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

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

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

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%).

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.

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 is 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)*

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.

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.

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References

[1] Buhler, P.," Scanning the environment: Environmental trends affecting the workplace", *Supervision*, No. 58, 1997, pp. 24-26.

[2] Dean, J.W., and S.A. Snell," Integrated manufacturing and job design: Moderating effects of organizational inertia", *Academy of management journal* Vol. 34, No. 4, 1991, pp. 776-804.

[3] Kent, R., and J.E. McGrath," Task and group characteristics as factors influencing group performance", *Journal of Experimental Social Psychology* Vol. 5, No. 4, 1969, pp. 429-440.

[4] Murnighan, J.K., and D.E. Conlon," The dynamics of intense work groups: A study of British string quartets", *Administrative science quarterly*, 1991, pp. 165-186.

[5] Ely, R.J.," The effects of organizational demographics and social identity on relationships among professional women", *Administrative science quarterly*, 1994, pp. 203-238.

[6] South, S.J., C.M. Bonjean, W.T. Markham, and J. Corder," Social structure and intergroup interaction: Men and women of the federal bureaucracy", *American Sociological Review*, 1982, pp. 587-599.

[7] Pelled, L.H., K.M. Eisenhardt, and K.R. Xin," Exploring the black box: An analysis of work group diversity, conflict and performance", *Administrative science quarterly* Vol. 44, No. 1, 1999, pp. 1-28.

[8] Confederation of British Industry, "Learning to Grow: What Employers Need from Education and Skills - Education and Skills Survey 2012 [Online]", 2012.

[9] Gilligan, C., *In a different voice*: Harvard University Press, 1982.

[10] Belenky, M.F., *Women's ways of knowing: The development of self, voice, and mind*: Basic books, 1986.

[11] Flynn, E.A., G. Savage, M. Penti, C. Brown, and S. Watke," Gender and modes of collaboration in a chemical engineering design course", *Journal of Business and Technical Communication* Vol. 5, No. 4, 1991, pp. 444-462.

[12] Carter, R., and G. Kirkup, *Women in engineering: A good place to be?*: Macmillan Education, 1990.

[13] Cocks, J., *The Oppositional Imagination (RLE Feminist Theory): Feminism, Critique and Political Theory*: Routledge, 2012.

[14] Chodorow, N.J., *Feminism and psychoanalytic theory*: Yale University Press, 1989.

[15] Lay, M.M.," Interpersonal conflict in collaborative writing: What we can learn from gender studies", *Journal of Business and Technical Communication* Vol. 3, No. 2, 1989, pp. 5-28.

[16] Blau, P.M., *Inequality and heterogeneity: A primitive theory of social structure*: Free Press New York, 1977.

[17] Kanter, R.M., *Men and Women of the Corporation*: Basic books, 1993.

[18] Gutek, B.A., *Sex and the workplace*: Jossey-Bass Inc Pub, 1985.

[19] Larkey, L.K.," Toward a theory of communicative interactions in culturally diverse workgroups", *Academy of Management Review* Vol. 21, No. 2, 1996, pp. 463-491.

[20] Blalock, H.M.," Per cent non-white and discrimination in the South", *American Sociological Review* Vol. 22, No. 6, 1957, pp. 677-682.

[21] Spangler, E., M.A. Gordon, and R.M. Pipkin," Token women: An empirical test of Kanter's hypothesis", *American Journal of Sociology*, 1978, pp. 160-170.

[22] Izraeli, D.N.," Sex effects or structural effects? An empirical test of Kanter's theory of proportions", *Social forces* Vol. 62, No. 1, 1983, pp. 153-165.

[23] Toren, N., and V. Kraus," The effects of minority size on women's position in academia", *Social forces* Vol. 65, No. 4, 1987, pp. 1090-1100.

[24] Hoffman, L.R., and N.R. Maier," Quality and acceptance of problem solutions by members of homogeneous and heterogeneous groups", *The Journal of Abnormal and Social Psychology* Vol. 62, No. 2, 1961, pp. 401.

[25] Wood, W.," Meta-analytic review of sex differences in group performance", *Psychological bulletin* Vol. 102, No. 1, 1987, pp. 53.

[26] Office for Standards in Education, "Evaluating Educational Inclusion", London: OFSTED, 2000.

[27] Clewell, B.C., and P.B. Campbell," Taking stock: Where we've been, where we are, where we're going", *Journal of Women and Minorities in Science and Engineering* Vol. 8, No. 3&4, 2002.

[28] Fennema, E., T.P. Carpenter, V.R. Jacobs, M.L. Franke, and L.W. Levi," A longitudinal study of gender differences in young children's mathematical thinking", *Educational researcher* Vol. 27, No. 5, 1998, pp. 6-11.

[29] Trentacosta, J., and M.J. Kenney, *Multicultural and Gender Equity in the Mathematics Classroom: The Gift of Diversity. 1997 Yearbook*: ERIC, 1997.

[30] Ong, M.," Playing with in/visibility: How minority women gain power from the margins of science culture", *Women in Higher Education* Vol. 10, No. 11, 2001, pp. 42-44.

[31] Leslie, L.L., G.T. McClure, and R.L. Oaxaca," Women and minorities in science and engineering: A life sequence analysis", *Journal of Higher Education*, 1998, pp. 239-276.

[32] Seymour, E., *Talking about leaving: Why undergraduates leave the sciences*: Westview Press, 2000.

[33] Ong, M.," Body projects of young women of color in physics: Intersections of gender, race, and science", *Social Problems* Vol. 52, No. 4, 2005, pp. 593-617.

[34] Steele, C.M.," A threat in the air: How stereotypes shape intellectual identity and performance", *American psychologist* Vol. 52, No. 6, 1997, pp. 613.

[35] Brereton, M., S. Sheppard, and L. Leifer, "How students connect engineering fundamentals to hardware design: observations and implications for the design of curriculum and assessment methods", *Proceedings of the 10th International Conference on Engineering Design Held: Prague, WDK*, 1995, pp. 336-342.

[36] Lave, J., and E. Wenger, *Situated learning: Legitimate peripheral participation*: Cambridge university press, 1991.

[37] Heitmann, G.," Project-oriented study and project-organized curricula: A brief review of intentions and solutions", *European Journal of Engineering Education* Vol. 21, No. 2, 1996, pp. 121-131.

[38] Dewey, J., *Logic-The theory of inquiry*: Read Books Ltd, 2013.

[39] Choi, J.N.," Group composition and employee creative behaviour in a Korean electronics company: Distinct effects of relational demography and group diversity", *Journal of Occupational and Organizational Psychology* Vol. 80, No. 2, 2007, pp. 213-234.

[40] Fay, D., C. Borrill, Z. Amir, R. Haward, and M.A. West," Getting the most out of multidisciplinary teams: A multi-sample study of team innovation in health care", *Journal of Occupational and Organizational Psychology* Vol. 79, No. 4, 2006, pp. 553-567.

[41] Shin, S.J., and J. Zhou," Transformational leadership, conservation, and creativity: Evidence from Korea", *Academy of management journal* Vol. 46, No. 6, 2003, pp. 703-714.

[42] Somech, A.," The effects of leadership style and team process on performance and innovation in functionally heterogeneous teams", *Journal of Management* Vol. 32, No. 1, 2006, pp. 132-157.

[43] Zajonc, R.B., *Social facilitation*: Research Center for Group Dynamics, Institute for Social Research, University of Michigan, 1965.

[44] Brown, S., "Minority women in graduate science and engineering education", *Abstract in Unity in diversity. Baltimore: American Association for the Advancement of Science annual meeting and science innovation exposition*, 1995.

[45] Walker, M.," Engineering identities", *British Journal of Sociology of Education* Vol. 22, No. 1, 2001, pp. 75-89.

[46] Connell, R.W., and R. Connell, *Schools & social justice*: James Lorimer & Company, 1993.

[47] Bryman, A., *Social research methods*: Oxford university press, 2012.

[48] Maslow, A.H., R. Frager, J. Fadiman, C. McReynolds, and R. Cox, *Motivation and personality*: Harper & Row New York, 1970.

[49] Pittman, T.S., and K.R. Zeigler," Basic human needs", *Social psychology: Handbook of basic principles* Vol. 2, 2007, pp. 473-489.

[50] Forsyth, D., *Group dynamics*: Cengage Learning, 2009.

[51] Sidner, C.L., C. Lee, C.D. Kidd, N. Lesh, and C. Rich," Explorations in engagement for humans and robots", *Artificial Intelligence* Vol. 166, No. 1, 2005, pp. 140-164.

[52] Healey, M., H. Matthews, I. Livingstone, and I. Foster," Learning in small groups in university geography courses: Designing a core module around group projects", *Journal of Geography in Higher Education* Vol. 20, No. 2, 1996, pp. 167-180.

[53] Harrison, D.A., K.H. Price, and M.P. Bell," Beyond relational demography: Time and the effects of surface-and deep-level diversity on work group cohesion", *Academy of management journal* Vol. 41, No. 1, 1998, pp. 96-107.

[54] Pollard, A., *The social world of the primary school*: Taylor & Francis, 1985.

[55] Connolly, P., *Racism, gender identities and young children: Social relations in a multi-ethnic, inner city primary school*: Routledge, 2002.

[56] Connell, R.W., and R. Connell, *The men and the boys*: Univ of California Press, 2000.

[57] Swain, J.," How young schoolboys become somebody: The role of the body in the construction of masculinity", *British Journal of Sociology of Education* Vol. 24, No. 3, 2003, pp. 299-314.

[58] Spender, D.," Man made language", 1985.

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