investigation is a brick in a bigger picture, a brick that adds depth to our understanding of gender and participation in a FC classroom.

Another challenge may be validity and transferability of the study. Since the second author was the teacher in the FC class, careful considerations were taken in analysing the data. The first author took the main responsibility for this part and analysed the interview separately before lifting the results for discussions with the second author. It reduced possibilities of intuition playing a role. Besides, the transcripts being analysed were direct quotes from Sofia, not field-notes or memos. To enhance transferability of the classroom setting, the access to data and the focus of the analysis are all described in detail to increase the possibility of use in other contexts. Selection of explanations to be analysed has been guided by an aim of focusing on parts where Sofia talks about her relation to the male students in class. Other parts of the interview did also contain gender-related issues but were not included as they did not point directly to Sofia's interaction with her peers. The following explanation, where Sofia was asked if she took advantage of asking questions during plenary discussions, is an example of this:

Sofia: It is somewhat hard to be able to put into words what I am struggling with, so I never used this plenary opportunity. This is about me, I should have asked. But often I was not sure what actually was the problem, thus I preferred to ask during group working sessions instead.

The statement can be interpreted in terms of the classroom's social structure and personal gender, but is not directly related to Sofia's interaction with the male students. Thus, it is not

included in the present discussion. We have done such judgements as researchers, deciding which statements to include to enlighten the research objective.

3. Results

In this section, three situations described by Sofia during interview are analysed by drawing on the four gender perspectives in the BN-framework. A schematic illustration of the analysis structure for all situations is given in Table 1. It illuminates what the perspectives are together with headwords about focus for each perspective.

3.1. Situation one: Group members that are not prepared

3.1.1. Quote

Sofia: Sometimes when I was participating in the group activities the other ones in the group had not seen the videos. I think—when looking back now—that this was the most demotivating part of working in groups because when I needed help to understand things I could not get this help from the group. Thus, I preferred to sit by myself and ask for help from you [the teacher]—which worked rather well.

Interviewer: This was because you had to use a lot of energy to make the others understand things?

Sofia: Yes, and it was often when the theme was something that I did not understand completely myself, thus I thought that now when we are four people we will manage this together. But then instead I had to try to figure it out myself while the other sat waiting for me to explain what I'd figured out. And I did not know if I was right, I did not get any confirmation from the others since they had not seen the videos.

3.1.2. Structural gender

The social structure of the flipped classroom as described by Sofia in this situation is both about the setting of working in groups versus working alone and about the preparation before coming to class. The two are combined as premises for working in groups but are not taking place as intended since the male students are not prepared for class. For Sofia this represents a gender segregation since she has done her homework but finds that the male fellow students in her group are unprepared.

3.1.3. Symbolic gender

The quote indicates that a normal situation in the flipped classroom is a prepared female student and unprepared male students, but with male students expecting explanations enabling them to solve the tasks. Among the male students, it is usual to meet unprepared to class and rely on being provided with proper explanations by the female student. It is taken for granted that Sofia is

Table 1. Schematic illustration of gender perspectives

Gender perspective	What	Headwords
Structural	Social structure of the setting	Structure of the investigated environment.
Symbolic	Perceived ideas of what are female and male domains	Stereotypic situations. Masculinity and femininity.
Personal	Perceived identity	Fit/not fit into the environment. Identity versus subjectivity.
Interactional	Social interaction between individuals	Negotiations of positions as part of the culture. What is done in relation to others. Feedback.

prepared and will provide necessary help; the female role is viewed as a "service-friendly"; making educational activities easier for the male students.

3.1.4. Personal gender

Sofia describes a group work activity that demotivates her. The cultural model of the males, which is to meet unprepared to class and expect to get proper explanations, does not align with Sofia's personal gender. She cannot identify with this as she usually is prepared and expresses bad consciousness in cases where she is not. She also states a concern about being in need of help and not getting it from the unprepared male group members. Sofia's initial expectation about a teamwork environment where solutions are worked out in collaboration has not come to pass. Instead, it is expected that Sofia takes a leading position, teaching her male peers the mathematics needed to solve the tasks. This demotivates Sofia as the work in groups does not pay the reward she has anticipated. It represents a tension in the group activities, which for Sofia results in a preference to work alone.

3.1.5. Interactional gender

A main difficulty in the described situation is the social interaction with group members. All arguments brought forward by Sofia refers to her positioning toward the male members of her group. She is the one having seen the videos while the others have not. She is the one not getting help from male group members, instead she faces an expectation to inquire into how to solve problems. She is the one lacking feedback that confirms that her derived solutions are correct. Sofia is the female student that the male group members rely on while she herself misses help from the male peers when she has not understood some video contents. This makes an unequal division of responsibility between group members.

3.2. Situation two: Explaining to others

3.2.1. Quote

Sofia: I like to explain things that I have understood well myself, I learn a lot from that. But when I am not sure, but still have to explain to others, I feel insecure because I do not want to teach someone the wrong things while I try to figure out what to do. This is difficult. However, I do not like to be the one who just sits there and cannot contribute with anything. It is actually the worst situation. To be like a question mark is not fun. In a way you are dependent upon the others to teach you.

3.2.2. Structural gender

The social structure in the present situation is about students who teach and explain to each other as a way to learn mathematics better. The gender perspective in this structure is marked by Sofia's expressed insecurity about saying something wrong in these teaching situations. She also feels the pressure to contribute. Sofia is not referring to this as a gender issue, but her statement about the unsatisfactory feeling when being dependent upon the others to give her an explanation is referring to her peers—who all are male students.

3.2.3. Symbolic gender

Sofia's arguments about the discomfort of appearing like a question mark underlines her unease in situations where the male students have to give her explanations. She clearly does not want the normality in the interactional collaboration to be one where the male students take the leading positions as the ones having knowledge in mathematics, thus with ability to teach the others while Sofia is the one being taught.

3.2.4. Personal gender

The situation illuminates a split personal gender as to how Sofia perceives the educational design of work in groups. On one hand, she feels insecure about own ability to teach her male group members when not being sure if she has understood the content correctly. This expresses a concern about teaching something that is wrong. It illuminates a doubt about being "good

enough" as teacher in a male dominated environment. On the other hand, Sofia does not like to be the one that the male group members have to teach some content, thus to be the one in need of help. It points to an identity as a female student not being a passive learner. Sofia wants to be a contributing participant in the collaboration, but in order to be so she expresses a need to be sure that she knows the content well.

3.2.5. Interactional gender

The interactional gender has similarities with the personal gender since teaching involves interactions with others. Sofia likes to explain mathematics to her male collaborators and dislikes being dependent upon others giving her an explanation. She also emphasizes a dislike of a position in the group one that is not able to contribute. Sofia compares herself to the other group members and seek to be in control of the mathematical content—thus being able to teach others, not being taught—but doubts whether she is able to do this.

3.3. Situation three—classroom environment

3.3.1. Quote

Sofia: It is a kind of competition in class. Many of the boys have a high level of understanding, I feel, when it comes to programming and those things they know a lot of from earlier. Then, it is somewhat icky to be the stupid one. I do not feel the same when it comes to mathematics, but we girls have in common that we do not really know what we do not understand. Then, when we come to class and these boys are saying "this is so easy", it is not fun to hear when you are struggling with something. This creates a somewhat difficult classroom environment for the girls, maybe.

3.3.2. Structural gender

This situation describes a social structure in class marked by competitive male students with experience in, and understanding of, programming. According to Sofia, this competence has increased their confidence level in mathematics too, even if Sofia feels that she has no inferiority to the male students in mathematics. The male students' confidence level, originating from knowledge in programming, gives a classroom structure marked by ruling male students while the female students feel that they struggle.

3.3.3. Symbolic gender

What has become normal in the present classroom is an environment where the male students have an inherent interest in programming, which is essential in a computer science engineering education, with gained experience in this from earlier. It makes a stereotype of male students as the dominant ones, showing off about being able to solve problems in mathematics easily. The symbol of females is more of a struggling person, even with Sofia who expresses more proficiency in mathematics. The symbol of the female students is one that signalizes uncertainty.

3.3.4. Personal gender

The classroom culture seems to have a big influence on Sofia's identification as student. The male students' advantages from being good in programming make them high in confidence, creating a situation where male students express proficiency in mathematics too. Initially, Sofia talks about confidence in own abilities in mathematics. Then, however, she explains how the classroom environment causes a doubt about own competencies, a feeling that she shares with the other female students in class. This is something that females have in common, thus as females they struggle in the male dominated environment.

3.3.5. Interactional gender

Sofia's description enlightens an interaction between male and female students that is not balanced. The male students dominate as they boast about catching things easily while the female students worry about what they do not understand. It creates a social interaction where the female students are verbally pushed down by the male students, making them struggle more than

the male peers do. This does not open for dialog with testing of ideas in a problem-solving situation, rather it encourages to give precise arguments immediately.

4. Discussion and conclusion

The data that the present work is based upon originate from another project (Fredriksen, 2020). Thus, a particular focus was not guiding the interview guide (Appendix in (Fredriksen, 2020)). Our research question thereby is somewhat general, asking how gender perspectives may elucidate the collaboration during group work in a flipped classroom. It invites for a variety of results as the previous section shows. However, as the analysis proceeded, a common tread became more visible: Sofia's dualistic view on the collaboration with male peers. The analyses illuminate different types of dualities becoming visible when drawing on the BN-framework (Bjerrum Nielsen, 2003), summed up in Table 2.

The perspectives sometimes lift forward contradictory views by Sofia, illuminating her interpretation of the flipped classroom arrangement. This is valuable when discussing collaboration activities.

The interactional gender is a confliction in all the situations described by Sofia. Interactional collaboration by solving tasks is a main activity in FC. It presumes that group members have watched the videos before coming to class, thus are prepared for the work. In the first situation, Sofia refers to male group members who have not prepared, expecting to get explanations from her. This demotivates Sofia and makes her feel pressured as she has to derive and explain solutions to problems without knowing if what she explains is correct. The teaching of others may be valuable as part of a self-directed learning path (Sahin, 2010), but this ought to be in a setting where the person who acts as teacher wants this. Sofia's arguments in the first situation shows that she does not always feel comfortable in her teacher position, especially when she merely seeks collaboration and discussion with group members. At the same time, however, Sofia does not like to be the one asking for help from her male collaborators. She dwells on this in situation number two. She expresses insecurity about some of her explanations being correct and not being comfortable giving these. Still, she does not like to be the one that needs others to give her explanations. Sofia states this to be the worst situation, not knowing how to proceed with the mathematics tasks, depending upon the male group members to give her an explanation. Thus, Sofia struggles with her position in the group work activity, upholding contradictory views. Sofia's role in the social interaction with peers (Wedege, 2007) is not clear.

Table 2. Schematic illustration of results

Gender perspective	Situation	Dualistic results
Interactional	- working with unprepared males - having to explain when being unsure - unbalanced interaction	- having to take charge of the group work progress also when not feeling confident - not wanting to be the one that needs to be given explanations
Structural and symbolic	- masculinity of the computer science environment - males stating mathematics to be easy	- dominance of male students due to being good in programming - knowing that dominance of males in mathematics is not in accordance with reality
Personal	- female focusing on what she cannot do and feels unsecure about - males illuminating confidence in self since being good in programming	- prepared female knowing that she is well-informed but still feeling unsecure - males not being well informed in mathematics but still having confidence in own abilities independent for subject

The structural—and in turn symbolic—gender is eminent in the third situation analysed. where in this situation Sofia talks about the classroom environment being marked by male students having earned confidence in own abilities from a long-time interests in computers and programming. This points to a masculine world where the male students' confidence in one subject makes them overall confident in own abilities. The masculinity connected to computer science engineering is recognized by researchers (Ivančević et al., 2013; Ottemo, 2016), a situation also being culturally situated to western countries like Norway (Mellström, 2009). Sofia knows and states that the male students are far less informed in mathematics thus should claim less expertise in this field. She accentuates equality with her male peers by the statement "I do not feel the same when it comes to mathematics", saying that the advantages male students may have from being proficient in programming are not directly transferable to their mathematics knowledge. Still, the male students dominate also in mathematics by claiming that the subject is easy. It relates to Solomon's communities of practise where male students' belief in own abilities made them dominant in class (Solomon, 2007). It is an example of the gap Sumpter discusses by drawing on a variety of theoretical standpoints, showing that female students evaluate girls performance in mathematics lower relative to boys, despite holding this to be false from an individual standpoint (Sumpter, 2012). Sofia even argues that this feeling of downgrading is a plausible reason why the other female students are not present in class anymore, being part of a larger dropout rate among female students (Ellis et al., 2016). The male dominance, together with their expectations of getting explanations from Sofia when not having watched videos in advance, bear a signal of male students orchestrating the flipped classroom. It indicates a type of gender stereotype environment defined by competence in programming being the vital part of the education. Such stereotypes are an underlying factor for the underrepresentation of females within engineering and computing (Corbett & Hill, 2015). This relates to Powell's results on female students' contradictory views on career choices (Powell et al., 2012). The female students of Powell's study were split in their opinions about a profession as engineer. It would imply being part of a male-dominated environment that on one hand seems to have gender equality, on the other hand upholding gender stereotypes as this being so-called masculine work. In line with Solomon's results, the male students in the flipped class experience an identity with the computer science community, an alignment overruling a lack of engagement in mathematics (Solomon, 2007). Sofia struggles with this, experiencing the dominance of male students in the flipped classroom setting even if knowing that they do not hold competence in mathematics that deserves this dominance.

At a personal level, Sofia's descriptions signalize a conscientious female student—usually having prepared for the problem-solving activities in class—but is at the same time insecure about own mathematical competence. She does not want this uncertainty to come forward, stressing the feeling of sitting like a question mark to be the worst thing that can happen to her. Thus, even if being a good student, she undermines own abilities and potential. This is in line with results from the Nordic countries on motivational factors for mathematics among engineering students, showing that females have higher learning demands on own behalf (Tossavainen et al., 2021). It is also confirmed by Solomon in her investigation of learning identities in undergraduate mathematics; the dominant feeling among female students in a UK university was that of being out of their depth (Solomon, 2007). The male students, on their side, express gendered identity as having confidence in own abilities, stating mathematics to be "easy". The male students focus on what they are good at, which is holding competences in programming. They measure themselves as successful in a computer science class and this may result in high self-evaluation (Devos & Banaji, 2003). Sofia focus on what she cannot do. She lifts forward situations where she does not have a complete understanding of mathematics rather than what she knows. Thus, the personal capacity is put on different things, like in Pelch's study (Pelch, 2018). While male student in Pelch's study drew attention to what they could do and what they mastered, emphasizing positive factors in their study situation, the female students focused more on problems they had. The secure/unsecure dualism is illuminated in Sofia's interpretation of own abilities relative to the males. On one hand she is confident in own competence in mathematics. On the other hand, she doubts that her performance is "good

enough" when meeting with her peers since they hold high beliefs in own performance. Sumpter points to a gap between individual and stereotyping views; even if being confident in own capacity on an individual level, females downgrade females' abilities (Sumpter, 2012).

A focus on social learning arenas is often considered an advantage for female learners in mathematics. Inclusion of collaboration rather than competition in classrooms, small groups rather than individual work, more communication, and/or more socially relevant mathematics is highlighted by Fennema (2000) as a feministic approach towards altering mathematics teaching. However, as we have seen during this analysis, the utilization of such social instruments of learning, which is paramount for the FC framework, may actually have the opposite effect for females.

To conclude the discussion, gender perspectives contribute to illuminate challenges with in-class collaborations during group work in FC. Both on context and individual levels there are arguments informing this activity. However, what is realised in the case of Sofia is that there are dualistic viewpoints raised within each perspective, sometimes conflicting each other. This speaks against a definite recommendation on how to facilitate FC better in gender perspectives. At the same time, however, a range of issues of relevance to a facilitation is illuminated through the present analysis. Since computer science engineering classes in most cases have far more male than female students (DBH; Powell et al., 2012), a consciousness about the design of groups in FC, for instance, avoiding too much mixing of gender and usually prepared/not-prepared students, is valuable. Teaching not-prepared peers may be instructive but if male students signalize being high in confidence, peer teaching may not be the optimal solution. Thus, at least throughout the first year of their studies, picked groups of students in FC may be considered. Later in the engineering studies students should be mixed in order to practise interpersonal skills since this is needed in working life (Sahin, 2010). Particularly designed groups are possible since the distribution of videos to prepare for class usually draws on web-based software systems that log the time each video has been watched by each student. Arguments about designing of groups include facilitation for male students too, but according to Pelch (2018), female students are more focused on emotions than male students are. Thus, working with peers that females feel confident in could prevent an impression of being less proficient in mathematics.

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