Addressing cultural and gender project bias: engaged learning for diverse student cohorts


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Chapter 7
Addressing Cultural and Gender Project Bias: Engaged Learning for Diverse Student Cohorts

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ABSTRACT

Engaged student learning is based on creating significant learning experiences for every student. Attracting a more diverse student body into Engineering requires a re-evaluation of the conventional project topics that dominate the discipline. Recognising and addressing cultural and gender bias in the development of project work allows for the education of Engineering faculty on the development of a range of project work opportunities that support the learning for a more diverse cohort. The selection of set project work has the potential to negatively impact the learning experience of minority students. This chapter considers the elements influencing set project work and provides strategies for understanding cultural and gender bias, and for redesigning project work that provides for a more diverse cohort.

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DRIVING DIVERSITY

It is most beneficial to consider all students as individuals and provide an education that caters to a full range of personalities, interests, backgrounds and social groups. In supporting diversity, there can be an underlying assumption that the driver is for an equality defined as “anonymity” within the cohort. Many of the strategies suggested in learning and teaching publications, for example on group work, advocate randomization as a way of ensuring that all students are treated equally (Race, 2006) and there is an emphasis on language that does not differentiate between students. However, this homogenization both assumes a balanced cohort profile as a starting point and that the minority should be always striving to become the “same” as the majority. In practice, isolating minority students within a dominant majority will not provide them with equality, as their voice will count even less as individuals spread throughout a dominant group, than if they were grouped together. Similarly, providing all students with the same project work and assessment mechanisms does not provide equity if those tools bias a particular student’s learning preferences over another and not support the development of diversity that the future of the profession needs to provide the balanced workforce. The argument that the outcome will be a spread of marks, with all having an equal chance, is superficial in that it does not take into account whether the dominant majority is repeatedly succeeding over minority groups. More fundamentally, it supports the notion that minorities with diverse learning preferences should adapt to suit the preferences of the dominant majority. This further sustains the existing paradigm.

According to scholarship on learning and teaching, Bloom’s definition of deep learning is required in order for students to genuinely gain an understanding of any subject. This applies to engineering education as much as for any other discipline—arguably perhaps more so because of the need for engineers to understand the broader implications of their work for the development of viable, rigorous, systems outcomes for specific tasks. Leaders in educational research argue that for this to be achieved, students need to be actively engaged in their learning. Dee Fink (2013) describes this as the need to provide significant learning experiences for individuals; that is, activities that they can each personally relate to.

This is without doubt a challenge, and particularly for a discipline with an inherited body of knowledge and practice that has evolved very specifically for a dominant majority. Yet the drivers here are not only about improving learning and teaching, or even about supporting diversity for its own sake, they also relate to changing practice in the profession as a whole and the need to evolve the discipline to encompass more divergent thinking and practices as professional engineering challenges are become more complex and interdisciplinary. In addition, as engineering outcomes grow with the perpetual development of new technologies, the range of
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potential “end users” is increasing in diversity, requiring an understanding of the complexities of society in the global community. By addressing the aim to support diversity in the classroom, engineering academics are also opening the door to a rethink of the assumptions and practices that the academic discipline is dominated by and that may be in need of revision in response to the changing requirements of an evolving industrial, social and economic landscape.

ENGAGED LEARNING

Educational theory contends that engaged students, those who feel empowered through their learning, are more likely to achieve deep learning outcomes than those who are not (Weimer, 2002). For engineering education, this can be more challenging than for some other disciplines because of the way it has traditionally been taught. Essentially, students tend to be taught the fundamentals in the early years of their degree, in preparation for the application work they engage in once those fundamentals are in place. Dee Fink (2013) argues that for authentic learning, students need to always be involved in learning experiences that have personal significance for them. This becomes a particular challenge in the context of engineering education. It is in direct opposition to the dominant learning pattern where students must understand the engineering science that provides the underpinning for the discipline prior to applying that knowledge in a particular scenario. However, engineering educators are increasingly working to provide practical learning experiences earlier in the degree where students can be involved in active learning and engage in Kolb’s (2014) learning cycle. What there is less evidence of, are challenges to the idea of engaged, significant learning as being limited purely to an expression of experiential learning. This narrow view of engaged learning in engineering education, as referring to practical engagement only, fails to take into account the issues relating to diversity within current student cohorts, and the understanding of what engagement for all students means.

If engaged student learning involves providing the opportunity for all students to be involved in projects that have some element of personal significance, then attracting a more diverse student body into engineering will require an extension of conventional project topics to appeal to a broader range of interests. Identifying cultural and gender bias and re-evaluating existing projects from this point of view supports the education of engineering faculty on the development of project work opportunities that support significant learning for a more diverse cohort. This chapter considers project themes and how the projects are framed, and it provides strategies for counteracting cultural and gender bias. It considers existing educational practices and student experiences and discusses redesigning project work for a more diverse
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cohort. It also considers the marketing of engineering to target audiences beyond the male gender.

The differences in the development of professions and their associated academic disciplines are determined by multiple factors that complicate an evaluation as to why a particular profession or discipline is dominated by a majority social group. There may be a temptation to predetermine, for example, the reasons for the majority dominance of women in fields such as Nursing and Education, as linked to ideas of a traditionally “female disposition”. The reality is more complex and driven by social and historical factors. This is illustrated by historical documents relating to the frustration of women during the Second World War, where they took over traditionally male jobs in areas such as manufacturing, then were forced to relinquish them once the male workforce returned home (Thompson, 2016). It is also illustrated by the 1960s necessity and success of Dame Stephanie Shirley in developing a work-sharing mechanism for women with dependents, to contribute to the information technology workforce at a higher level than previously possible (Kavanagh, 2002). Yet even in contemporary societies where women have achieved a level of parity in the workplace, and parity in academic achievement in schools, this has still failed to translate into females choosing to study science-based subjects at University in equal numbers to their male counterparts. Whatever the issues, the reality is that females are still very much in the minority in post-high school science and technology education and are particularly under-represented in engineering in higher education programs of study.

At the secondary level, female students continue to lag behind male students in rates of physics course-taking in high school (Riegle-Crumb, Farkas, and Muller, 2006; Ma, 2011b). Indeed, this gender disparity has remained fairly constant over the past 30 years even as the overall percentage of students taking physics has increased (Freeman, 2004; Nord et al., 2011). This gap stands in contrast to trends in advanced math course-taking, as females have reached parity with male students in rates of completing high school calculus (Hyde et al., 2008), as well as trends in test scores, such that while small gender gaps in math and science achievement remain, they have shrunk considerably over the last several decades (Xie and Shauman, 2003). Despite progress on these other indicators…women have made little inroad into physical science and engineering college majors over the last 30 to 50 years (England and Li, 2006; Riegle-Crumb and King, 2010). (Riegle-Crumb & Moore, 2013, p. 253)

In addition, once enrolled in an engineering degree, those same females who achieved success in high school may be disadvantaged once enrolled in tertiary education. This is because whilst there is considerable research on the learning preferences of pupils in high schools relating to gender and the impact of different teaching approaches and assessment mechanisms on success (e.g., Baldiga, 2013), there is little evidence of this research impacting engineering education. Similarly,
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there is little evidence of culturally aware teaching approaches and assessment mechanisms, or of the significant inclusion of cross-cultural examples in lectures or projects. Culture is a significant factor in the structure and values re-enforced in a discipline and bound up with ideas relating to identity. An example would be the impact on Scandinavian aesthetics on form, material choice, construction techniques, etc., for study within that country. Similarly, the schools of thought in Japanese architecture illustrate the impact of cultural referencing and identity on market acceptance and value for specific places. The tenets of engineering education in the US, UK, and Australia are bound up with a Western experience and perspective of the Industrial Revolution that inform the learning activities within engineering education in these countries. In both respects, there is little evidence of academic programs actively support for diversity—gender or cultural—in the way that engineering is taught and assessed.

This chapter will focus on providing starting points for improving support for diversity in engineering cohorts, by considering the implications of re-invigorating project work. It is not a comprehensive review in responding to learning preferences for all students studying engineering, but rather it provides a provocation for challenging existing practices in engineering education. Disciplinary traditions have a major influence on the shape and values within a discipline, for example because of the impact of a train of thought or philosophy that has dominated its development, for example for disciplines subject to the influence of the Bauhaus. This chapter calls for academics to objectively consider their practice from outside discipline norms, to inform their understanding of the implications of their teaching practices. Genuinely providing for diversity requires a rethink in relation to many factors impacting the development and delivery of a program. Faculty need to be helped to see the value in addressing these issues and challenging the existing paradigms for all stakeholders, and then provided with clear strategies to do so.

Gender Bias

This study is guided by theories of gender as a social structure or system, one that is constructed across multiple levels or dimensions, ranging from the macro level of large-scale institutions and broad cultural beliefs to the micro level of local environments and personal interactions (Risman, 2004). Past research has documented how inequality is created and maintained by reinforcing connections between beliefs, norms, and behaviors across these various domains (Ridgeway, 2011). Yet it is also important to focus on variation in the extent of inequality and search for those places gender appears to be less salient in shaping expectations and behaviors (Eisenhart and Finkel, 1998; Deutsch, 2007; Risman, 2004). When viewing gender through this lens, theorists argue that gender can be alternatively constructed or deconstructed in
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ways that resist or subvert traditional paradigms, revealing that gender differences are neither inevitable nor omnipresent. (Riegle-Crumb & Moore, 2013, p. 253)

When considering gender in education, it is fundamental to understand gender as a continuum and not as a binary condition. This is not about a biological constant but about whereabouts on a continuum, from one extreme to the other, the students self-identify. As Riegle-Crumb and Moore point out “…gender can be alternatively constructed or deconstructed in ways that resist or subvert traditional paradigms, revealing that gender differences are neither inevitable nor omnipresent” (2013, p. 253). However, even within this approach, the idea of a continuum would have layers of interpretation—for example, would the continuum be based on male to female social stereotypes or would it be based on definitions of extreme male brain as systemizers to extreme female brain as empathizers? Is it explained by behavioral and attitude preferences, and how much are these impacted by socialization and cultural attitudes in different settings? For the scope of this chapter, the important element here is that understanding gender as a factor is not seen as merely providing for two opposites as “male” and “female” but rather as providing for a range of individuals with complex learning needs, interests and preferences. In improving diversity in the classroom, academics need to ensure that project work is not defined by limited ideas of gender that further re-enforce stereotypes, but support learning opportunities that individual students from diverse backgrounds and with diverse learning preferences and interests can identify and engage with. Academics need to cultivate a lack of predetermination, and foster inclusivity and supportive language in the classroom. This aligns with the professional development that engineering academics are likely to be engaged with at this time for the integration of experiential learning into the curriculum. This relates to the need to graduate increasingly innovative engineers who can work across disciplines in large, diverse teams on problem framing as well as complex problem solving.

Strategies to provide for cultural diversity in the educational experience are equally based on providing a paradigm where the basis for the learning experience is not predetermined by assumptions and assessment and not constrained by conventions. To provide a student with learning opportunities that are embedded within their identity requires structures that enable the student to tailor the project, rather than be faced with a fixed framework for learning that does not allow for their unpredictable experiences and background. With the rapid rise of globalization (Gore, 2013), it is the right time for the engineering faculty to embrace this challenge and provide a major shift in discipline thinking to foster a new learning paradigm, supporting classroom diversity. This will support the abilities of all students to work effectively in global teams, and on more diverse projects than are currently standard in some models of engineering education.
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Project Bias

If ideas of gender are removed as much as possible from an evaluation of set project work in engineering, and gender instead considered as a continuum (even if the model used is not a complex or layered one) then it provides a starting point for considering the provision of projects that support diversity. For this chapter, the continuum being considered is based on Baron-Cohen’s ideas on the relationship between systemization and empathy (Billington, Baron-Cohen, & Wheelwright, 2007). The intent is to provide an approach to developing study project options that work along that continuum without being gender specific.

A recommended starting point for self-evaluation would be for academic teams to plot the projects that form the basis of their in-class activities and assessments along a systemization and empathy continuum. If there is a bias towards one end of the continuum or the other, then there is an argument for providing a broader range of options in order to engage a more diverse cohort. However, the reality is that most project work can be reframed to allow the student to work along that continuum at where they best self-identify. The important element is how it is framed, expressed, supported, informed and then, most vitally valued and assessed. For example, a project that is based on bridge building can be presented as purely about structures, independent of any other factors. This learning experience could then potentially fail to engage students whose learning preferences are not at the extreme systemizing end of the spectrum. However, if the project was provided within a context that links it to a social imperative, such as providing a bridge for a specific purpose, then it could extend the learning benefits to include students with learning preferences towards the empathetic end of the spectrum. The purpose could be as unusual and diverse as to allow elephants to cross a chasm in a game park, or to provide a way for joggers pushing prams to cross a motorway. Not only could this approach to framing the project work engage those who identify more on the empathetic end of the continuum, but also ideally it could form the basis for academics to support individual students in tailoring the project to their own personal experiences and interests. This could create the opportunity for genuine significant learning and stimulate innovative thinking for all students, including the systemizers dominating existing cohorts.

There are implications for assessment with this approach, as mechanisms would need to be adjusted to provide marks for context research and for showing how this informed the project as well as the fundamental mathematics and physics involved. As importantly, the individual bridge design would need to be able to fail without jeopardizing marks for the students because it would not be pre-tested by the academic. This could add to the subjectivity of the marking, and that would add to the importance of moderation and a trained—preferably diverse in terms of the con-
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tinuum—academic team. However, the benefits could potentially be more engaged, deeper learning outcomes for the entire cohort. In the longer term, this could lead to better retention. Changing the educational paradigm is not without risk or effort and would need to be part of a long-term strategy for the department for which all academics were educated and to which they are committed.

Project Strategies

Rather than focusing on narrowly pre-defined topics, a change in paradigm for engineering education needs to be based on providing students with a broader range of options within a manageable, directed study area. For example, the growing sustainability imperative provides a myriad of project options that would cater for the interests of systemizers and empathizers all along the spectrum. For students focused on fundamentals, the projects could be objective rather than sympathetic, whereas for students self-identifying as more interested in empathetic projects, there would be options for community or environment-based topics. For curriculum reasons, these would still include constraints such as the use of a motor, or levers and pulleys, but the context of the learning would become less rigid.

There are other advantages to this themed approach. Firstly, students would be able to be involved in real-world learning, and that has been found to be an effective learning strategy for engaging students. Secondly, it creates learning situations where the outcomes are not predetermined by the academics, with the students required to contribute more to their own learning. This changes the balance of power in the classroom, moving the academic from the role of expert, to the role of facilitator. This has also been found to be a strategy that empowers learners and improves learning outcomes (Weimer, 2002).

Stepping back from the immediate classroom situation and considering transferable skills, graduate outcomes and the changing nature of problem framing, problem solving and team work characteristic of the emerging professional engineering environment, this approach has the added benefit of supporting the development of pro-active, lifelong learners. Rather than following instructions, learners engaging in a broader project approach such as this, will learn research, decision making and self-reliance as well as problem framing, solving and communication.

Language

As engineering education moves towards experiential learning and project based learning, then there will be more of a requirement for students to communicate and collaborate. If that is the case, then part of the professional development for academics and learning for students in terms of supporting diversity, needs to be
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around understanding and supporting the choices students make, and the values and life experiences behind those choices. This includes creating a safe, yet critically engaged learning environment, and teaching students to provide peer review and feedback on projects that have different priorities and values from their own. Language provides pitfalls for both academics and students in a majority dominant situation. For example, the way that students, including those who identify as LG-BTI, who have been socialized as females will communicate differently from the way students socialized as males will. Studies have shown that language patterns relate to socialization and these can cause communication problems and bias. For example, language patterns typically used by females to make complaints can be characterized as “whining” even when spoken by males. Groups socialized as female will communicate differently from those with members socialized as males. Patterns of communication in minority groups, such as LGBTI, have been found to differ again. Culturally diverse groups also bring language patterns that are inconsistent, and colloquialisms can further complicate communication.

For project work to effectively support diversity, there is considerable groundwork that needs to be conducted within a learning group. The academic needs to establish the working practice, communication and values of the group in collaboration with the group itself. The challenge is to do this in ways that will empower the individuals and not merely re-enforce the views and ideas of the dominant majority. Short lead-in activities and engaging the students in deliberately diverse projects will help to build a shared language and values for the group. This may involve pushing students—and academics—outside their normal practice to deliberately engage in projects from the opposite ends of the spectrum as a way of rebalancing the group and indicating to the majority the level of acceptance for alternative views and interests. However, this is a challenging strategy to adopt and academics need to have experience of managing the discussions this will provoke.

According to Martin and Barnard (2013), women who choose male-dominated careers are likely to switch into gender-balanced or female-dominated careers. One of the reasons the authors describe is that women feel pressured to change their natural behavior in order to achieve in a male dominated environment. For example, Wolfe and Powell (2009) argue that male engineers have particularly negative perceptions of what they consider to be female-typical speech patterns and language. Women were expected to “mirror” male behaviors and attitudes in order to gain acceptance, yet Wolfe and Powell’s (2009) research also found that engineering males were actively more critical of women who made mistakes than they were of their male counterparts. If that is the case, then team working on projects in engineering education without sufficient foundation work will perpetuate gender issues and, based on the research (Martin & Barnard, 2013), contribute to female attrition.
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According to Prescott and Bogg (2011), and re-enforced by the research of Martin and Barnard (2013), women are motivated by different drivers to those of men. They identified men as being motivated by competition through ideas of status, power and social comparison, while women desired to do a their job well, and be recognized for that, and also to positively contribute to the function of the organization. If this is the case, then it also impacts the nature of projects and assessments and how they are organized in engineering education. Projects that have a competitive focus, such as those involving racing cars, or moving freight, are therefore less likely to provide motivation to female students. Projects based on social and community issues, such as improving safety, are more likely to be of interest to females than males.

Martin and Barnard (2013) argue that “organizations need to legitimize women’s characteristics, natural behaviours and values and give them a platform in order to level the playing field for both genders”. Adding in diversity across the gender and cultural spectrums the same imperative applies—to legitimize individuals’ characteristics, natural behaviors and values, and then to provide opportunities for all to excel without compromising, and without being pressured to “mirror” the behavior of a dominant, entrenched majority. Increasing the sense of responsibility for supporting diversity within the engineering community, developing support strategies and networks, investigating responsiveness and increasing awareness of acceptable group behavior is necessary for a genuinely level playing field to exist.

The process of developing a holistic understanding of the issues surrounding gender is complex and potentially endless. Within the scope of this chapter and the topic of diversity in engineering, there can be limited development of feasible solutions for the complex challenges surrounding gender issues. However, it is possible to highlight the values and attitudes that exist within traditional disciplines such as engineering and those who work in the field. Academics can reflect on current teaching practices, how they impact on the diversity of student cohorts and the retention of minority groups—and how those actions and attitudes are contributing to the wider society.

In Davey’s (2008) study, typical masculine behaviour related to success in a male-dominated environment included political game playing, aggressiveness, back-stabbing, point-scoring, overconfidence and “stitching people up”. The mechanisms women use to cope in male-dominated environments include mentorship and adopting participatory leadership styles like being caring, fair and encouraging, which is more attuned to their natural feminine inclination (Chovwen, 2007). Contrary to this, female graduates adopted uncharacteristic masculine behaviour, like self-seeking and individualistic behaviour, to survive (Davey, 2008). Ironically, some opinions point to the detrimental effect of adopting characteristic male behaviour on women’s feelings of authenticity and work identity (Du Plessis & Barkhuizen,
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Therefore, women seem caught between resisting and accommodating masculine politics (Davey, 2008). (Martin & Barnard, 2013, p. 3)

Cultural Diversity

Mā te kōrero, ka mōhio.
Mā te mōhio, ka mārama.
Mā te mārama, ka mātau.

Through discussion we become aware.
Through awareness we gain understanding.
Through understanding we gain proficiency/expertise.

Whakataukī
Culturally responsive learning contexts are those where the learner can bring their own experiences into the classroom context. (Te ManaKōrero: Relationships for Learning, 2007)

The impact of cultural diversity on experiential learning planning goes deeper than providing a choice of projects to suit the interests of different groups of students. It is about academics being willing and able to embrace everything diversity means. This includes being open to the social context influencing the attitudes and values for a particular cultural group, as well as factors such as historical influences, attitudes to technology, customs and ideologies. These factors will impact what the student values, and their approach to framing problems, working through research and experimentation, and their final evaluation of the outcomes, as well as how they present them and communicate the results. This can be challenging for academics.

Even successful teachers can find it difficult to teach students and incorporate content from a culture that is not their own. Teaching for diversity, supporting minority students, and using culturally-responsive teaching practices are well-known concepts (for example, Airini, O’shea, Tarawa, Sauni, Ulugia-Pua, Sua-Huirua, & Curtis, 2007; Bevan-Brown, 2005; Bishop, Berryman, Cavanagh & Teddy, 2009; Cummins, 2001; Gay, 2000; Ramsden, 2003; Zepke & Leach, 2005). However, the transition from understanding the theory to implementing it in practice is often complicated—and when such practice requires teachers to step outside their cultural comfort zones, it can be downright intimidating. (McDonald, 2008, p. 5)

Different cultural groups have beliefs and traditions that will bias what they consider to be important. This is recognized across sub-cultural disciplines within engineering itself, where the priorities and approaches for civil, mechanical, electrical, etc., are different. The Victoria University of Wellington, New Zealand, Strategic
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Plan, 2009 – 2014, emphasizes the importance of recognizing the different learning needs of students by using a variety of teaching approaches and showing sensitivity to cultural issues. Introductory activities to help everyone involved—students and academics—to gain an understanding of the different attitudes in a cohort are necessary prior to engaging in major project work.

Sensitivity to cultural issues requires providing students with an opportunity to illustrate, demonstrate and discuss what these are and where the points of difference may be. For many students there will be a lack of understanding of what the characteristics, attitudes and values of the groups they themselves are part of, and those their peers identify with. Preparatory activities can help students to explore these values and explain them to other students. However, these activities may themselves be fraught with problems. An example from first year studies in the Digital Media program at Griffith University, Australia, illustrates these challenges. It involves a project designed for first year students on George Orwell’s novel *1984* ([1949] 2011). Students were asked to read the text, select a major theme relating to critical production of mass media and discuss, defend and critique their outcome within a group.

Students within this project experienced a number of diversity-based issues, the most dominant of which did not become obvious until after the project was completed. The brief asked students to critique their role within a political system that produced mass media and the relational impact of this upon its consumers. The “dominant majority” of students could relate to this topic within the context of their use of dominant social media (such as Facebook) and critical literature surrounding data collection and an individual’s right to privacy. However, what was not fully considered by the teaching team was the background and political experiences of the cultural minorities. Students with diverse international backgrounds were unable to engage in the topic the same way, believed it was inappropriate, or found it ethically challenging. Within their teams, the minority students found it difficult to engage in all discussions and sometimes became the “quiet non-participator”. In this example, the majority group reflects individuals who have the Western cultural capital, who often had little exposure or knowledge of international differences regarding freedom of speech or laws preventing the criticism of government. They “Western majority” expected their team members to voice their opinions freely and reflect on society in a critical manner and demonstrated little compassion or support to their team members who failed to contribute equally. The marking criteria added another level of majority bias by disadvantaging students who did not participate in critique or discussions.
Classification of Project Work Strategies

Engineering is a practical discipline. It is a hands-on profession where doing is key. Consequently, prior to the creation of engineering schools, engineering was taught in an apprenticeship program modelled in part after the British apprenticeship system. These early engineers had to design, analyze, and build their own creations—learning by doing. (Feisel & Rosa, 2005, p. 122)

The foundations of engineering education began with the apprenticeship model. Practical problem solving and experimentation through engagement with real world problems therefore formed the basis of learning for future engineers. As engineering moved into academia, the practical aspects have become to an extent institutionalized. According to Fiesel & Rosa (2005), engineering laboratories have become less about the exploration of engineering science principles and more about the qualification of data.

When students, especially undergraduates, go to the laboratory, however, it is not generally to extract some data necessary for a design, to evaluate a new device, or to discover a new addition to our knowledge of the world. Each of these functions involves determining something that no one else knows or at least that is not generally available. Students, on the other hand, go to an instructional laboratory to learn something that practicing engineers are assumed to already know. That ‘something” needs to be better defined through carefully designed learning objectives if the considerable effort devoted to laboratories is to produce a concomitant benefit. (Feisel & Rosa, 2005, p. 121)

The recent recommendations of accrediting organizations, such as Engineers Australia, expand the substance of practical work in engineering education from fundamentals testing to project work that includes “engineering ability” and “professional attributes”:

On the basis of previous recommendations by the Engineers Australia as well as national and international research, it is very important and critical that a framework is defined and is unique to Engineering projects. Based on Engineers Australia Stage 1 competencies it is proposed here that fundamental knowledge base, engineering ability, and professional attributes are the key elements of competency and part of the integrative learning principle for a project approach. (Chandrasekaren, Stojecevski, Littlefair, & Joordens, 2012, p. 6)
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However, this definition is limiting. If engineers are to have the “big ideas” of the future, then engagement in practical and project work needs to foster a more ambitious intent for engineering education, and that should drive learning opportunities. Fiesel and Rosa (2005, p. 121) argue “The function of the engineering profession is to manipulate materials, energy, and information, thereby creating benefit for humankind. To do this successfully, engineers must have a knowledge of nature that goes beyond mere theory”. According to Chandrasekaren et al. (2012), project work in engineering education can be organized into three classifications: university-based projects, industry-engaged projects, and community project work. Feisel and Rosa (2005, p. 123) disagree, stating that the three classifications need to be brought together: “A common goal is to relate theory and practice or to bring the “real world” into an otherwise theoretical education”. The differences are essentially based on how the brief is established, sources for research and criteria for evaluation. For university-based projects, students have more freedom to work on their own brief, but potentially less objective research material to draw on. Industry-based projects tend to be more constrained, but the real word context can provide a motivator for students.

Industry projects are project-based activities in partnership with an industry organization. Students complete a research project focused on a given leisure, event or industry issue, problem or opportunity. Students mostly work independently on their selected topics. A teaching and learning approach where individuals conduct work activities (paid or voluntary), including research combined with intentional educational activities. The project involves a substantial research component, which can range from market research such as a questionnaire survey or focus groups, to observation, in-depth interviews or analysis of existing data. (Chandrasekaren et al., 2012, p. 4)

Community projects can be more complex to manage and the outcomes often less clear. However, they can provide students with more understanding of problem framing and project management, as well as problem solving.

These projects provide an opportunity to connect with other students from different faculties and get actively involved in the community. By doing these projects, students will not only be contributing their knowledge and skills towards helping others in the community, but they also gain a range of career related transferable skills such as networking, teamwork, marketing, supervising, coordinating, organizing, public speaking and more. (Chandrasekaren et al., 2012, p. 5)
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As highlighted in the directive from Engineers Australia, the inclusion of project work, and the organization of that project work, in engineering education expands the brief beyond the technical into a collaborative and leadership role in technological and human development. Engineers need to be able to view problem framing, research and problem solving holistically in order to maintain relevance in an increasingly complex professional work environment.

After World War II many of the great inventions that occurred as a result of the war were developed by individuals educated as scientists rather than engineers. The ASEE chartered a committee to “…recommend patterns that engineering education should take in order to keep pace with the rapid developments in science and technology and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter century”. (Feisel & Rosa, 2005, p. 122)

A key issue here is the ability of engineers to be able to look at problem solving without traditional discipline boundaries and limitations. They need to be able to contribute productively to teams working on increasingly complex, cross-disciplinary problems.

…engineers who can speak many languages—and I don’t mean French or Mandarin; I mean the ability to talk to lawyers, users, and policy makers—those were the most effective engineers. (Holmes, 2015)

In addition to building multidisciplinary teams, greater diversity in conventional engineering teams will provide new perspectives. This is a key issue identified for other disciplines where minorities—in engineering-related disciplines, these often include women—are under-represented.

If you have women on the design team, you’re more likely to get discussion about privacy side effects and human/computer interface. Having a diversity of views and experience always leads to better results. (Holmes, 2015, p. 26)

In providing alternative viewpoints, diversity can challenge the ethnocentricity that can occur in majority-dominated groups. The recognition that there are alternative attitudes and modes of practice support the development of positive graduate attributes for internationalized professional practice. However, it is not enough to simply improve diversity within members of a learning group, the academics need to actively provide learning opportunities that provide positive re-enforcement of ideas, attitudes and preferences different to those of the dominant majority. In order
to swing the pendulum back to the middle, arguably academics need to deliberately push the pendulum of the characteristics of learning experiences to the other side of the arc.

**Engineering Empathy**

In reviewing the profile of project themes in engineering education, one of the key characteristics is the reliance on competition and speed as a basis for project work. Racing cars—model and full size—is a recurring theme in engineering education. While there will be female students who are motivated by the same elements that drive an interest in competitive sport, there will also be females and males for whom the motivations are more subtle. Yet, if considered objectively, this can be seen as a gender bias, rather than based on genuine constraints imposed by the discipline. Deliberately choosing projects that have their foundations in feminized interests and activities sends a clear message to students that such projects are acceptable and even—ideally to help reset opinion—encouraged. Project work in areas that are less overtly feminized can also provide respond to the drivers that research identifies as motivators for women more than men.

Projects with foundations towards the empathy end of the continuum can be less overtly embedded in feminized areas of interest, but still provide a response to alternative motivators than competition. A good example would be project work that is linked to working with life-improvement for animals. One approach would be to combine opportunities for students to choose to work with sports technology and animal husbandry within the same project. For example, with projects framed from a review of the horse racing industry. From transport, to the construction of jumps, to safety barriers, to racing helmets, to the development of racing shoes, innovations in the treatment of leg breaks and the movement of horses for vets—a single theme can provide for a broad range of interests without being overtly one type of project or another. Even if this approach caters for one additional student, and the majority still choose projects that are competition based, or purely mechanically driven, it will provide the opportunity for those with more diverse interests to study engineering and new ways of looking at engineering problems in the world.

*Engineering is really just a way of thinking about things. And when you go out in the real world after class, you see things differently. It’s really cool to know what goes on behind the scenes in your everyday life. Engineers shape the world that everybody else lives in. They don’t just live other people’s ideas. And to be a part of that creation, to me, is just awesome. (Lindsay Perry on Engineer Your Life, 2016)*
This approach would not only provide for diversity, it would contribute to the broader shift in paradigm for engineering education advocated by researchers in the discipline:

A cultural change is warranted in engineering, as is reform of the established theory-based curricula; currently there is little emphasis on experiential learning through design or the development of creativity. By contrast, design pedagogy fosters creativity by developing and nurturing problem-solving skills and providing regular opportunities for students to refine these skills through experiential project-based learning. Creative activities such as “reflection in action”, problem framing, divergent thinking and open-ended problem solving are integral to the designer’s education, but are notably absent from engineering curricula. Yet creativity is central to innovative problem solving and as such should be integral to the education of engineering designers. To be creative, engineers must desire uniqueness, accept unusual ideas, tolerate the unconventional and seek unexpected implications. In this regard, the engineering community can benefit from close observation of design pedagogy. (De Vere, 2009, p. 1)

Projects that are deliberately embedded in cross-cultural situations can provide students with learning’s that challenge their conventional perspectives. The fundamentals can be taught within an extreme variation of contexts; for example, based on an extreme challenge, such as supporting the latest generation of Gurung tribes people in Nepal. For centuries, the Gurung people, who live near Lamjung in the Himalayas, have scaled the severe cliffs to harvest honey from hives from underneath overhangs. However, this tradition is dying out because of the dangers associated with the climb. The feats of engineering required to tackle the task, plus the social issues around the changing priorities of young people in the area combined with the threats—and opportunities—of tourism, provide technical and social challenges. There are issues involved with teaching a project based in a different country that can impact the experiential learning involved—and the latest research into the detrimental impact of volunteer tourism (Loy, Tatham, Healy, & Tapper, 2016) discourages direct involvement of students with projects in remote regions—but academics can take the essential basis for the project brief and adapt it to their students’ learning environment, and still have the opportunity to bring in learning on alternative cultural perspectives, and human-centred engineering. The mechanics involved would remain the same, while the context would provide a fresh approach to learning the fundamental principles. Feisel and Rosa (2005, p. 121) assert “the overall goal of engineering education is to prepare students to practice engineering and, in particular, to deal with the forces and materials of nature.”
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Mixed Messages

But it has few women, few minorities and far fewer women than other areas of computer science....this creates a chilly climate for both women and minorities. (Holmes, 2015, p. 27)

Marketing engineering to females is currently full of curiously mixed messages, from “Girls Only” days (“Girls’ Day” 2016), which suggest that girls will not engage in a normal open day and yet somehow then cope with a predominantly male cohort, to images of women in hard hats contrasting the bright colourful graphics chosen for certain websites targeting girls for engineering (Engineer Your Life, 2016).

This confusion may in part be caused by confusion within the profession itself as to how it markets itself. The reality is that, as for all diversity issues, rebalancing the profile of those in power—in this the academics and professional leaders in engineering—there will always be confusion. For engineering more than other disciplines, this seems to be a challenge, which could in part be due to the funding-related priorities for appointments.

As so many engineering programs have developed an increasing interest in research, the faculty reward system, in the opinion of many, has shifted away from recognizing contributions to undergraduate education and toward rewarding research productivity. (Feisel & Rosa, 2005, p. 123)

During a series of interviews conducted by the author with potential engineering academics the response to a question on what the candidate would do to address the gender imbalance in the undergraduate engineering program, responses included the repeated comment that it would be good to have more women as they “make everything so pretty”, that women would not be interested in engineering because it is a “dirty” job, and that women are “incapable of the thinking required for engineering”. On questioning, it was found that many applicants had never taught a female, nor worked with a female, nor published with a female. This appeared to be a particular issue in relation to candidates from cultures where the opportunities for women were restricted and there were gendered expectations in the workplace.

Furthermore it also provides empirical support for the idea that the salience of gender varies across contexts, so that not only countries but also communities differ from one another in the extent to which traditionally gendered status expectations shape beliefs and behaviors (Deutsch, 2007). In communities where a higher percentage of working women are employed in STEM occupations, larger gender stereotypes at the societal level may be subverted by a picture of what is possible that differs from that typically associated with more traditional gender roles. Such
alternative definitions of gender likely permeate the interactions and experiences not only of high school girls, but those of parents, teachers, and men and women throughout the community. (Riegle-Crumb & Moore, 2013, p. 268)

Standardized tests recorded in the US confirm that in schools girls score just as well as boys in mathematics (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). Yet while statistics based on research in the Netherlands reinforce mathematical parity, with 48% of undergraduate degrees in mathematics being achieved by females, the same research shows that the perception that females lack mathematical ability still persists in parents and teachers. Men remain highly over represented in science-based subjects in higher education—in particular engineering—whereas women are over represented in medical studies and social sciences (Riegle-Crumb & Moore, 2013). One argument is that personality types associated with gender socialization could be a factor. Research conducted in Austria suggests that different personality characteristics on their own continuum, such as extravert to introvert, are identifiably related to different professional interests and preferences (Boone, van Olffen, & Roijakkers, 2004).

Several studies have shown that there are significant differences in personality characteristics between boys and girls (e.g., Costa et al. 2001 for an international comparison in 26 cultures across the world; Goldberg et al. 1998 for a U.S. sample; Hendriks et al. 2008 for a Dutch sample). Scholars often use the Big-Five factor structure of Goldberg (1993) to describe people’s personality characteristics, using five dimensions: Extraversion, Agreeableness, Conscientiousness, Emotional Stability (or inverse Neuroticism), and Openness to Experience (NEO-PI-R; Costa and McCrae 1992) or Autonomy (FFPI; Hendriks et al. 1999a,b). (Korpershoek, Kuyper, & van der Werf, 2012, p. 623)

How quantifiable this is, and how much it is predetermined by nature versus nurture is still the subject of debate, but nevertheless it highlights the importance of ensuring that the learning environment and the professional working environment are overtly driven by open-ended learning experiences that do not favour one individual over another.

RECOMMENDATIONS

Despite an increase in calls for reform of engineering education, engineering faculties continue to focus somewhat narrowly on the science of engineering, without sufficient curriculum opportunities for students to develop either design skills, or creative methodology. Design is fundamental to engineering practice, and therefore should be a motivating factor in engineering learning. Without focusing on design activities and creativity, we will continue to graduate engineers who are competent
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Technically, but not prepared for the practice of engineering nor the challenges of the 21st century. (De Vere, 2009, p. 1)

The essential recommendations for meeting the needs of student diversity through project opportunities for students are based on challenging the stereotypes that currently dominate project selections. Rather than replacing the current selection of projects with a broader range of projects that could label the student who chose the ones less stereotypical for the group, the recommendation is that academics develop an approach that allows for gradations in project work along a continuum from those appealing to pure systemizers to those drawn to empathetic projects, and a mix of projects in between. This allows students to self-identify academic practice and theory that meets their interests and breaks down a binary division between project profiles. Ideally, students would be encouraged to work across overlapping and related projects, and where possible identify shared research foundations on which they could build collaborations.

We collaborate all the time. If we didn’t, we’d be lost! And once you get out into real-world engineering, it’s not just going to be one engineer working on one problem. Collaboration is important. And that means communication skills are really important. You have to be able to present your ideas effectively. (Reeves, 2016)

Ideally, projects should introduce new topics each time. These would allow students to genuinely engage with challenges that are new to the department and academics, and also reduce the ability of students to plagiarise the work of their peers. Ideally themes should provide opportunities for students to genuinely engage with the work from a particular point of view. They could explore and explain their perspective without being penalized for being different to that of the academic or a dominant majority within the cohort. One approach is to constantly engage with real-word developments for project themes. For example, based on emerging technologies and theory on the development of future cities. Legge (2012) discusses developments that provide good examples for rethinking practice as project starting points. These include themes such as “collaborative urbanism” and the “pop-up movement”. Other themes suitable for working across the systemizer to empathizer spectrum are identified in the 2015 publication 31 Brilliant Ideas for a Better World (Nolan & van Lier, 2015), including “Emergency Building for People in Need” (p. 28), “Building Block for Habitat” (p. 68), and “Saving Nature by Designing It” (p. 78). By focussing on project work that has no traditions attached, students will be free to develop their own learning without prejudice. Riegle-Crumb and Moore (2013, p. 253) suggest “Local environments have the capacity to construct their own micro-level gender systems where individuals are less constrained by traditional
definitions of gender”. By providing projects that are less predetermined, more complex and require students to practice their interpersonal skills as well as demonstrate technical knowledge and research, engineering education is responding to the needs of the profession in repositioning it as outward looking, and engaged for the emerging inter-disciplinary context most engineers will be working in for the future. This repositioning should help universities to attract students with a wider range of attitudes and personalities to re-invigorate the profession as at the forefront of innovation and real world problem, community-based engagement.

The study of Morgan et al. (2001), for example, found that college students in the U.S. perceived science-related careers as less likely to afford interpersonal goals such as helping people. A practical implication of the results presented is that, as a consequence of the overrepresentation of the more introverted students in the SCIENCE profile, stimulating introverted students to choose the SCIENCE profile in secondary education might be more effective than trying to convince extraverted students to pursue a math/science career (Korpershoek et al., 2012, p. 12)

CONCLUSION

It is difficult to discuss diversity and inclusion without straying into assumptions and stereotypes. As discussed in this chapter, it is more beneficial to consider all students as individuals and provide an education that caters to a full range of personalities, interests, backgrounds and social groups. What engineering as a profession and academic discipline must not do is ignore the lack of diversity in cohorts and the attrition of students. As with all disciplines where a majority has dominated for generations, the reasons are deeply embedded and complex. Changing attitudes requires professional development and open collaboration and engagement. Positive discrimination could help to redress the gender balance for academics, which would in turn help support a more diverse cohort, but ideally the rebalance would come from a repositioning of the discipline to respond to the changes required for the evolution of the profession worldwide. By changing the priorities for the profession, the discipline faculty would change, as would the basis for project work, and subsequently, with appropriate marketing, the profile of the students interested in the degree. It is a long-term challenge, but one that engineers and academics need to engage with in order to maintain the relevance of the subject, and keep engineering at the forefront of leadership in an evolving world.
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REFERENCES


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KEY TERMS AND DEFINITIONS

**Diversity:** The state of being different, a point of difference.

**Dominant Majority:** The driving sub-group within a larger group, based on size or profile.

**Empathy:** An understanding of another person’s feeling and the projection of oneself into the situation of another to help that understanding.

**Ethnocentricity:** A belief that one’s own culture is superior to others and central to activities.

**Experiential learning:** An approach to learning based on activity and reflection.

**Gender bias:** Sociological prejudice that is based on gender.

**LGBTI:** Refers to individuals who identify themselves as lesbian, gay, bisexual, transsexual and / or intersex.

**Paradigm:** A pattern or model of typical or stereotypical examples.