

Refereed paper presented at 30th Australasian Association for Engineering
Education Conference , 8-11 December 2019, Brisbane

Development of Educators' Resources for Creating Inclusive Teamwork in Engineering and Computer Science

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Introduction

Women remain under-represented in engineering, to society's detriment (Ihsen & Buschmeyer, 2007). Countless organisations undertake programs to encourage women to study engineering, yet insufficient attention is paid to the cultures they face at university and in the workplace. Interactions in engineering workplaces have been found to marginalise the professional identities of women (Hatmaker, 2013). Furthermore, in the university context, female students within student teams have been found to be marginalised: under-recognised, doubted, and experiencing difficulty accessing the same resources as male students (Tonso, 2007). Thus, without intervention, efforts to increase the motivation and participation of women in engineering could be undermined before the women even graduate.

Academics have a responsibility to ensure that all engineering students experience an inclusive opportunity to learn and belong. As teamwork is critical to engineering practice, engineering education should and is designed to support students to develop teamwork skills. Teamwork is also valuable in the curriculum because interaction consolidates learning. Thus, academics also have a responsibility to support our graduates with the skills and attributes to lead inclusive teams. Beddoes and Panther (2018, p. 10) found that "faculty members play a pivotal role in students' experiences of engineering education". Consistent with the AAEE 2019 conference theme, we have a responsibility to be agents of change.

Unfortunately academics may not be prepared to support inclusive teamwork. Beddoes and Panther (2018) found that many engineering educators are ill-prepared to assist students to develop capabilities to work inclusively and to become leaders who improve practice. Indeed, Mills, Ayre, and Gill (2010, p. 52) recognise faculty development as a strategy to effect change towards inclusive engineering education.

This paper reports on the findings from an in-progress project investigating and improving the gender inclusion of student teamwork within the context of a research-intensive university in Australia. The aim of the project is to translate into practice, research on how educators can support inclusive student teamwork in an undergraduate and postgraduate engineering and computer science context.

This paper focuses on the second and third stages of the project – the development and delivery of resources for engineering and computer science educators aimed at assisting them in supporting inclusive student teamwork. We report the process of developing training materials for delivery in an in-person interactive faculty development workshop. We describe the development of learning objectives informed by extant literature and baseline data established in the first stage of the project. An overview of the workshop structure and an example of the content is provided. Learnings from workshop delivery and future plans are outlined.

Research Questions

The first stage of the study addressed the question "What are educators' perceptions and practices and students' experiences with respect to gender inclusion in engineering and computer science student teams in an Australian research-intensive university?" With the findings addressing this first question, we then asked "How can we support educators to

implement new practices for improving gender inclusion in engineering and computer sciences classes, enhancing student education overall?" This paper describes the development of educator resources that aim to answer this question.

Methodology

Theoretical Perspectives

The methodological approach for this project combined 'studying up' and 'studying down' (Beddoes, 2017; Beddoes & Panther, 2018). We assume that engineering faculties are gendered organizations (Acker, 1990) reinforcing a gendered hierarchy that favours stereotypically masculine traits and practices. Further, as culture is often invisible to those for whom it is familiar (Ihsen 2005), we also expected that many academics and students would be unaware of the gendered nature of the faculty, and of teamwork.

Stage 1 - Establishing the Baseline: The dual approach enabled the establishment of a baseline of experiences, perceptions and practices of engineering and computer science students and educators relating to gender inclusion in student teamwork. The baseline dataset was created through a mixed-methods convergent triangulation approach (Borrego, Douglas, & Amelink, 2009) commencing November 2018 and completed in May 2019.

Stages 2 and 3 - Workshop Development and Delivery: The subsequent stages of the study involved the development of evidence-based resources for teaching staff and the delivery of these resources through a training workshop. In these stages, the main objects of enquiry were educators' perceptions and practices. Extant knowledge, contextualised with points of concurrence and contrast between baseline educator perceptions and practices and student experiences from Stage 1 of the project, informed the development of resources tailored for the specific university context.

Participants

The participants in this project were students and educators in engineering and computer science. Students were currently completing or had recently completed a unit of study in engineering or computer science that included teamwork-centred activities. Educators were coordinators of teamwork-centric units.

In Stage 1, students' experiences of teamwork were ascertained using an online survey ($N = 78$ male respondents: $n = 50$, female respondents: $n = 26$, did not respond: $n = 2$). Two focus group discussions, conducted in November 2018 and May 2019, allowed additional and deeper exploration of the first research question. The initial focus group comprised all male students ($N = 3$), aged between 21 and 23 ($M = 22$, $SD = 1$). A second focus group was attended by two female students and one male student, aged between 18 and 22 ($M = 19.3$, $SD = 2.3$). Educators' perceptions and practices were elicited through in-person semi-structured interviews. Following a criterion sampling approach (Miles & Huberman 1994), teaching staff with unit coordinator responsibility for teamwork-centric units within the engineering curriculum were invited to participate by the lead researcher. Six interviews were performed with unit coordinators from a range of engineering disciplines. Four participants held full professorial status (male: $n = 3$, female: $n = 1$), and two participants held associate professor status (male, $n = 2$, female: $n = 0$).

For Stage 3, academic staff with unit coordinator responsibility for teamwork-centric engineering and computer science units were invited to participate in a training workshop. A purposive sample (Blaikie, 2010) of 12 unit coordinators was approached by a member of the research team. These were primarily coordinators of final year design project units which are core units in which students work in teams of about five students for full semesters. Students in all disciplines of engineering complete two semesters of design units. Seven unit coordinators indicated that they would be interested in participating in the staff development workshop, and four unit coordinators attended the scheduled session. These included three

male participants with responsibility for a discipline specific post-graduate design project unit and one female participant with dual unit coordinator responsibility for a first year foundation unit and a discipline specific post-graduate design project unit. In addition to the unit coordinator participants, a faculty educational developer and a visiting scholar from an overseas university attended the scheduled session.

Three unit coordinators were unable to attend the workshop due to personal commitments or heavy workload. One of these is receiving individual support from a member of the research team through the current semester.

Approach to Workshop Development and Delivery

The development of resources for teaching staff was informed by constructivist theories of teaching and learning (Perkins, 1999) and strategies for implementation and embedding of gender inclusive engineering education described by Mills, Ayre and Gill (2010).

In their discussion of implementation of gender inclusive engineering education, Mills et al. (2010, p. 152) state that “recommended improvements or developments in teaching, learning and assessment processes need to be communicated to the teaching faculty in persuasive and credible ways, rather than relying on faculty to read the education literature”. A professional development workshop was deemed a suitable medium to communicate in a credible and persuasive way with engineering and computer science educators. A workshop would enable them to gain an understanding of gender inclusive education research and provide an environment for reflection on and integration of current practice and new knowledge into future plans for action (Kolb, 2015; Prince, 2004).

The initial stage of workshop development involved the formation of learning objectives, which informed the structure and content of the workshop. Training materials were structured around the four dimensions of teamwork identified by Beddoes & Panther (2017, 2018), being: Team Formation, Team Roles, Teamwork Experience and Assessment & Evaluation. A ‘workshop module’ was developed for each teamwork dimension. Further detail of this is provided in the following section.

Data collected in Stage 1 of the project were analysed using a framework provided by the same four dimensions of teamwork identified by Beddoes & Panther (2017, 2018). Each data source was analysed separately. Qualitative and quantitative data were integrated during analysis. Points of concurrence and contrast between student voices and staff perceptions and practices provided a point of departure for the development of workshop content.

Training materials were delivered in a two hour in-person workshop entitled ‘Creating Gender Inclusive Classes – a workshop for unit coordinators’ by a member of the research team, on campus. Participants were provided with hard copies of workshop slides. A workbook included: a one-page summary of key points and best practices for each dimension of student teamwork for quick reference, and worksheets to capture individual reflection, group discussion and future plans. Participants sat in clustered tables of groups of 2 or 3, to facilitate interaction and active learning (Prince, 2004).

After the workshop, participants were asked to provide written feedback. Open-ended questions prompted an evaluation of the workshop, an indication of participant perceived change in understanding due to the workshop, and of potential areas of further support.

Creating Gender Inclusive Classes – a workshop for unit coordinators

A Summary of Baseline Perspectives

A brief synthesis of student and teaching staff perspectives from the Stage 1 baseline dataset provides context for the workshop development and delivery.

Team Formation: Student teams are commonly formed by teaching staff – an uncomfortable experience for students but aligned with recommended inclusive practice. Gender composition of team is sometimes considered in conjunction with other student characteristics, by both teaching staff and students.

Team Roles: Gender segregation of roles within student teams occurs but is not often observed by teaching staff. A gendered difference in students' perceived i) freedom to choose a role, and ii) exclusion from technical roles ($n = 63$, $p = 0.003$) exists.

Teamwork Experience: Gender is not perceived as an influence on students' teamwork experiences. Gender exclusion is seen as a '*a workplace, not university, issue*' (Focus group participant, male). However, survey data indicates a significant gender difference in the feelings of inclusion ($n = 63$, $p = 0.016$) and respect ($n = 63$, $p = 0.042$) within student teams. Further, female students perceived that their gender had a negative impact on teamwork experiences ($n = 63$, $p = 0.002$).

Assessment & Evaluation: Gender is not perceived to be an influence by students or teaching staff. Despite non-awareness of the impact of gender on assessment & evaluation, teaching staff displayed elements of inclusive practice. Female students are more likely to be dissatisfied with workload allocation within teams.

Learning Objectives and Workshop Structure

Baseline perspectives of teaching staff from Stage 1 data analysis (Male, Marinelli & Kim 2019) highlighted a need for an introduction to important teamwork concepts, including definition of each teamwork dimension derived from Beddoes & Panther (2018) and the impetus for educators to consider these teamwork aspects in their teaching. Further, in line with findings from Beddoes & Panther (2018) teaching staff did not perceive teamwork to be a site of gender difference, and subsequently gender was rarely considered when designing, implementing and assessing teamwork-centric learning activities. Little attention was paid to gender, and the impact of international students' English-language ability was viewed as more significant to many students and teaching staff, as described by one Professor:

[Gender] to me is a much smaller issue than English speaking or overseas students. I have 80 per cent overseas students so that English speaking is a minority, and of that probably 60 per cent is Chinese. So the dominant culture is Chinese. (P1, Professor, male)

Thus, a primary function of the workshop became the communication of information about student teamwork, and the prevalence and nature of gendered teamwork in engineering education. This informed the first learning objective. In order to enhance the persuasiveness and credibility of this information, a summary of extant research was combined with evidence from staff and students in the faculty derived from Stage 1 of the project.

A key aim of the broader project is to develop capability among engineering teaching staff to support their students to practice in and lead inclusive teams. Thus, a second learning objective was to provide unit coordinators with information about the approaches that they can use to improve gender inclusivity of teamwork and experiences of female students in their units.

A third objective of the workshop was to challenge participants to reflect on current practices and perceptions related to gender inclusive teamwork. In their discussion of the implementation of evidenced based interventions, Beddoes & Panther (2018) posit that instruction of evidence based best practices may not be sufficient to change educators' perceptions and practices. Rather, effective change requires educators to address any underlying beliefs that they may hold about that prevent them from adopting evidence-based practices. A first step is to critically reflect on current practice and perceptions and to consider why these are used (Gibbs, 2013). Participants were asked to reflect on their current practice at the end of each module and at the end of the workshop. Reflective prompts are provided in Table 1.

Table 1 - Reflective Prompts

End of Module Reflection	End of Workshop Reflection
<ol style="list-style-type: none"> 1. What is your current practice? 2. Why do you choose this approach? 3. What could you do differently? 4. What are the limiting factors? 	<ol style="list-style-type: none"> 1. How has your understanding of the influence of gender on student teamwork changed? 2. What is the key area that requires attention, if any, in your units? 3. What are barriers to implementing supportive strategies and interventions in your classes? 4. How can we help you to further support your students in leading and participating in gender inclusive teams?

The fourth learning objective required participants to translate reflection into action, through the identification and commitment to making a change in one or more of the four teamwork dimensions. Participants were invited to identify priority areas in their particular unit and document their commitments in an action plan, which was collected by the workshop facilitator for future stages of the project.

The four workshop learning objectives and a corresponding high-level summary of the generic structure of each module are presented in Table 2.

Table 2 - Module Structure by Learning Outcome

Learning Objective	Module Structure
Objective 1 - Recognise the ways in which gender impacts student's experiences in teamwork environments.	<ul style="list-style-type: none"> • Definition of teamwork dimension • Evidence of the importance of considering this in teaching • Summary of relevant previous research • University baseline findings - Stage 1
Objective 2 - Understand the approaches that educators can use to improve gender inclusivity of teamwork and experiences of female students.	<ul style="list-style-type: none"> • Summary and discussion of suggested best practices for educators, drawn from literature and University baseline
Objective 3 - Reflect on current practices and perceptions related to gender inclusive teams.	<ul style="list-style-type: none"> • Individual reflection and group discussion of: <ul style="list-style-type: none"> ○ current perceptions & practices ○ reasons for current perceptions & practices ○ workshop content ○ what could be done differently ○ limiting factors
Objective 4 - Plan practical and pragmatic interventions to enhance the gender inclusivity of teamwork in your Semester 2 classes.	<ul style="list-style-type: none"> • Identification of key area requiring attention • Completion of 'My Plans' sheet for coming semester with targeted changes in team dimensions

Module Content

The workshop contained four modules addressing the four dimensions of teamwork identified by Beddoes and Panther (2018) as sites of gendered work. The content for each module was developed using the module structure presented in Table 2. To provide an example of module content development, drawing on extant literature and refined by university specific data, a summary of the key content for Module 1 – Team Formation is presented below.

Module 1 - Team Formation

Team formation was defined as the approach taken to putting students into teams to perform teamwork activities, and available approaches were described. The importance of considering team formation and gender inclusive formation practices was related to the benefits of diverse and heterogeneous teams, team performance (Page 2007), balanced resource distribution among teams and equitable learning opportunities for students (Meadows & Sekaquaptewa, 2013; Stein, Aragon, Moreno, & Goodman, 2014). The debate between solo and grouped female students was highlighted (Beddoes & Panther, 2018; Dasgupta, Scircle, & Hunsinger, 2015; Mills et al., 2010; Viallon & Martinot, 2009).

Evidence provided by university specific data indicated that teaching staff employed a variety of team formation approaches, with an emphasis on instructor formed teams. Several staff described purposeful formation approaches, considering gender as one of many student characteristics. This was convergent with the reported student experience and suggested best practice (Beddoes & Panther, 2018; Kavanagh, Neil, & Cokley, 2011; Lloyd & Szymakowski, 2016). University specific evidence enabled emphasis of existing good practice within the faculty, adding to the credibility and persuasiveness of the module content. Baseline university data also highlighted the important team formation processes that occur after team allocation. This represented an extension of previous research on gender and teamwork within engineering education, and enabled the integration of team development theory (Tuckman & Jensen, 1977) into the module.

Suggested best practices for inclusive team formation encouraged participants to adopt instructor formed teams, to purposefully consider student characteristics, including gender, with the aim of avoiding team homogeneity and if possible avoid isolating students, and to consider team formation as a process extending beyond allocation. Suggested actions for support of team formation through the stages of team development were provided.

Workshop Delivery

Participant Feedback

The workshop was well received with positive and constructive feedback received from participants. Responses to feedback questions indicated that participants perceived an increased awareness about the presence and prevalence of gender exclusivity within the faculty. One unit coordinator expressed surprise at student responses collected in Stage 1 indicating that teamwork in engineering and computer science is indeed a gendered worksite.

Unit coordinators felt that they now had awareness of techniques to implement gender inclusive teamwork within their own units. However, a lack of time was highlighted by three out of four unit coordinators as a barrier to their implementing supportive strategies.

One unit coordinator, who had been apprehensive about attending the workshop commented:

"Much better than I feared! Some good ideas to improve design units, in general teamwork, not just specific to gender or ethnicity" (W1)

In a post-workshop email communication to the researcher who facilitated the workshop, the same unit coordinator elaborated that gender inclusivity was not a key concern in his unit and rather his focus was on inclusivity relating to other minority groups, specifically international students. He felt that much of the information provided was readily transferable, supporting Mills et al (2010), and three weeks after the workshop reported having taken two specific actions to support his student teams to act inclusively.

Participant feedback also highlighted opportunities for refinement. These included suggestions for content delivery methods that could maximise group discussion time. Two suggestions related to workshop reach: the need to extend the availability of the workshop to

face-to-face teaching staff without unit coordination responsibility (such as tutors and facilitators). It was also recognised that support of students by teaching staff to practice inclusively should commence in first year of university studies and be embedded and reinforced throughout the duration of a degree.

Participant Plans

All unit coordinators nominated a different 'teamwork dimension' as their area of focus for their unit/s. When documenting a plan for the coming semester, the dimensions of 'Team Roles' and 'Teamwork Experience' were most frequently nominated.

For team roles, interventions included: rotation of team roles, ensuring that all team members perform technical work, and refocusing students on learning outcome rather than final product. For teamwork experience, interventions were primarily student focused. One unit coordinator nominated the use of team contracts, while another planned to ask students to reflect on their teamwork experience as a means for monitoring student dynamics and contributions. A third coordinator planned to invite alumni into his classroom to give advice. Another participant, whose unit relied on facilitators to run face to face student classes, planned to disseminate information to teaching staff through a lecture to them on inclusive teamwork. Interventions listed under these dimensions were mirrored by plans for "Assessment & Evaluation", which included listing of student contributions and ensuring that all students had opportunity to perform technical work elements and report these in assessment submissions.

Conclusions and Future Plans

This paper describes the second and third stages of an in-progress project with the broad aim of developing capability among engineering and computer science teaching staff to support their students to practice in and lead gender inclusive teams.

In order to support engineering and computer science educators to implement new practices for improving gender inclusion in student teams, evidence-based resources were developed and delivered in a face-to face workshop. Training materials were developed on a foundation of extant research and contextualised with university-specific baseline data. A key action of contextualisation was to facilitate awareness and challenge beliefs of teaching staff with regards to the gendered nature of student teamwork. The use of context-specific data to do this proved to be a powerful and persuasive approach. The delivery of the workshop, based in constructivist, active learning perspectives, both informed participants and required them to critically reflect and commit to action. Feedback from participants indicate that the workshop was well received, and learning objectives were met.

To achieve the aims of the broader project, workshop post intervention data will be collected. For teaching staff, this will comprise a mid-semester check-in in the form of an open questionnaire (pending ethics amendment approval) and a final brief online survey towards the end of Semester 2. Students will be concurrently invited to complete a brief online survey to capture any changes to their experiences of gender inclusivity that may have resulted from changes made by unit coordinators.

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Acknowledgements

We gratefully acknowledge staff and students for participating in this research. We are thankful to Oceanworks and The University of Western Australia School of Engineering, and School of Physics, Mathematics and Computer Science for financial support.

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