Group work experiences of women students in a Scottish chemical engineering programme

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Abstract

Chemical Engineering, similar to other Engineering courses, has seen an undergraduate gender shift in recent years towards greater women student representation. This raises the issue of the inclusion, in terms of equality of participation and opportunities, of these women students in learning activities and also the role that they can play in encouraging inclusion and development of others, which can have implications, not only for their current studies, but their future careers. This paper provides both statistical evaluation of students’ attainment from group working activities, and a narrative account of the students’ experiences along with the resulting impact on their inclusion, engagement and group interactions. We highlight the changing role filled by women students and their awareness of these changes and impacts. Notably, the work identifies a change in attitude with regards to roles for women in facilitating group work with many women students purposefully avoiding the additional work-load that past studies have identified.

Keywords: Focus groups, Gender, Group interactions, Narrative, Surveys
Introduction

Similar to other engineering courses, Chemical and Process Engineering at the University of Strathclyde has seen an environmental shift in recent years towards a balance in gender population. While a completely balanced population does not exist at present, there has been a significant move toward more equal balance from the heavily men-dominated composition at the start of the millennium. There is a growing interest in diversity, both as a result of the growing number of minority personnel (including women) within the workplace [1] and the move for organisations to utilise the varied skill sets and backgrounds offered by their workforce [2]. Researchers have previously found gender diversity to produce a variety of effects of on group performance, including reduced cognitive task performance as a result of gender heterogeniety [3, 4], improved same-gender support [5] and impaired men-women support [6]. Conversely other researchers have reported no such effects [7].

As a result of the gender shift in the Department, this paper aims to fill a gap in the literature, by providing an account of the experience of women students within group activities, in an environment that was previously almost exclusively men. These activities are designed to develop group working skills and to foster inclusion of all students, which is important for women engineers due to demands that industry has set for its graduate level employees [8].

The role of women in team activities has been evaluated as cooperative, as opposed to the competitive nature associated with men students: this has, in turn, suggested that women students are more suited to collaborative working than their male colleagues [9, 10]. Despite their natural cooperation in group situations, it has also been reported that women students often face negative attitudes from their men peers [11, 12], and may be allocated group roles, such as secretarial tasks, based on gender related assumptions. It is notable and encouraging, however, that University teaching staff offer fair treatment to all students regardless of gender [11] [12]. The assignment of office based tasks may result from women students’ inherent feelings towards contributing to the nurturing and people oriented areas of group dynamics [11]. It has also been postulated that such submissive behaviour may be related to the established but, more importantly, latent male dominance evoked by the cultural system of reproduction [13] or instilled definition of role via gender associated parental bonding [14]. Studies have suggested a move towards androgynous group working, allowing some socialised reversal of established roles, whereby men students may, for example, demonstrate a more nurturing character [15]; supported to some degree by a proposal for the wider acceptance of
men to adopt more woman-like characteristics, again to develop their nurturing side [14]. One criticism of such changes in stereotypical behaviour is that ‘female’ characteristics may cause, as well as resolve, conflict in a team, by making individuals less assertive, easily dominated by ‘male’ colleagues or against female authority as a result of interpersonal conflict with women leaders [11].

A question that has been extensively investigated in the literature is the issue of proportional representation in group activities: while some have argued that increased gender representation should not only increase interactions between men and women [16], but also reduce stereotypical role assignment [17], and the overlap of sexual and workplace roles [18], hence removing barriers to inclusion [19], others have argued that increasing the minority threatens status of the majority [20]. In addition, there are conflicting reports of negative [21, 22] and positive [6, 23] outcomes for numerical minorities within group work, and gender-heterogeneous groups have been shown to perform both better [24, 25] and worse [3, 4] than gender-homogenous groups, suggesting that the issue is heavily subjective. Hence, the study undertaken here does not seek to balance gender within groupings, which would not be possible for all groups due to the under-representation of women students in the total cohort. Rather, the Department adopts a random allocation of students to groups, to more accurately simulate the potential working environments faced by students whilst also offering insight into the effects of women representation on academic attainment.

It is important, in light of the collaborative working environment expected, not only in chemical engineering, but also the wider industrial sector, that students are able to integrate into teams and work collaboratively with colleagues, as and when required. Hence, the principal aim, over all degree streams and years of study, is to foster inclusion of all students to achieve their maximum potential, which can be an issue for the integration of minority groups, such as women students. It is worth considering inclusion within education as a broad and complex issue, impacting more than a single group of learners, providing ‘equal opportunities for all pupils, whatever their age, gender, ethnicity, attainment and background’ [26].

Previous studies into the development of science and engineering first year women undergraduates have focussed on the social aspects of their inclusion and experience, including socialisation practices based on gender [27-29], the impact of negative interactions with peers and University staff [30-32], and dissuasion of continuation by stereotyping [33, 34]. Chemical engineering teaching often
uses group work to simulate the real-life working environment that students will encounter upon graduation, and previous research indicates that such practices can enhance student learning [35, 36] by providing students with exposure to the same methods that they will employ in the workplace [37, 38]. However, studies on team diversity have generally focused on functional and educational diversity [39-42] rather than specifically on gender. Knowing that an isolated individual’s behaviour is very different to their behaviour in a group situation [43], and that women students, especially those from minority backgrounds, have been previously cited as preferring to work in teams [44], the programme studied at Strathclyde promotes group work and integration as a means to enhance both learning and employability.

This paper aims to build on a solid foundation of earlier research, most notably the contributions of Walker, who argued that, ‘women’s and men’s experiences are bound into the construction of their engineering identities through relations with others and under particular social and individual conditions of (gendered) possibility’ [45]. Students continue to be bound in the construction of these identities, but the social and individual conditions have changed. This paper explores the impact of group activities on student attainment and reports students’ experiences (both men and women) of diverse group working. It highlights a shift in the role many women engineering students occupy within this educational domain.

**Research methods**

**Ethical considerations**

Before the study began all students were given a description of the study and a Participant Information Sheet. Students were provided with a consent form and the opportunity to address any questions about the study. Following completion of the consent form, a questionnaire was used to gather basic socio-demographic information. Students had the ability to remove themselves and their data from the study at any point. In the discursive sections below, pseudonyms have been used.

**Composition of the study**

The student population sampled was composed of 120 first year students aged 16 to 18 years old and enrolled on either a 4 year BEng in Chemical Engineering, 5 year MEng in Chemical Engineering, or 5 year MSci in Applied Chemistry and Chemical Engineering. These students all entered their degree programmes at the University of Strathclyde in the autumn of 2012, and the population of 120
represents the full cohort for intake to the three degree streams for the academic session 2012 – 2013.

**Gender balance**

Table 2 illustrates admissions trends to the chemical engineering BEng/MEng programmes at the University of Strathclyde for the period 2003-2015. As these statistics illustrate there has been an increase in the number and ratio of women students. Representation of women in the cohort was 21.6%, which is in line with previously reported demographics [12], and a slight increase on the historical average up to that time (19.4%).

**Cultural/social**

As mentioned above, on the first day of lectures students were asked to complete a questionnaire, which aimed to capture various pieces of socio-demographic information. One of the questions asked the students if they have ever been involved in any form of extracurricular activities, without placing significance on the type of activity. Out of the 120 students surveyed only 12 students had never taken part in any activity additional to their studies. The remaining 90% responded that they were involved in an extracurricular activity, with the vast majority of respondents listing multiple activities, many of them with differing natures, such as a sport coupled with playing an instrument, and the majority group based activities. This reveals that most students within the study took advantage of opportunities to develop themselves beyond or outside of academia, and such prior experience is not atypical of applicants to the Chemical Engineering courses at Strathclyde. A variety of implications that can be drawn from this, however, in terms of inclusion, it illustrates that the majority of students have been afforded the opportunity to engage with a social group outside of their family unit. Arguably, they have been exposed to a variety of situations that, tethered together, have developed an element of social capital. Indeed, this exposure to various forms of socio-cultural integration can also be linked to finance, as these students had the financial means to participate.

**Economics**

The effects of economic factors were somewhat limited in this study as the students taking part attend a Scottish University and the vast majority (> 98%) meet the Government’s requirements to guarantee a free five years’ of education, with fees paid directly by the Student Awards Agency For Scotland. However, this is not to devalue the importance of economic drivers as it is appreciated that these factors had a great influence on how the places were filled. As Connell comments, ‘Education is
not…a mirror of social or cultural inequalities. That is all too still an image. Education systems are busy institutions. They are vibrantly involved in the production of social hierarchies. They select and exclude their own clients; they expand credentialed labour markets; they produce and disseminate particular kinds of knowledge to particular kinds of users' [46]. Hence students participating in this study are, by their nature, participating at University, having successfully gained a place of study, hence, their economic backgrounds were not examined in detail, although the authors do acknowledge the demands of external commitments, such as part-time work, and that financial matters can deduct from a student's time. However, all students are reminded during their time at University of the need for a work-life balance and the maximum hours that should be undertaken in external activities, whilst there is also significant student support for those suffering economic hardship so as to reduce the burden on student time.

**Formation of groups**

In order to understand student interaction within groups, students from two classes were (1) assessed in terms of attainment and (2) asked to participate in focus groups to discuss their experiences from their group based activities and pre-University activities and learning. Students recounted experiences related to their weekly tutorial/workshop sessions (over ten weeks for each class), and also within their Chemical Engineering laboratory sessions that took place in the first semester. The tutorial/workshop sessions were guided by fourth/fifth year undergraduate student tutors, supported by lecturers, who were also present to help with questions. It should be appreciated that the main interaction in these sessions was peer-to-peer and student to student tutor. The tutorials provided a time for small groups to work through various practical problems that, in many cases, forced students to use the knowledge from lectures, and in other cases to expand their reasoning skills beyond the course material. Students also undertook a group-based project in semester two that required little formal contact with teaching staff but, nevertheless, provides an additional comparison on the basis of group composition and attainment.

The first year students in Chemical Engineering, and Applied Chemistry and Chemical Engineering discussed their experiences from their core classes: ‘Basic Principles of Chemical Engineering’ and ‘Chemical Engineering: Fundamentals, Techniques and Tools’. The groupings for the tutorials were different for each module, however, it should be noted that in all instances the Department strived to ensure integration of students on the basis of degree stream and no other factors; the Department
teaches two pure chemical engineering degree courses, but also co-teaches on the MSci in Applied Chemistry and Chemical Engineering, which has a much smaller intake (~25 versus ~100 for the chemical engineering degrees), hence, it is seen as an important factor to encourage integration of the two streams.

Groups consisted of exactly twelve students in ten groups for tutorial sessions in ‘Basic Principles of Chemical Engineering’, where gender composition was randomised, simulating the unknown group composition found in employment, as discussed above. Despite the random allocation, it is notable that all groups contained between two and four women students. The ‘Basic Principles of Chemical Engineering’ class also required students to work within a group environment in their ‘Renewable Energies’ laboratory project, this time is groups of five (thereby giving 24 groups), of which eight were composed purely of men students while the others contained between one and three women students. Although this did create six groups with only one woman student, attempts to prevent minority groups sets a false perception of future working environments, which the Department feels should, in itself, be avoided. Workshop teams in ‘Chemical Engineering: Fundamentals, Techniques and Tools’, analogous to the tutorial groups of the Basic Principles in Chemical Engineering’ class, consisted of five students per team for 24 teams, the random allocation giving rise to seven teams with men students only, all other teams again containing between one and three women students.

Finally, students undertook a paper-based ‘Frontiers in Chemical Engineering’ research project in ‘Chemical Engineering: Fundamentals, Techniques and Tools’, working in 30 groups of four, creating nine groups of only men students, all other groups containing between 1 and 3 women students. These multiple groupings created a platform for discussion across a range of situations and environments.

Each class employed student tutors of both genders, the principal lecturer for ‘Basic Principles of Chemical Engineering’ was a woman while a man principally lectured ‘Chemical Engineering: Fundamentals, Techniques and Tools’.

**Focus groups**

Focus groups were selected, over interviews, as a method to allow students to voice their opinions as:

1) there was a specific theme emphasised, which could be explored more deeply; 2) there was more than one session, to probe inclusion in group dynamics; 3) emphasis was placed on ‘the ways in
which certain individuals discuss a certain issue as members of a group, rather than simply as individuals' [47].

Mid-way through both semesters, focus groups were held to provide students with opportunities to reflect and comment upon their trajectory of study and development. In the first semester, students were provided with the option to attend a focus group of their choice. In the second semester the focus group was integrated into the students' coursework and built into summative assessment, which required students to attend the discussion within their defined workshop groups. It is also notable that these project groups, used in the second semester, were encouraged to meet outside of the timetabled sessions to undertake their project work. While this differs to the tutorial activities in semester one, a parallel group work activity ('Frontiers in Chemical Engineering' project) did allow for such socialisation aspects in semester one providing a basis for comparison. There was a difference in the number of responses collected according to the grouping (Table 1).

The focus groups proved to be a beneficial method of enquiry, as students were able to deconstruct their experiences, while either challenging or agreeing with other students' perceptions. This generated data that, in some cases, was unexpected about the first year experience and their perceived meaning of it. As students explained their experiences, this led many to qualify or, in certain cases, modify some of their classmates' responses. This element of challenge was highly important as it arguably offers a more realistic and unbiased account. Overall it is also anticipated that this method has allowed students to reflect on their experiences and develop a deeper awareness of their role within group interactions.

Statistical evaluation of attainment

The marks awarded for group project activities ('Renewable Energies' and 'Frontiers in Chemical Engineering') and final examination marks for both modules were treated as discrete variables and were analysed by determining the arithmetic mean or average, \( \bar{x} \), from a population of \( n \) samples, where \( x_i \) is the value of sample \( i \):

\[
\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i
\]

The standard deviation of \( x_i \), for sample \( i \), from the mean (\( \bar{x} \)) was determined using:
Focus group outcomes

Belonging is a basic human need [48, 49]; the desire to belong is encapsulated as a significant element of the first year university experience. For many students their relational paradigm may have shifted significantly due to relocating for their studies, moving away from family, friends, and/or traditional roles in established peer and family groups. As a result, an increased importance is placed upon new relationships that mainly evolve around aspects of the educational institution. This transitional phase is also true for students not required to relocate, as their paradigm is still likely to have undergone a transformation to accommodate the demands of their course. In either scenario, students are likely to experience some element of struggle as they assume their new role.

During the focus groups with the students, many students of both genders clearly expressed that the level of group interaction directly from the start of the semester was unexpected, but a pleasant surprise:

*Focus group moderator: Have you been surprised at the amount of group work required?*

*Matthew: Yeah you think that I am at Uni and I am going to have to work by myself…*

*Rachel: Especially at the start!*

*Matthew: Yeah, it helped get you into it.*

Other groups of students, especially women students, were equally positive about the introduction of group work early on:

*Becky: It is a good way to meet people.*

*Maria: Yeah we have different people in every group.*

Becky and Maria expressed sentiments similar to many of their fellow students in that the variety of group work forced social interaction that may not have occurred otherwise. This also relates to the re-definition of students’ social dimensions and stresses the importance that they place upon meeting and interacting with others in the early stages of their degree.
A few of the students also reflected on how group work served to help with their personal development and overall sense of worth, specifically with regard to the work undertaken outside of timetabled classes.

Simon: You feel more responsible because you are not being told when or how often to meet your groups.

Students also expressed that the novelty of the experience has not been without challenges.

Focus group moderator: How is your group work going so far?

Raj: It has been rather good.

Freddie: Yeah….challenging, but good.

Focus group moderator: And what has been challenging?

Freddie: I guess thinking and behaving in different ways than in school.

All: Yeah (nods of agreement)

Interestingly, even though the emphasis on group work in the syllabus may be rooted in the need for students to develop transferable skills, such as responsibility, time management and communications, for their future professional careers, the work also serves to develop many important elements of each student’s sense of belonging and identity. This sense of identity within a group is distinct as it can break down barriers; as Forsyth states ‘[g]roups blur the boundary between self and others, for members retain their personal qualities, their motives, emotions and outlooks, but add to them a sense of self that incorporates their collective rather than their individual characteristics’ [50].

Despite the positive reactions from students, some groups’ work continued to be more productive than others' and, similarly, certain groups claimed that the experience was more rewarding than others. Common issues for differences in group integration and progression are discussed below.

**Disengagement**

Engagement in the chemical engineering degrees occurs in two ways: (1) as an individual with the course itself and (2) in myriad group activities with the assembled team. Defined as the ‘process by which individuals in an interaction start, maintain and end their perceived connection to one another’
[51], engagement requires interaction from all team members for the second case considered here, hence, disengagement by even one group member can affect the whole group.

Disengagement can manifest in a range of forms, e.g. individual disengagement, the domination of a group by one or more members, or complete group breakdown as in a collection of individuals who do not integrate or collaborate as team workers. Disengagement from groups by members presents a major challenge and an on-going obstacle to groups reaching their full potential. During the study, two principal explanations for disengagement from group work manifested in the majority of cases. Firstly, the amount of previous experience that students had working with others was evident. The focus groups served as an outlet to confirm these observations. This disengagement is not deemed as a severe concern as it is a skill that is more innate for some and, ultimately, can be developed by anyone. Students who experienced previous group work through school, sports, work or clubs generally took more naturally to the task; although it is important to emphasise that simply having a job, playing a sport or being a member of a club did not serve to automatically enhance one’s ability to function in a group.

Secondly, disengagement may also be related to the fact that some students struggled with the concept of the ownership for learning through a group structure, which includes the domination of the group to the potential exclusion of others, thereby enforcing disengagement.

Phillip: I know that I am a bit of a control freak, but I need to be. (Laughter) I just don’t trust the other members of my group to upload the work on time. I don’t like to be this way, but I feel I must be this way…

A related theme of interest that appeared from the focus groups was how the structure of the work given to the students could either foster or diminish the incentive to work as a group. For example, if the work could be easily sub-divided into equal or almost equal parts then students admitted to splitting the work and working independently until it was necessary to submit the work as a unit, circumventing the group process and the potential learning and skills development opportunities that it affords.

Lucca: I don’t really see what we did as group work. Is that bad to say…? Each person took their part then when that was complete we spent a little bit of time putting all of our individual parts together. I still don’t think that it read as one report….
There have been three previous conclusions offered from research into disengagement, however we found these to be unfounded in our study. Firstly, according to Healey, some students find the ‘active’ role to be quite difficult to fulfil and preferred to be passive learners [52]. It is possible that some first year students might wish that they could go back to their ‘passive’ selves, as at school, and not be responsible for their own learning. However, none of the students in the focus groups verbalised any evidence of this. Secondly, diversity within group work may also be another factor in disengagement; although, as in the case above, there is no direct evidence from our study to link to previous studies that confirm this. As Harrison et al. argue, there are two types of diversity, ‘surface level diversity’, which can include overt factors such as a person’s age, gender, and ethnicity, and ‘deep-level diversity’, which refers to differences in values, beliefs or attitudes [53]. During the focus groups, students made no reference to gender or ethnicity. Age was referenced, although not in a negative manner: while it showed that students were aware of the difference, they did not find that it deterred from group work in any way. Finally, the inherent difference in status may ‘impede communication between high status and low status members’ [53]. It is quite significant that this theme did not emerge. In fact from the study there is evidence that students felt equality among their peers.

Claire: I enjoy all the teamwork, really because everyone is in the same kind of position, like you don’t really know many people, if anyone, at University, so working in a team helps that. It also shows that everyone is interested.

Paul: Everyone is putting in the same effort as everyone else, because it’s not like schoolwork where somebody gets it and somebody doesn’t.

The evidence from the focus groups suggests that the incoming first year students were at the top of their year at school; however, after they entered University they felt no real advantage over other students, which is reflected in the statements expressed by the students above. The equality, perceived by students, at least before the first university marks were assigned, was something of a struggle for those who linked their identity to their performance in school. Thus it was quite difficult as they jockeyed for position among their new peers.

Jackie: Yeah, the days of being the best in each area are over. It is kinda strange to consider being weak…or less knowledgeable in an area….
Andrew: …the days of being top student are over! (Laughter and the consensus of other students)

**Gender differences**

Peer interaction and socialisation are fundamental elements of any educational setting. Much of the previous research in this area has been dedicated to studying the formation of masculine identities and the pressure to adapt to specific gendered norms [54-56]. According to Swain, ‘the boys’ position in the peer group is determined by an array of social, cultural, physical, intellectual and economic resources that they are able to draw on’ [57].

The introduction of a higher number of women into this environment has consequences for all participants. This was expressed during the focus groups by a number of men students as they vocalised surprise at the number of women in the program. Some of the men students expressed that there was equality within the groups with no gendered differences clearly apparent. Others expressed that there were differences, but indicated that the differences were positive.

Jacob: I am really happy to have girls in my group. They are much better than me at organising and keeping the group on task.

During many of the group discussions the theme of leadership within the group was addressed.

*Focus Group Moderator: Does group work improve if you have males and females working together?*

*8 of 10 students: Yes*

*Focus Group Moderator: And why?*

Hugh: I guess you can chat more

(Laughter)

*Focus Group Moderator: And who would you say is usually the leader, a female or a male?*

*Paul: A female*

*Lily: Yeah*

*Chen: Always a female*

*Robbie: I don’t have any females in one of my groups*
Focus Group Moderator: So, is there a leader to keep you on task?

Robbie: No

Focus Group Moderator: Do you stay on task?

Robbie: No

In another focus group similar sentiments arose.

Focus Group Moderator: Does a mix of guys and girls work well?

Pete: All my groups are all male, apart from my elective

Sam: Mine is all male, except for one group there is a girl and she is very good at keeping us on task

Barry: Yeah, I would say the same thing

Thomas: Yeah me too

Sam: It is good to have somebody like that

Igor: All my groups have girls in them and it works well

Pete: Yeah in my elective I am in a group with four girls and it seems like I do less work

It is notable that this final statement (from Pete) takes a bit of a negative turn from the ‘positive difference’ outlined above, this was repeated in other groups.

Henry: Having the girls in the group is great...

Focus group moderator: And why is that?

Henry: Well I have less work to do. I can turn on the charm and the girls don’t mind doing a bit extra. They want it done a really certain way....

Across all of the focus groups there were women who voiced concern with the problem of students not engaging within group work.

Focus group moderator: Would you be more concerned with people not engaging?

Multiple students: Yeah
Holly: Quite a lot of people in my renewable energies group were slow to start and engage, but me and another girl were like ‘we need to start!’

This final statement is quite revealing as in-class observations by staff confirm that, in many cases, women students were responsible for encouraging the group to engage as a unit.

In the second semester, students attended the focus groups within their project group. This yielded differing results to the first wave of focus groups. In total the students were split into 30 groups and only one of these groups mentioned that there was a difference in gendered inclusion within the group dynamic. From this we can infer that there has been a shift from first semester to second: women were less willing to take on more of the work.

Jill: I told the rest of them no, that we could all plan the meetings

Focus group moderator: And was that difficult for you?

Jill: Well kind of, but I had enough after the first term [semester]

Many women did not mention any type of struggle in ensuring that the work was split equally. Instead groups spoke of ‘democratic processes’ and everyone rotating through the various roles. Both men and women students commented on this being the best way forward with their collaborative work. Such views were more prevalent in the second semester and this suggests some development of the understanding of group processes and dynamics, as well as maturation within their study methods.

**Attainment**

Analysis of the academic performance of the four group working activities in the two classes observed showed that for ‘Chemical Engineering: Fundamentals, Techniques and Tools’ there was no statistical difference in student final examination performance with respect to workshop group allocation: final examination average 81(2) with averages for the workshop groups in the range 80 - 82 (n = 24). The group based ‘Frontiers in Chemical Engineering’ project saw a comparable trend of minimal variance between groups: averages were in the range 63 - 68 (n = 30), with a global average of 65(6), suggesting that the groups perform to a similar level irrespective of gender composition. In the class ‘Basic Principles in Chemical Engineering’, there was, again, no clear difference in student attainment as a result of group composition: exam average was 65(9) with values in the range 60 - 67 (n = 12).

These results cover a range of working compositions and group sizes (four to twelve team members),
suggesting that group size and number of women participants had little impact on overall group
member performance in these specific instances.

It is notable, however, that, by contrast to the results discussed above, the ‘Renewable Energies’
group project for ‘Basic Principles in Chemical Engineering’ saw an increase in student attainment
with representation of women within the group, while the global average was 67(8) in the range 65 -
73 (n = 24), those groups with no women members saw the lowest final grades with an average of
65(6), while those with three women students, thereby creating a minority of men students, achieved
an average of 73(2).

This raises the question of: what are the differences about the group based project of ‘Basic
Principles in Chemical Engineering’ compared to the other forms of group working in the first year of
Chemical Engineering? Firstly, one stark difference is that this is the only laboratory based
component of those assessed, with all others based on purely theoretical and paper-based research
methods. The difference in performance agrees well with the trend observed for gender averaged
marks achieved in the first year chemistry practical laboratory class, which is the only other hands-on
activity undertaken by the cohort (average for mean students 80(6) (n = 91); average for women
students 86(5) (n = 86(5)). Secondly, the assessment of the ‘Renewable Energies’ project happens at
the end of the first semester, while all other assessments are undertaken in semester two. As
indicated by the previous discussion, and supported by the open literature [11], there is a tendency for
women students to rebel against their assumed roles but only once they have identified that ‘pigeon-
holing’ has occurred. It could, therefore, be that women students’ awareness of being assigned
specific tasks happens during semester one, during which time they have assumed greater
responsibility for these tasks, such as the report presentation and group organisation required in the
‘Renewable Energies’ project, correlated to an increase in marks for women-dominated groups. By
semester two, women want to be treated equally and no longer adopt these roles so easily, as
discussed above, hence there is greater homogenisation of attainment, as evinced by the grades
achieved in the ‘Frontiers in Chemical Engineering’ project. It is interesting that this dismissal of
assumed roles appears, in turn, to negatively impact on the attainment of the women students
themselves, leading to homogenisation of attainment as well as group contribution.
Conclusion

This paper presents a short-term longitudinal study across two semesters and the results, in the first semester, point to the same direction as Harrison et al. who argued that diverse groups were more effective in identifying problems and generating solutions than their homogenous counterparts [53]. Indeed, diversity at all levels is needed within students’ group work as it is increasingly reflective of the professional environment that students will find themselves in after graduation. While it is clear that women students play an early vital role in facilitating group work, the progression of students’ mentality, even within the year-long timeframe of this study, is evident: during semester two, long-embedded roles adopted by women students are rescinded as many women students purposefully avoid taking on the extra work-load that past studies have identified. This is a positive step in the transition towards gender equality, as it is only when students conform to these expectations that inequality is perpetuated [58]. However, this response may also be detrimental to women students’ attainment. The progressive nature of student perceptions and action would benefit from a longer term longitudinal study, especially in view of the continually increasing proportion of women students within the cohort.
Acknowledgements
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Table 1: Distribution of invitations and completions/attendees for questionnaires and focus groups used in this study.

<table>
<thead>
<tr>
<th></th>
<th>Questionnaires (given)</th>
<th>Questionnaires (completed)</th>
<th>Invited to a focus group</th>
<th>Number attended the focus group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students (first semester)</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>108</td>
</tr>
<tr>
<td>Students (second semester)</td>
<td>-</td>
<td>-</td>
<td>120</td>
<td>114</td>
</tr>
</tbody>
</table>

Table 2: Total students enrolled on MEng/BEng degrees and the number of women students with calculated percentage.

<table>
<thead>
<tr>
<th>Year of entry to degree programme</th>
<th>MEng and BEng (total)</th>
<th>MEng and BEng (No. women)</th>
<th>MEng and BEng (% women)</th>
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* Cohort of study