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

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8 **Abstract**

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

20 *Keywords:* Focus groups, Gender, Group interactions, Narrative, Surveys

21 **Introduction**

22 Similar to other engineering courses, Chemical and Process Engineering at the University of
23 Strathclyde has seen an environmental shift in recent years towards a balance in gender population.
24 While a completely balanced population does not exist at present, there has been a significant move
25 toward more equal balance from the heavily men-dominated composition at the start of the
26 millennium. There is a growing interest in diversity, both as a result of the growing number of minority
27 personnel (including women) within the workplace [1] and the move for organisations to utilise the
28 varied skill sets and backgrounds offered by their workforce [2]. Researchers have previously found
29 gender diversity to produce a variety of effects of on group performance, including reduced cognitive
30 task performance as a result of gender heterogeneity [3, 4], improved same-gender support [5] and
31 impaired men-women support [6]. Conversely other researchers have reported no such effects [7].
32 As a result of the gender shift in the Department, this paper aims to fill a gap in the literature, by
33 providing an account of the experience of women students within group activities, in an environment
34 that was previously almost exclusively men. These activities are designed to develop group working
35 skills and to foster inclusion of all students, which is important for women engineers due to demands
36 that industry has set for its graduate level employees [8].

37 The role of women in team activities has been evaluated as cooperative, as opposed to the
38 competitive nature associated with men students: this has, in turn, suggested that women students
39 are more suited to collaborative working than their male colleagues [9, 10]. Despite their natural
40 cooperation in group situations, it has also been reported that women students often face negative
41 attitudes from their men peers [11, 12], and may be allocated group roles, such as secretarial tasks,
42 based on gender related assumptions. It is notable and encouraging, however, that University
43 teaching staff offer fair treatment to all students regardless of gender [11] [12]. The assignment of
44 office based tasks may result from women students' inherent feelings towards contributing to the
45 nurturing and people oriented areas of group dynamics [11]. It has also been postulated that such
46 submissive behaviour may be related to the established but, more importantly, latent male dominance
47 evoked by the cultural system of reproduction [13] or instilled definition of role via gender associated
48 parental bonding [14]. Studies have suggested a move towards androgynous group working, allowing
49 some socialised reversal of established roles, whereby men students may, for example, demonstrate
50 a more nurturing character [15]; supported to some degree by a proposal for the wider acceptance of

51 men to adopt more woman-like characteristics, again to develop their nurturing side [14]. One
52 criticism of such changes in stereotypical behaviour is that 'female' characteristics may cause, as well
53 as resolve, conflict in a team, by making individuals less assertive, easily dominated by 'male'
54 colleagues or against female authority as a result of interpersonal conflict with women leaders [11].

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

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

76 Previous studies into the development of science and engineering first year women undergraduates
77 have focussed on the social aspects of their inclusion and experience, including socialisation
78 practices based on gender [27-29], the impact of negative interactions with peers and University staff
79 [30-32], and dissuasion of continuation by stereotyping [33, 34]. Chemical engineering teaching often

80 uses group work to simulate the real-life working environment that students will encounter upon
81 graduation, and previous research indicates that such practices can enhance student learning [35, 36]
82 by providing students with exposure to the same methods that they will employ in the workplace [37,
83 38]. However, studies on team diversity have generally focussed on functional and educational
84 diversity [39-42] rather than specifically on gender. Knowing that an isolated individual's behaviour is
85 very different to their behaviour in a group situation [43], and that women students, especially those
86 from minority backgrounds, have been previously cited as preferring to work in teams [44], the
87 programme studied at Strathclyde promotes group work and integration as a means to enhance both
88 learning and employability.

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

97 **Research methods**

98 ***Ethical considerations***

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

104 ***Composition of the study***

105 The student population sampled was composed of 120 first year students aged 16 to 18 years old and
106 enrolled on either a 4 year BEng in Chemical Engineering, 5 year MEng in Chemical Engineering, or 5
107 year MSci in Applied Chemistry and Chemical Engineering. These students all entered their degree
108 programmes at the University of Strathclyde in the autumn of 2012, and the population of 120

109 represents the full cohort for intake to the three degree streams for the academic session 2012 –
110 2013

111 ***Gender balance***

112 Table 2 illustrates admissions trends to the chemical engineering BEng/MEng programmes at the
113 University of Strathclyde for the period 2003-2015. As these statistics illustrate there has been an
114 increase in the number and ratio of women students. Representation of women in the cohort was
115 21.6%, which is in line with previously reported demographics [12], and a slight increase on the
116 historical average up to that time (19.4%).

117 ***Cultural/social***

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

133 ***Economics***

134 The effects of economic factors were somewhat limited in this study as the students taking part attend
135 a Scottish University and the vast majority (> 98%) meet the Government's requirements to guarantee
136 a free five years' of education, with fees paid directly by the Student Awards Agency For Scotland.
137 However, this is not to devalue the importance of economic drivers as it is appreciated that these
138 factors had a great influence on how the places were filled. As Connell comments, '*Education is*

139 *not...a mirror of social or cultural inequalities. That is all too still an image. Education systems are*
140 *busy institutions. They are vibrantly involved in the production of social hierarchies. They select and*
141 *exclude their own clients; they expand credentialed labour markets; they produce and disseminate*
142 *particular kinds of knowledge to particular kinds of users' [46]. Hence students participating in this*
143 *study are, by their nature, participating at University, having successfully gained a place of study,*
144 *hence, their economic backgrounds were not examined in detail, although the authors do*
145 *acknowledge the demands of external commitments, such as part-time work, and that financial*
146 *matters can deduct from a student's time. However, all students are reminded during their time at*
147 *University of the need for a work-life balance and the maximum hours that should be undertaken in*
148 *external activities, whilst there is also significant student support for those suffering economic*
149 *hardship so as to reduce the burden on student time.*

150 ***Formation of groups***

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

164 The first year students in Chemical Engineering, and Applied Chemistry and Chemical Engineering
165 discussed their experiences from their core classes: 'Basic Principles of Chemical Engineering' and
166 'Chemical Engineering: Fundamentals, Techniques and Tools'. The groupings for the tutorials were
167 different for each module, however, it should be noted that in all instances the Department strived to
168 ensure integration of students on the basis of degree stream and no other factors; the Department

169 teaches two pure chemical engineering degree courses, but also co-teaches on the MSci in Applied
170 Chemistry and Chemical Engineering, which has a much smaller intake (~25 versus ~100 for the
171 chemical engineering degrees), hence, it is seen as an important factor to encourage integration of
172 the two streams.

173 Groups consisted of exactly twelve students in ten groups for tutorial sessions in 'Basic Principles of
174 Chemical Engineering', where gender composition was randomised, simulating the unknown group
175 composition found in employment, as discussed above. Despite the random allocation, it is notable
176 that all groups contained between two and four women students. The 'Basic Principles of Chemical
177 Engineering' class also required students to work within a group environment in their 'Renewable
178 Energies' laboratory project, this time in groups of five (thereby giving 24 groups), of which eight were
179 composed purely of men students while the others contained between one and three women
180 students. Although this did create six groups with only one woman student, attempts to prevent
181 minority groups sets a false perception of future working environments, which the Department feels
182 should, in itself, be avoided. Workshop teams in 'Chemical Engineering: Fundamentals, Techniques
183 and Tools', analogous to the tutorial groups of the Basic Principles in Chemical Engineering' class,
184 consisted of five students per team for 24 teams, the random allocation giving rise to seven teams
185 with men students only, all other teams again containing between one and three women students.
186 Finally, students undertook a paper-based 'Frontiers in Chemical Engineering' research project in
187 'Chemical Engineering: Fundamentals, Techniques and Tools', working in 30 groups of four, creating
188 nine groups of only men students, all other groups containing between 1 and 3 women students.
189 These multiple groupings created a platform for discussion across a range of situations and
190 environments.

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

194 ***Focus groups***

195 Focus groups were selected, over interviews, as a method to allow students to voice their opinions as:
196 1) there was a specific theme emphasised, which could be explored more deeply; 2) there was more
197 than one session, to probe inclusion in group dynamics; 3) emphasis was placed on *'the ways in*

198 *which certain individuals discuss a certain issue as members of a group, rather than simply as*
199 *individuals' [47].*

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

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

218 ***Statistical evaluation of attainment***

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

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

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

$$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2}$$

224 **Focus group outcomes**

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

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

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

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

238 *Rachel: Especially at the start!*

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

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

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

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

244 Becky and Maria expressed sentiments similar to many of their fellow students in that the variety of
245 group work forced social interaction that may not have occurred otherwise. This also relates to the re-
246 definition of students' social dimensions and stresses the importance that they place upon meeting
247 and interacting with others in the early stages of their degree.

248 A few of the students also reflected on how group work served to help with their personal
249 development and overall sense of worth, specifically with regard to the work undertaken outside of
250 timetabled classes.

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

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

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

255 *Raj: It has been rather good.*

256 *Freddie: Yeah....challenging, but good.*

257 *Focus group moderator: And what has been challenging?*

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

259 *All: Yeah (nods of agreement)*

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

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

270 ***Disengagement***

271 Engagement in the chemical engineering degrees occurs in two ways: (1) as an individual with the
272 course itself and (2) in myriad group activities with the assembled team. Defined as the 'process by
273 which individuals in an interaction start, maintain and end their perceived connection to one another'

274 [51], engagement requires interaction from all team members for the second case considered here,
275 hence, disengagement by even one group member can affect the whole group.

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

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

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

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

300 *Lucca: I don't really see what we did as group work. Is that bad to say...? Each person took*
301 *their part then when that was complete we spent a little bit of time putting all of our individual*
302 *parts together. I still don't think that it read as one report....*

303 There have been three previous conclusions offered from research into disengagement, however we
304 found these to be unfounded in our study. Firstly, according to Healey, some students find the 'active'
305 role to be quite difficult to fulfil and preferred to be passive learners [52]. It is possible that some first
306 year students might wish that they could go back to their 'passive' selves, as at school, and not be
307 responsible for their own learning. However, none of the students in the focus groups verbalised any
308 evidence of this. Secondly, diversity within group work may also be another factor in disengagement;
309 although, as in the case above, there is no direct evidence from our study to link to previous studies
310 that confirm this. As Harrison *et al.* argue, there are two types of diversity, 'surface level diversity',
311 which can include overt factors such as a person's age, gender, and ethnicity, and 'deep-level
312 diversity', which refers to differences in values, beliefs or attitudes [53]. During the focus groups,
313 students made no reference to gender or ethnicity. Age was referenced, although not in a negative
314 manner: while it showed that students were aware of the difference, they did not find that it deterred
315 from group work in any way. Finally, the inherent difference in status may '*impede communication*
316 *between high status and low status members*' [53]. It is quite significant that this theme did not
317 emerge. In fact from the study there is evidence that students felt equality among their peers.

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

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

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

329 *Jackie: Yeah, the days of being the best in each area are over. It is kinda strange to consider*
330 *being weak...or less knowledgeable in an area....*

331 *Andrew: ...the days of being top student are over! (Laughter and the consensus of other*
332 *students)*

333 **Gender differences**

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

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

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

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

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

349 *8 of 10 students: Yes*

350 *Focus Group Moderator: And why?*

351 *Hugh: I guess you can chat more*

352 *(Laughter)*

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

354 *Paul: A female*

355 *Lily: Yeah*

356 *Chen: Always a female*

357 *Robbie: I don't have any females in one of my groups*

358 *Focus Group Moderator: So, is there a leader to keep you on task?*

359 *Robbie: No*

360 *Focus Group Moderator: Do you stay on task?*

361 *Robbie: No*

362 In another focus group similar sentiments arose.

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

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

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

367 *Barry: Yeah, I would say the same thing*

368 *Thomas: Yeah me too*

369 *Sam: It is good to have somebody like that*

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

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

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

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

375 *Focus group moderator: And why is that?*

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

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

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

381 *Multiple students: Yeah*

382 *Holly: Quite a lot of people in my renewable energies group were slow to start and engage,*
383 *but me and another girl were like 'we need to start!'*

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

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

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

392 *Focus group moderator: And was that difficult for you?*

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

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

399 **Attainment**

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

410 suggesting that group size and number of women participants had little impact on overall group
411 member performance in these specific instances.

412 It is notable, however, that, by contrast to the results discussed above, the 'Renewable Energies'
413 group project for 'Basic Principles in Chemical Engineering' saw an increase in student attainment
414 with representation of women within the group, while the global average was 67(8) in the range 65 -
415 73 (n = 24), those groups with no women members saw the lowest final grades with an average of
416 65(6), while those with three women students, thereby creating a minority of men students, achieved
417 an average of 73(2).

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

438 **Conclusion**

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

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Table 1: Distribution of invitations and completions/attendees for questionnaires and focus groups used in this study.

	Questionnaires (given)	Questionnaires (completed)	Invited to a focus group	Number attended the focus group
Students (first semester)	120	120	120	108
Students (second semester)	-	-	120	114

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

Year of entry to degree programme	MEng and BEng (total)	MEng and BEng (No. women)	MEng and BEng (% women)
2015-2016	113	38	34
2014-2015	105	31	30
2013-2014	108	27	25
2012-2013	88	19	22
2011-2012	85	23	27
2010-2011	83	15	18
2009-2010	106	28	26
2008-2009	106	17	16
2007-2008	88	11	13
2006-2007	88	12	14
2005-2006	67	14	21
2004-2005	54	11	20
2003-2004	64	11	17

* Cohort of study