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Gender Dynamics: A Case Study of Role Allocation in Engineering Education

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ABSTRACT The underrepresentation of women in engineering remains a problem till this day, where women made up 4% of its registered professional engineers in South Africa in 2014. The experience of women engineers in industry and women students in engineering courses can play a significant role in their decision to remain in engineering or pursue a different career path. The investigation of gender dynamics in small groups of engineering students, specifically focusing on the participation and role allocation of women students, can shed light on the experiences of women students in the engineering education environment. This paper shows that, although women engineering students are still in the minority in engineering courses, many are active participators in groups and fulfill leadership roles in those groups.

INDEX TERMS Gender dynamics, engineering, engineering education, women.

I. INTRODUCTION

Despite decades of research and efforts to recruit and retain women engineers in South Africa, women still remain underrepresented in the engineering industry. Previous studies detail the efforts to increase these numbers, including increasing awareness of engineering as a career amongst young female learners [1], [2]. The enrolment of women students, however, does not guarantee the retention of women in engineering careers since classroom environments can undermine diversity and inclusivity in engineering [3]–[6]. The experiences of women students in engineering play a significant role in their decision to remain in engineering or pursue a different career [7]–[9]. Balakrishnan and Low [7] states that the learning experience of a women student is directly related to student's intention to pursue their career in engineering. It is observed in several instances that women students tend to engage less in the technical issues/work in a group or practicals and more in support activities, including group organization and documentation [10]–[13]. Negative experiences in these classroom interactions can demotivate women engineering students or decrease their interest in engineering as gender stereotypes are reinforced [14].

This paper aims to investigate the operational role allocation and task designation process followed within a small team of engineering students, specifically focusing on the interaction and experience of the women students. Much can be deduced about the accommodation of women in engineering education by determining if women students actively take part in the role allocation decision-making processes or simply become observers. Additionally, it might be possible to identify negative experiences by women students by observing the process followed by engineering students to allocate roles in small teams. This paper focuses specifically on a class of third year electrical engineering students in a systems engineering and design module. To facilitate demonstration of the systems engineering process the class were grouped into small teams of students (approximately 10 students per team) to work together as a simulated company to design, build and race an energy efficient vehicle. The process of operational role allocation within each team, with a specific focus on women students, is investigated through written questionnaires and observations by video recording of the students when roles are allocated within the team.

The outline of this paper is as follows: Literature related to women in engineering and group dynamic in engineering education is discussed in Section II. The research methodology is presented in Section III, and Section IV provides the results of the study. Section V includes a discussion on the research findings and Section VI concludes the paper.

II. RELATED LITERATURE

A. UNDER REPRESENTATION OF WOMEN IN ENGINEERING

The United Nations Education, Scientific and Cultural Organisation (UNESCO) states that the active inclusion in and participation of women in science is an important factor in improving a country's ability to tackle poverty issues [15]. The organization acknowledges that the shortage of women in the field of science is a challenge in the developed and developing world [14] and it is believed that the attraction and retention of women in engineering fields is important for the sustainability of the field and the improvement of economic prospects [15]–[19]. Despite the recognition of the importance of women in the field as well as various campaigns and efforts to improve the representation of females in Science, Technology, Engineering and Mathematics (STEM) disciplines, the attraction and retention of women in these fields remains low [14]. This underrepresentation is a concern all over the world, with South Africa being no exception [12]. Records from South African universities in 2010 indicate that women's participation in STEM fields was very low, but even lower in engineering, where only one in four registered engineering and engineering technology students at tertiary institutions were women and only one in three published scientists was a woman [20], [21]. In 2011, there were approximately 35 000 engineers in South Africa, of whom 3000 were women [22].

According to the Engineering Council of South Africa (ECSA) 2013/2014 annual report, women make up 4% of its registered professional engineers, where women only account for 12.5% of new registrations in 2014. These statistics show the extent to which women engineers fail to enter to the professional engineering industry [14]. A large and diverse body of research shows that the underrepresentation of women in science and engineering is influenced by a number gender-specific challenges such as gender stereotypes/bias, unequal remuneration, lack of flexibility options for women, sexual harassment/discrimination and the perception of limited career progression [14], [18], [21]. Traditionally, science and engineering are still seen as masculine fields, which is difficult for women to adjust to as they may feel unwelcome and intimidated [12], [23], [24]. Breakwell, Vignoles and Robertson [25] argue that a woman's participation in the sciences can be a threat to her identity, where similar research found that girls interested in science and women scientists are seen as an exception to the rule and deviates from female group norms [12].

The retention of women in engineering is also threatened by the fact that women tend to be concentrated in lower paying jobs and jobs with lower status positions (including supporting roles) compared to their male counterparts with equal abilities and qualifications [10]–[13], [18]. Researchers have also noted these circumstances are related to the fact that women feel they are not taken seriously and they do not receive challenging opportunities [18], [26]. In addition to the perceived bias relating to women's abilities, discrimination relating to their commitment to engineering (as opposed to family and parenting responsibilities); exclusion from social networks; and harassing behaviour from male counterparts are also mentioned which influence the retention of women in engineering [13], [14].

Although a fair amount of research has been done into the challenges faced by women in engineering and the science workplace, limited research has been conducted on the experiences of women engineering students at universities in South Africa [14]. Gender stereotypes and discrimination are not only present in the workplace, but have been reported to be in issue at universities as well, reflecting the broader social patterns and influencing the women students studying towards an engineering or science degree [27].

B. GROUP DYNAMICS IN ENGINEERING EDUCATION

The benefits of group work for students in engineering courses have been presented in various studies, including improved learner motivation, critical thinking, problem solving, reading and communication skills [28]–[30]. Furthermore, under the Washington Accord, one of the graduate attributes to be demonstrated in an accredited engineering programme and therefore mandated as an exit level outcome prescribed by ECSA, requires that the student be able to demonstrate his/her ability to function effectively in a group or multidisciplinary team [31].

Various research studies relating to group dynamics and best practices in the creation of effective student teams exist [28], [29], [32]. Considerations for the creation of effective student teams include team size, range of abilities and perceptions, and diversity to mirror social society. Tonso [32] has shown that women as a minority in groups in an academic environment can have negative experiences and lead to reduced performance due to stereotype threat and a feeling of isolation [3]–[6]. Furthermore, women students can often feel unvalued by the majority as they are assigned unimportant or supporting roles – reflecting the societal stereotype of men in engineering being the experts and women the support [29], [33], [34]. International research found that first year undergraduate women students are less active participators than men, where men often handle the technical content of a presentation [29].

The fact that women engineering students are in the minority to start with, and then further marginalised in the university setup, is concerning since the initial, introductory experience may influence their decision to remain in an engineering career or pursue a different career.

III. RESEARCH METHODOLOGY

This work investigates the gender dynamics in engineering student teams, specifically in a third-year systems engineer module in an electrical engineering programme at the University of Johannesburg. The study was undertaken to determine if women students, who represent a minority in the module, are subject to negative experiences in the teams, including gender stereotypes and discrimination; and whether they exhibit specific behaviour such as reduced participation and fulfilment of unimportant roles, as a result thereof. The following aspects were observed and conversational analysis was employed where appropriate to analyse structured discourse amongst project members:

1) Operational role allocations of women engineering students in a team-based engineering project;
2) Participation of the women in group discussions where they represent the minority; and
3) Leadership of women students in these groups.

The analysis of women engineers' experience in a team-based model allows engineering educators to identify potentially demotivating factors that influence women students and to address these in future.

A. PROJECT DESCRIPTION

The study involved eighty students in the systems engineering and design module, taught over two semesters in the third year of the electrical engineering programme. In this module, the engineering students are required to apply Systems Engineering principles and methodology to solve a real-world energy efficiency challenge in the form of participation in the Shell Eco-Marathon event in South Africa [35]. This event is hosted annually by the University of Johannesburg and challenges learner teams to design, build, test and demonstrate energy-efficient vehicles (HEV). The module requires students to work together in small teams constituted as engineering companies to design, build and race an energy efficient vehicle at the global Shell Eco Marathon event. The ECSA Exit Level Outcome 8 for Teamwork and Exit Level 9 for Project Management [31] are assessed through participation in this module.

Team Organization: This module is designed to teach the students the process of systems engineering through participation in a practical real-world project [36]. At the start of the year, the class is divided into two large groups, or teams, each responsible for designing, building and racing a vehicle at the Shell Eco-Marathon event. Within each team, four smaller groups, constituting separate engineering companies, are formed. Each company is responsible for an aspect relating to the design and building of the vehicle as they must each produce a sub-system which will be integrated into a system to perform the project task. The following companies were [36]:

1) SysCo, Systems Engineering company responsible for the overall systems engineering effort and the systems solution in fulfilment of the client requirements.
2) MechCo, Mechanical Engineering company specialising in the design and manufacture of a light weight vehicle chassis, responsible for the mechanical design and construction of the vehicle such as the chassis, brakes and steering sub-system.
3) EnergyCo, Energy Engineering company specialising in the design and production of a propulsion sub-system for use in the energy efficiency vehicle.
4) LogCo, Logistics Company specializing in procurement, marketing, media, fund raising and logistical support. This company offers audit services for the demonstration of safety compliance requirements.

This structure supports eight student companies, consisting of approximately ten students each, with four companies constituting each group team. In each company, the following operational roles must be allocated to the team members:

1) The Chief Executive Officer (CEO) role responsible for project management. The CEO's duties include the management of the available resources such as time, money and human capital.
2) The Chief Systems Engineer (CSE) role responsible for the overall technical effort of the project as well as assuming the role of the design authority.
3) Engineering specialists (E) roles for each component of the product.
4) Additional duties that may include administration, marketing, Chief Financial Officer (CFO) etc.

Team Selection: The students were assigned into companies through the use of the Comprehensive Assessment for Team-Member Effectiveness (CATME) software tool [37]. CATME software requires each student to complete a survey relating to inter alia skills, role preference, time availability and leadership. Based on the data collected in the survey, CATME creates teams using predetermined criteria for diversifying or homogenizing team compositions. CATME was configured to divide the students into eight groups, where team selection criteria were selected to promote homogeneity in terms of race, gender and skills ability. As there were only eight women students in the class, CATME distributed the women students across all eight teams, ending with one woman in each team.

During the first semester, each team selected a company they wished to represent (either SysCo, MechCo, EnergyCo or LogCo). These eight companies were then grouped into two primary groups, labelled Alpha-group and Beta-group respectively; and comprising the four company structures each. Internal to each company, the students appointed their own CEO and CSE and specialists engineers. The team membership stay the same throughout the first semester. In the second semester, students left or were added as result of module enrolment, therefore requiring a rearrangement of the groups. The students that participated in the first semester remained in their groups and corresponding companies. The new students complete the CATME survey and are divided into eight new teams, separate from the eight existing teams. The new teams were then responsible to select an existing team which they would like to become part of - and the two new and existing teams were merged to form the updated company for the remainder of the project in the second semester.

B. RESEARCH STRATEGY AND DESIGN

All the students participating in the first and the second semester of the subject were included in the study. During the course of the first semester, students were continuously asked to rate their fellow team members on their performance in tasks, including what role they fulfilled and if they completed it successfully. The assessments also asked the students various questions relating to their roles in their company as well as their perceived skills and the skills of other members of their company. The feedback was provided by the eight student groups through the CATME online assessment software and printed class assessments.

At the start of the second semester, the old and new teams were combined to form the new company. During the merger of these two groups, all members were required to re-negotiate the various roles and responsibilities of each member in the newly established company teams. Thus, the new company team had to select a CEO, CSE and assign roles for the other engineering specialists. Although members of a company team had certain roles and responsibilities throughout the first semester classes, they were provided the opportunity to re-establish these roles. The role of the company itself, however, was not allowed to change. In order to ensure the students clearly understood the task they must fulfil, the task of role allocation was clearly explained to the companies before task allocation begun. As the updated companies were communicated to the students, each company was separately taken to a conference room equipped with video recording capabilities. The lecturer explained to the company that they should now allocate various roles to each group member and provide details on the various tasks and responsibilities of each member. The conclusion from their discussion must be indicated on the white board (including their name, role, task and responsibility).

Although specific focus was placed on the women students in the groups, all students were observed during the team discussion and asked to complete written questionnaires. Although only eight student groups (each containing at least one women) were investigated, the sample is believed to be representative to allow the evaluation of the gender dynamics in the student teams in this class scenario.

C. CLASS DESCRIPTION

All the student who participated in the study were registered for the systems engineering and design module. In total, 79 students participated where 67 were male and 12 were female students with ages ranging between 20 and 25 years of age. These students formed the 8 groups evaluated in this study. A summary of the demographic information of the various groups are provided in Table 1.

TABLE 1. Summary of demographic information of student groups.

Group	Number of students in group		
	Total	Male	Female
Alpha-group MechCo	12	10	2
Alpha-group EnergyCo	9	8	1
Alpha-group LogCo	14	13	1
Alpha-group SysCo	9	7	2
Beta-group MechCo	9	8	1
Beta-group EnergyCo	10	8	2
Beta-group LogCo	11	9	2
Beta-group SysCo	9	8	1
Total number of students: 83			

The race and ethnicity of the students were not recorded in this study as this study focuses on the impact of gender dynamics on role allocation. The impact of race and ethnicity in role allocation in groups are considered to be a different study.

D. DATA COLLECTION

The following section describes the two data collection process which were employed for the study, namely class assessments and video observations.

1) VIDEO OBSERVATIONS

In total, approximately three hours of video footage was obtained and analysed. All eight company teams were recorded and the interaction of the team members analysed to determine how the various operational roles in the company teams were assigned. This video footage was analysed in three stages:

Stage 1 (Conversational Analysis): Conversational analysis was employed to study the discussion and collective interaction amongst the students, with the intention of viewing the participation of women students in the group. It was also applied to determine and analyse the underlying context and influences that other project members exhibit towards gender parity in a project setting. The study and analysis of formalised social interaction provides a socio-cultural perspective on students' value systems, including an understanding of their views on the role of women within society, higher education and in this particular study, project management. For this analysis, the researchers assessed the interaction of the students based on the lengths of their conversations with each other. Students' participation in the conversation was analysed on the basis of three predefined categories, namely speaking (S), listening (L) and no talking (NT).

- Speaking (S) included all the time spent by a student talking to another student, to the lecturer or to the group as a whole.
- Listening (L) included the time spent by a student listening to another person speaking. This includes time when the conversation was directed at the specific student.
- No Talking (NT) includes the time that a student was not part of the main conversation. This includes times when students were taking notes, observing or not actively engaged in the conversation. This may also include times of complete silence and general chatter/laughter.

The conversation analysis required the video to be time-coded where the activity of each student in the group were coded for any given point, based on these three broad categories. The average time of a conversation was calculated and the various conversations between the students were analysed.

Stage 2 (Writing and Note Taking Analysis): Students' activity relating to note taking and reading (research) were noted on the basis of four predefined categories: white board (W), note taking (N), reading (R), no writing (NW).

- White board (W) includes the time spent by a student at the white board, where every student's role and responsibility had to be recorded.

- Note taking (N) includes the time spent by a student taking notes on a note pad or digital tablet.
- Reading (R) includes the time spent by a student reading from notes.
- No writing (NW) includes times where a student did not engage in any writing activities.

As with the first stage, the video footage were timecoded where the writing activity of each student in the group were coded for any given point, based on these four broad categories.

Stage 3 (Role Allocation): At the end of the team conversation, the content on the white board, stipulating the role and responsibility of each student, was collected. This data can be seen as the result or outcome of the team deliberations. The results obtained from the video analysis provided sufficient information on the interactions of the women students in the groups as well as the roles and responsibilities they are to fulfil in their groups.

2) SKILLS ASSESSMENTS

In total, seven surveys/assessments were collected from fifty students in the first semester. The data collected from the assessments was in the form of five online CATME assessments and two printed questionnaires completed. Skills analysed through the range of assessments included leadership, creativity, technical ability, communication ability, writing, research, administration, marketing and pacifier. These surveys were analysed to determine the following:

- Initial assessment: What skills did the student feel they had at the beginning of the year?
- Own assessment: What skills did the female students think they possessed at the end of the first semester?
- Group assessment: What skills did the other members of the team think the women student possessed?
- Lecturer assessment: What skills did the lecturer feel the women student possessed?

From the analysis of the various assessments, it could be determined if there is a disconnect between the skills the woman student feels she is good at, what the team thinks she is good at, and what she is currently doing in the team. In addition to the students' assessments, the lecturer also rated the women students based on observation.

IV. RESULTS

In total, eight women students were present in a class of fifty students in the first semester, where twelve women students were present in a class of eighty-three students in the second semester. It can be seen from these numbers that women engineering students are underrepresented in this class, confirmed by the literature discussed in Section 2.

The results from the video footage analysis revealed patterns of conversational participation amongst the students in the eight company teams. The participation and interactions of the women students during the team discussions were correlated with their skills assessments. The obtained results provides information on the role distribution, participation and leadership of the women students. The results of the women students in the various groups are summarized below.

A. ROLE ALLOCATION

The role allocation of all the participating women students are shown in Table 2.

TABLE 2. Women students' final role allocation.

Group	Women student role allocation	
	Student 1	Student 2
Alpha-group MechCo	CFO	CEO
Alpha-group EnergyCo	Risk Manager	-
Alpha-group LogCo	CEO	-
Alpha-group SysCo	CFO	Marketing
Beta-group MechCo	Secretary	-
Beta-group EnergyCo	Secretary	Admin
Beta-group LogCo	CFO	Marketing
Beta-group SysCo	HR	-

From Table 2 it can be seen that 6 women students were allocated roles which can be seen as leadership positions, which included two CEO's, three CFO positions and one Risk Manager position. Five of the positions can be viewed as supporting roles of secretarial, administrative and human resources.

B. PARTICIPATION

In order to determine the participation of the women students in the group, the conversational relationships in the group was determined. These conversational relationships are illustrated through the use of a graph, as observed through the video analysis. The dotted lines denote below average length conversational relationships, where a solid line denotes conversations above the average length. The male students are denoted by M1, M2, M3 ... and the women students by F1, F2 ... In addition to the annotation, the final role allocated to the students are also included below the annotation. For example: the first male student in a group, selected to be the CEO, will be named "M1:CEO". A "Group" and "Lecturer" tag is also added to the figure to indicate conversations aimed at the team or the lecturer.

1) ACTIVE PARTICIPATION

From the conversational analysis it was seen that in most of the teams, the women students did not hesitate to participate in the group discussions. In three of the groups, a woman student took the lead in the group discussions. In two of these groups, these women students were elected in the role of CEO by her peers. The conversational relationship of one of the elected women CEOs, from Alpha-group MechCo, is shown in Figure 1.

It can be seen from this conversational relationship diagram, that the woman student (F2:CEO) interacted with most of the students in the team directly, with the lecturer and addressed the team as a whole. It can be seen from the graph above that this student did most of the talking as little other conversational relationships were established,

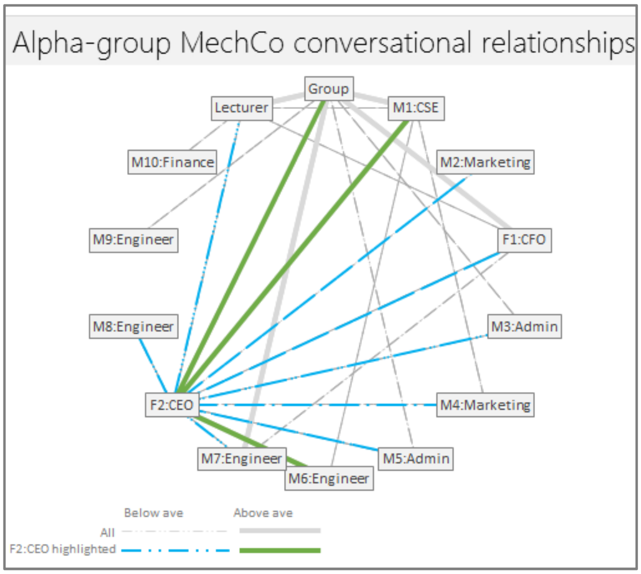

FIGURE 1. **Alpha-group MechCo conversational relationships.**

indicating that she orchestrated and managed the group conversation. This student was also the only student who wrote notes and recorded the roles on the whiteboard during the team discussion. From the observations, it was clear this student was an excellent communicator as she managed the group discussions and that she displayed strong leadership skills as the team selected her to be in the role of CEO. It must also be noted that this data reflects the conversation process to attain the role allocation, not the conversation after the role allocation process. Therefore, it can be seen that the CEO was a strong communicator before selected as the CEO.

The conversational relationship graph of a second woman student who took the lead in the team discussions is shown in Figure 2.

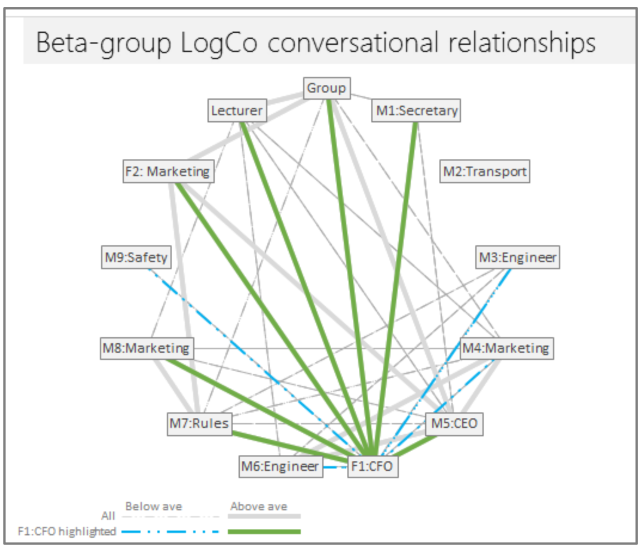

FIGURE 2. **Beta-group LogCo conversational relationships.**

It is evident from Figure 2 that this student interacted with all the students in the group, except one, as well as with the lecturer and the group as a whole. Most of her conversations were longer than the average time. This student volunteered to be the CFO of the company and the team agreed to her proposal. From the observations, it was evident this student was an excellent communicator as she managed and orchestrated the team discussions.

When considering the participation of other women in the group discussions, an additional four women students actively participated in their relevant group discussions with more than one above average length conversation and more than one below average length conversation. Table 3 summarizes all the active participating women students' conversational relationships.

TABLE 3. **Active participating women students' conversational relationships.**

Group	Student	Role	Conversations
Alpha-group MechCo	F1	CFO	Below ave: 3 (21%) Above ave: 1 (7%)
Alpha-group MechCo	F2	CEO	Below ave: 8 (57%) Above ave: 3 (21%)
Alpha-group SysCo	F2	Marketing	Below ave: 5 (45%) Above ave: 3 (27%)
Beta-group LogCo	F1	CEO	Below ave: 4 (31%) Above ave: 7 (54%)
Beta-group LogCo	F2	Marketing	Below ave: 3 (23%) Above ave: 2 (15%)
Beta-group MechCo	F1	Secretary	Below ave: 5 (45%) Above ave: 3 (27%)

The table indicates that the women students who participated in the group discussions fulfilled a range of roles, namely CEO, CFO, marketing and secretary.

2) LESS ACTIVE PARTICIPATION

In contrast, the other six participating women students were not actively involved in the group conversations. The conversational relationship graph of a third woman student who was less active in the group discussions is provided in Figure 3.

Figure 3 indicates that this student only had a below-average interaction with the Lecturer, CEO and CSE. It can be seen that although this student did not actively partake in the group conversation, she stated that she would fulfil the role of administrative assistant to ''oversee all the reports''.

Upon further evaluation, it was determined there were five other women students who did not actively partake in the group conversations, where only below average conversation lengths were recoded. The final role and conversational relationships for the less active women students' team are summarized in Table 4 below. It can be seen from the table that these students also fulfilled a range of functional roles, including CFO, risk manager and secretaries. One interesting observation is that of Alpha-group LogCo, where the women student were voted to be the group CEO, although she was not an active participator in the group discussion.

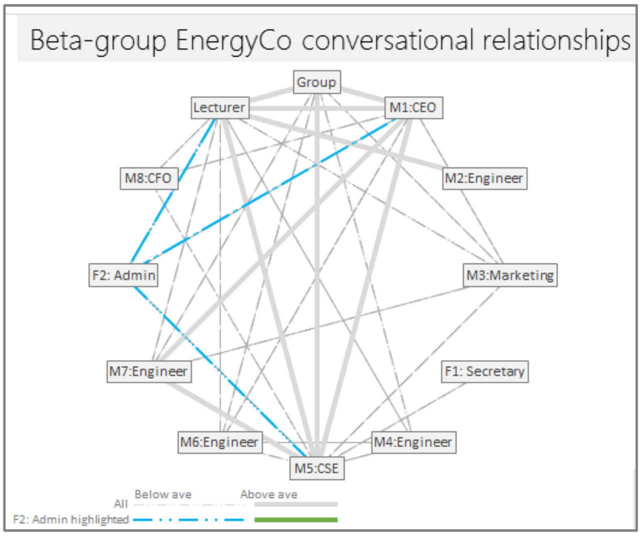

FIGURE 3. **Beta-group EnergyCo conversational relationships.**

TABLE 4. **Less active participating woman students' conversational relationships.**

Group	Student	Role	Conversations
Alpha-group EnergyCo	F1	Risk Manager	Below ave: 3 (27%) Above ave: 0 (0%)
Alpha-group LogCo	F1	CEO	Below ave: 3 (27%) Above ave: 1 (9%)
Beta-group EnergyCo	F1	Secretary	Below ave: 1 (8%) Above ave: 0 (0%)
Beta-group EnergyCo	F2	Admin	Below ave: 1 (8%) Above ave: 0 (0%)
Alpha-group SysCo	F1	CFO	Below ave: 1 (9%) Above ave: 1 (9%)
Beta-group SysCo	F1	Secretary	Below ave: 3 (25%) Above ave: 0 (0%)

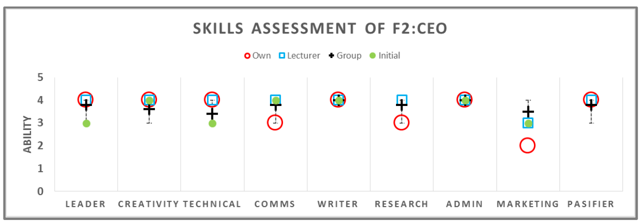

FIGURE 4. **Woman student of Alpha-group MechCo skills assessment.**

C. LEADERSHIP

From the role allocation and participation results, it can be seen that 6 women students fulfilled leadership positions in their groups. The skills analysis of a selection of these students are illustrated in figures, which indicates the ratings of the various skills of the woman student by herself (initial and end), the team and the lecturer. The various skills are listed in the graph along with a rating out of 4 for each of the skills by the various parties. The rating scale for the skills review was the following: Excellent (4); Good (3); Average (2) and Poor (1).

The skills assessment of the student elected as CEO, from Alpha-group MechCo, is shown in Figure 4 below.

Figure 4 indicates that the team gave high ratings for her leadership, creativity and technical ability. Her team members stated she has "good communication" and "good leadership" skills, that she "has (the) skills required to ensure requirements are "done" and has a "clear picture of work". It can also be seen initially the student rated her own leadership abilities as "Good (3)", but at the end of the first semester changed it to "Excellent (4)". These skills were clearly observed in her conversational relationships shown in Figure 1.

The skills assessment of the CFO for Beta-group LogCo is shown in Figure 5 below.

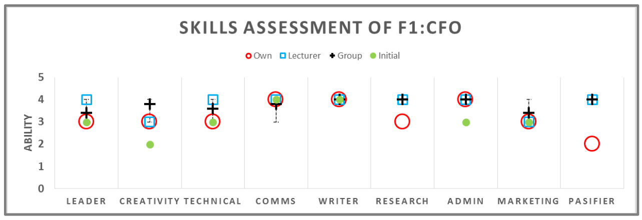

FIGURE 5. **Woman student of Beta-group LogCo skills assessment**

Firstly, it can be seen from the skills assessment that the student stated that she is a good communicator and writer, a statement echoed by her team and observed by the lecturer. She demonstrated her good communication skills in the team discussion, shown in her conversational relationships in Figure 2. The second observation is that, in most cases, the student gave herself a lower rating than the team or lecturer gave her.

The skills ratings of the six women students who fulfilled leadership positions in the groups are summarised in Table 5. It can be seen that in the skills assessment, most of the women leaders scored high in the Leadership, Communication and Administration sections.

TABLE 5. **Skills ratings of women students in leadership positions.**

Group	Student	Role	Skills rating
Alpha-group MechCo	F1	CFO	Leadership: Good Communication: Good Administration: Excellent
Beta-group LogCo	F1	CFO	Leadership: Good Communication: Good Administration: Good
Alpha-group MechCo	F2	CEO	Leadership: Excellent Communication: Excellent Administration: Good
Alpha-group EnergyCo	F1	Risk Manager	Leadership: Average Communication: Excellent Administration: Poor
Alpha-group LogCo	F1	CEO	Leadership: Good Communication: Good Administration: Good
Alpha-group SysCo	F1	CFO	Leadership: Average Communication: Excellent Administration: Good

The elected Risk Manager in the Alpha-group MechCo group scored an "Average" for Leadership and "Poor" for

Administration skills. The elected CFO for Alpha-group SysCo scored an "Average" for Leadership.

V. DISCUSSION

A. PARTICIPATION

From the presented results, it can be seen there were women students who actively participated in the team discussions, as well as women students who were less active participants. When considering that in all the teams the women students were outnumbered, it can be deduced that most of them were not intimidated by the male dominant team and actively participated in the discussion. The woman student who was elected as CEO by her team managed the entire group conversation. In other instances, women students were highly active participants in the group discussions, although not fulfilling the role of the elected leader (CEO).

It was observed that there were women students who were less active participants in the group discussions. In one group discussion, a woman student had a single below average length conversation with the Chief Systems Engineer where she only put up her hand to indicate that she will fulfil the role of the secretary. In other cases, less active women participants were elected into leadership positions even though they were not active participants in the group discussions. One example is that of the Alpha-group LogCo group, where the women student were voted to be the group CEO, although she was not an active participator in the group discussion.

From the results it can be deduced that the lack of participation of certain women students cannot be solely attributed to gender, as there were women students with strong personalities as well as students who are quieter by nature. In addition, it cannot be stated that the majority of the women students were less active participators than the men, as there were on average three men per group who also did not actively participate in the group discussions.

B. ROLE ALLOCATION

The operational roles finally fulfilled by the women students ranged from leadership positions, including CEO, CFO, Risk Managers, to supporting roles of secretarial and administrative. When looking at the participation of these students, as discussed above, it can be seen the leadership positions were not solely fulfilled by the more active participants. From the obtained results, it also cannot be deduced that all the majority of the women students were assigned supportive or less important roles. In three of the groups, a male students were assigned the role of secretariat, where in four other groups a women fulfilled the secretarial role. One group did not elect a secretary. In two of the group discussions, two women students volunteered fulfil the role of secretariat. The woman student who fulfilled the CEO position of Alpha-group MechCo, took the lead in the discussion and were nominated and elected by the team of male students as the leader.

An important observation made was none of the women students were assigned a technical role as an engineer. All eight groups assigned only male students to be the engineers, fulfilling the technical duties in the group. Although not all the roles the women students fulfilled can be seen as supporting activities (CEO, CFO, Risk Manager), none of the women students volunteered or were selected to be an engineer.

C. GENDER STEREOTYPING

Throughout the process of the conversational analysis, any indication of gender stereotyping was recorded. Two instances were observed where women students were targeted by male students to be a secretary, because they are female.

In one team discussion, the male student, elected to be the CEO, stated they required a secretary. He directly addressed a woman student and asked her to be the secretary. The women responded with the statement "Don't even try me". Although all the group members acknowledged that a secretary is an important and required role in the company, no male student volunteered to be the secretary. Only after the role was renamed to "administrative officer" and "secretary general", a male student volunteered to fulfil the role. The final role allocation of the woman student was marketing. In a second team discussion, a male student stated that they should select a secretary and made the statement "I am looking at the girls" whereupon one woman student responded with the statement "You don't know me, yet". She continued to ask the rest of the group if anybody was interested in the role and when none replied, she agreed to be the secretary. In response, the male student stated "You have to make sure that we are all happy . . . ". These were the only two gender based comments recorded, which can be attributed to single individuals, not teams as a whole.

D. IMPLICATIONS IN THE CONTEXT OF ENGINEERING

It is stated in literature that women engineers are underrepresented in the classrooms. This finding is reflected in this study as well. In isolated instances, evidence of gender stereotyping was present, but can be attributed to individual male students and not to a group as a whole. However, contrary to the literature, the following was found in this third year engineering class:

- The role allocations of the students could not be solely attributed to gender or gender bias. The woman students fulfilled a range of operational roles, ranging from CEOs and CFOs to secretaries and admin officers.
- The students' participation or lack thereof cannot be attributed to gender alone. Many of the women students were actively involved in the group discussions. While a set of women students were less active participants, it cannot be solely attributed to gender, as on average three men students per group were also less active/inactive participants.

- When a woman student displayed strong leadership skills, the woman student were nominated and elected by the team into a leadership position.

VI. CONCLUSION

This paper contributes to the body of knowledge relating to the experiences of women engineering students at universities. It is stated in literature that the experiences of women students in engineering courses can play a significant role in their decision to remain in engineering or alternatively pursue a different career. This paper investigated the operational role allocation and designation process followed within a small groups of engineering students, focusing on the interaction and experience of the women students. A class of third year electrical engineering students in a systems engineering and design module were divided into small teams of students (approximately 10 students) to work together to design, build and race an energy efficient vehicle..

The results of this study showed that, although the women engineering students are in the minority and that gender stereotyping still exists in the classroom, many women students are active participants and do fulfil leadership roles in these groups. Not all women students were assigned supporting roles, where a selection of the women were elected by their male peers to leadership positions. However, there were multiple women students who were allocated to be the group secretary or administrative assistant. Interestingly, it was noted that not one woman student was elected or volunteered to be an engineer or technician, tasked with the technical aspects of the project.

This evaluation of the gender dynamics in small engineering groups assisted in the identification of possible negative experiences by women students, which can be diffused in the future. It also showed that in this engineering class, women students displaying strong leadership skills were nominated and elected by the group into a leadership positions.

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