Where are the Women in Mineral Processing?

KATHRYN HADLER
Department of Earth Science and Engineering, Imperial College London,

Introduction

Throughout my career in the minerals processing academic community, it has often seemed that women are in a minority, both in terms of presence at meetings and conferences, and on site. In this study, I have set out to quantify the number of women in mineral processing, using data on those graduating with mineral processing degrees, delegates lists from selected conferences and other sources (namely the Minerals Council of Australia report 'Unearthing New Resources'). The purpose of this study is not to propose reasons for or solutions to any indicated imbalance, but to draw attention to the numbers of women in the industry, in order to generate discussion on the topic of attracting and retaining a broad diversity of skilled workers and innovators.

The Gender Diversity in Positions of Esteem

In order to quantify the proportion of women working in mineral processing (both academia and industry), we can look first to the International Mineral Processing Council; the body whose "principal purpose" is to "maintain oversight over the various formal activities of the international mineral processing community and to represent the views of the international community of mineral processors" (www.impc-council.com). The council comprises 18 members, predominantly from the academic community, of which one member is female (Diana Drinkwater) (www.impc-council.com). This means the proportion of

women on the council is 5.6%. While this might seem low, does it represent reasonably the gender diversity of the industry?

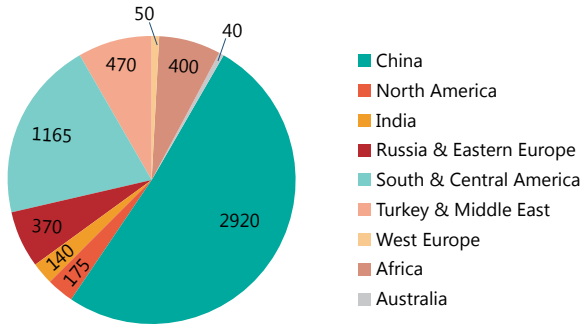
Another source of data on gender from what could be described as a position of esteem within the industry is the stream and symposia chairs of the recent IMPC in Quebec City. There are many such conferences that could be used as an example, however since the IMPC is promoted as the biggest gathering of mineral processors worldwide, then it is a suitable benchmark. In the conference proceedings, there are listed 36 people involved as technical and symposia chairs, of which 3 are women (Proceedings of the XXVIII International Mineral Processing Congress (2016)). This makes the proportion of women involved 8.3%. This is clearly higher than the 5.6% present on the Council, but is it more representative of the industry as a whole, or does it reflect simply the proportion of women at higher positions within the sector?

The Gender Diversity of Mineral Processing Graduates

At the XXVI IMPC held in 2012 in New Delhi, India, a symposium was held on Human Resource Development. As part of this symposium, a survey was carried out to investigate the supply and demand of minerals engineers as at 2010 (Cilliers, 2013). One of the questions asked in this survey was regarding the proportion of female graduates in mineral processing subjects, therefore giving a good indicator as to the supply of females into the mineral processing sector. It should be noted, however, that not all countries/regions deliver mineral processing specific degree programmes (either undergraduate or graduate), nor were the data exhaustive. Nevertheless, this gives a good benchmark for quantifying the proportion of women entering the industry.

Figure 1 gives a breakdown of the distribution and numbers of mineral processing graduates produced by the different countries or regions that contributed to the survey. While China dominates with 50% of the graduates, it is interesting that countries/regions with significant mining industries (Australia, North America) produce relatively few mineral processing graduates. This is discussed further in the original study (Cilliers, 2013).

Figure 1: Distribution and numbers of mineral processing graduates by country/region (adapted from Cilliers, 2013)



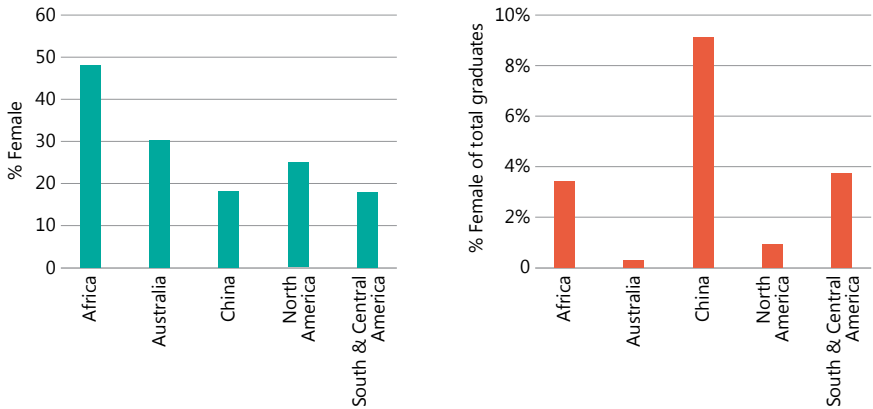
With regards to the proportion of female graduates, Figure 2 gives the proportion of women graduating from mineral processing degree programmes from selected regions where data were provided. This represents around 82% of the total number of mineral processing graduates, with data from India, Russia and Eastern Europe, Turkey and the Middle East, and Western Europe unavailable. On the left, the data show that the African region produces mineral processing graduates comprising almost 50% women, while China and South and Central America both have female participation of 18%. Considering the data supplied, all countries/regions produce mineral processing graduates with a significantly higher proportion of women than are represented at positions of esteem in the community (i.e. IMPC, technical stream chairs). Comparing the numbers in this way does not give any indication of changes over time; it might be assumed, for example, that numbers of women entering and working in the industry have increased in previous decades. It does, however, start to give an indicative number of the proportion of women in the mineral processing industry.

On the right in Figure 2 is the estimated proportion of women graduating from mineral processing programmes by country/region as a fraction of the total production of mineral processing graduates globally. It should be noted that these data are calculated on the basis that all countries/

regions in Figure 1 are represented (i.e. the 18% of mineral processing graduates for which no data were available on the numbers of females included no women).

In total, using the available data, the proportion of global mineral processing graduates that are female is estimated as 17.2%. This is based on the above assumption, however if we assume that the five countries/regions in Figure 2 are representative of the whole supply of mineral processing graduates, then the proportion of women rises to 20.9%. This is broadly in line with the proportion of female engineering undergraduates in the UK, at 16.1% (Equality in Higher Education: Statistical Report, Part 2: Students, 2015). As a point of comparison, in the same UK study, 39.6% of physical sciences undergraduates were female.

Figure 2: Proportion of female graduates in mineral processing (LHS) and contribution of female graduates to total supply of mineral processing graduates (RHS) by country/region (adapted from Cilliers, 2013).

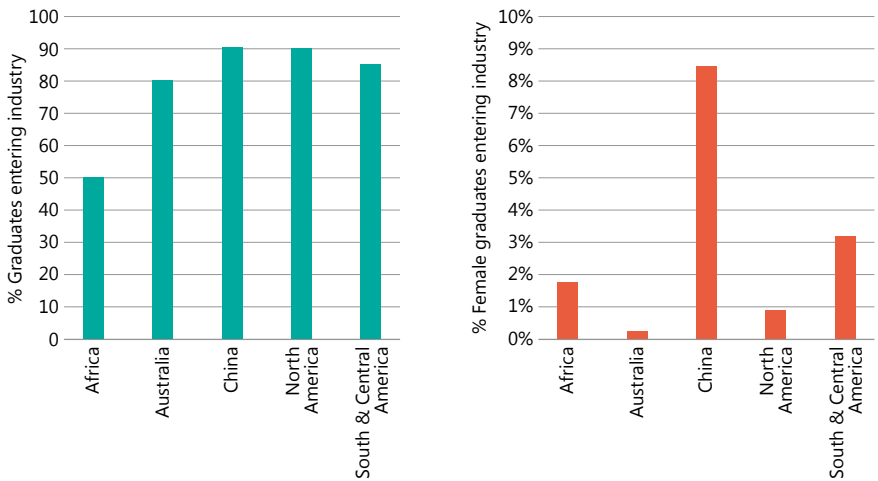


In the supply and demand study from the IMPC Commission on Human Resource Development, the survey included a question on the number of mineral processing graduates entering industry; these data are shown in Figure 3 (on the left). Of note here is the low fraction of African mineral

processing graduates entering industry, at 50%. It is thought that this low value is related to other industries (e.g. financial) being attracted to the skillset acquired by mineral processing/engineering graduates. Across the other countries/regions where data were available, the uptake of graduates into industry is estimated as being between 80 and 90%. Taking these values into account, the proportion of women entering the mineral processing industry directly from mineral processing degree programmes is 13.9% (based on no women entering the industry from countries/regions where no data were available) or 19.9% (based on the five countries/regions representing the whole supply). The lower value represents around 1 in 7 graduates entering the industry being female, while the higher value is 1 in 5. It is likely that the "true" value lies between these limits.

The data gathered in the IMPC Commission suggest, therefore, a value for the proportion of women entering the industry with a mineral processing degree of between 13.9% and 19.9%.

Figure 3: Proportion of female graduates entering industry (LHS) and contribution of female graduates to total supply of mineral processing graduates entering industry (RHS) by country/region (adapted from Cilliers, 2013).



The Gender Diversity of Delegates at Mineral Processing Conferences

The data investigated so far give an indication on the proportion of women entering the mineral processing industry, and those at positions of esteem, however we can also use those attending conferences as a reasonable indication of the diversity of the industry. Using delegate lists from selected MEI conferences (http://www.min-eng.com/), it is possible also to obtain an indication of the gender diversity of the different sectors within mineral processing, both in terms of academia/industry split and by the specific field (i.e. Flotation, comminution, process mineralogy).

As with all data, there are assumptions and caveats that have been made in order to draw broad conclusions from the information. These are as follows:

- People attending conferences have a range of backgrounds (e.g. non-technical, sales etc.)
- People in mining and mineral processing tend not to work in the same country from which they graduated
- Many people enter technical and academic mineral processing roles from backgrounds such as chemical engineering
- There is no classification of hierarchy in the analysis; i.e. a professor and PhD student count equally as "academic"
- Delegates representing industry will typically be those at higher positions within the organisation; this may not reflect accurately the gender diversity of a company/the industry
- Some names may have been misplaced

With these assumptions and simplifications in mind, in the following section, we estimate the demographics of delegates at five MEI conferences: Flotation '03, '07, '15, Comminution '14 and Process Mineralogy '14.

Flotation Conferences

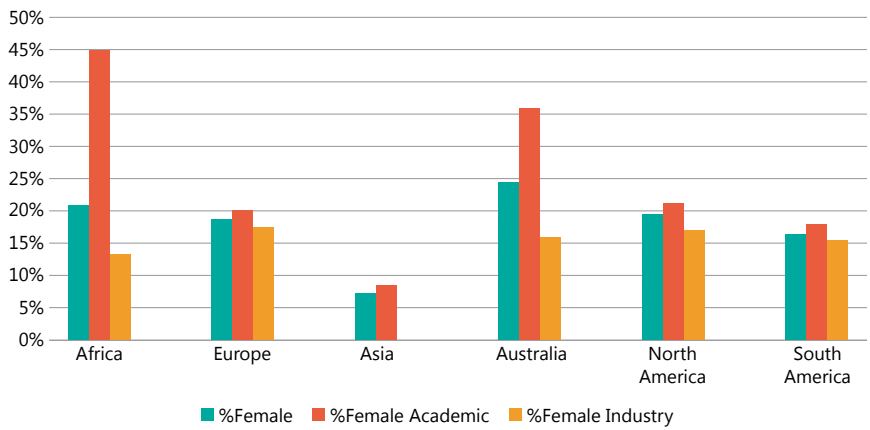
The breakdown of female delegates attending the Flotation '15 conference, held in Cape Town, by region and by sector (i.e. academia or

industry) is given in Figure 4. Overall, there were 238 delegates, of which 64.3% were from industry. The greatest geographical contributor of delegates was Africa, which is to be expected given that the conference was held in South Africa.

Considering only the female delegates, it is noticeable that the proportion of women in academia attending the conference is higher than those representing industry, for all regions, but particularly Africa. The percentage of academic women attending from the African region shows good agreement with the proportion of female mineral processing graduates from the same region. The difference between academic and industry female delegates is also particularly notable for Australia. There are a number of possible explanations for this difference (e.g. those in academia at all levels are more likely to attend conferences, more attractive working conditions in academia), however it is beyond the scope of this study to investigate the causes.

Considering all delegates, the proportion of women was 18.9%, with 27.1% of academic delegates being women, compared to 14.4% of industry delegates.

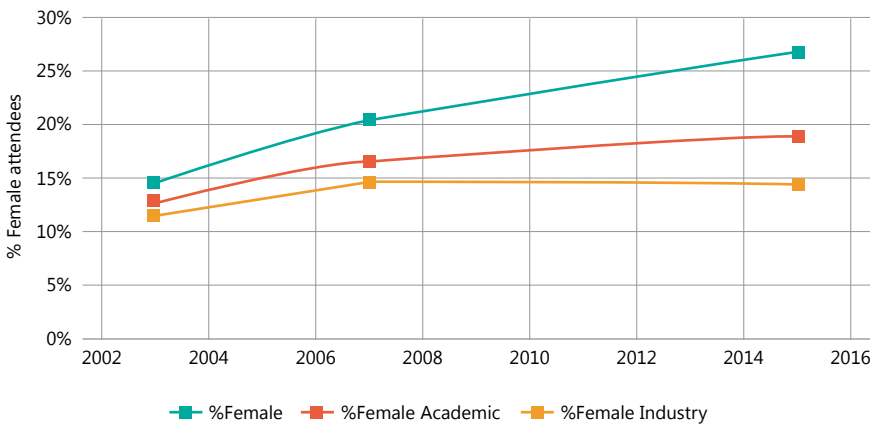
Figure 4: Proportion of female delegates at MEI's Flotation '15 by sector and region



It is also interesting to study the demographics of delegates to the same conference series over time; to this end Figure 5 shows the proportion of female delegates attending Flotation '03, '07 and '15. A point to note is that the 2003 conference was held in Helsinki, while 2007 and 2015 were held in Cape Town. Consequently, in 2003, 65% of delegates were European (with only 5.5% European female delegates from industry), while in 2007, 47% of delegates were African. In spite of this change of location, it can be seen that while the proportion of female academics has increased over time, from 14.3% in 2003 to 27.1% in 2015, the attendance of industry women has remained broadly constant at around 14.5% (with 11% in 2003). Overall this results in an increase in female delegates from 12.5% in 2003 to 18.9% in 2015.

The data suggest, therefore, that there has been a general increase in the proportion of women in mineral processing, specifically flotation, in recent years in academia, but that the numbers in industry remain relatively constant, at 14.5%. This number correlates well with the lower estimate of women graduating with mineral processing degrees that enter industry (13.9%).

Figure 5: Proportion of female delegates attending MEI's Flotation '03, '07 and '15 conferences



Comparison between conferences

Flotation is a complex process, involving chemistry, surface science, hydrodynamics and multiphase flow, to name just a few of the many fields within the subject. It is helpful, when considering the numbers of women in mineral processing, to include also other disciplines, namely comminution and process mineralogy.

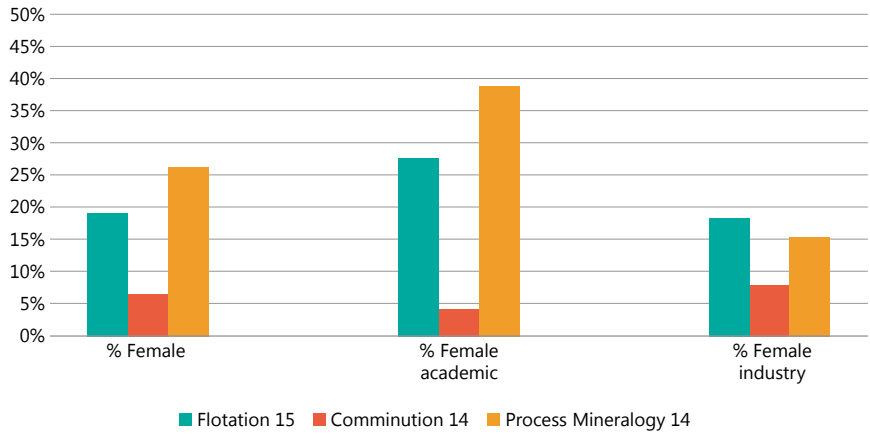
A comparison of the gender balance of the three most recent MEI conferences held in Cape Town in these fields is given in Figure 6. Overall, it has been shown that 18.9% of delegates at Flotation '15 were female; Process Mineralogy '14 (total number of delegates: 74) had a total of 25.7% female attendees. This originates in the significantly higher proportion of female academics in this field, at 38.2%, as industry contributed 15% female delegates. The industry value of 15% is strikingly similar to that for the flotation conferences, showing good agreement with the lower value for female mineral processing graduates. The field of comminution, on the other hand, appears to attract a much lower proportion of women, across both academia and industry. At Comminution '14 (total number of delegates: 229), just 6.6% of the delegates were female; in this case, academic women accounted for a lower percentage (4.0%) than did industry women.

While the possible reasons for this will not be speculated here, it can be assumed that the three conferences give a reasonable cross section of the general make-up of the mineral processing community. Weighting the data by number of delegates attending the three conferences, therefore, the total proportion of female attendees was 14.6%, with 18.8% from academia and 11.5% from industry. This suggests the number of women in mineral processing lies at approximately 1 in 7.

Other Studies and Future Prospects

A comprehensive study on attracting and retaining women in the Australian minerals industry was published by the Minerals Council of Australia in 2007 (Unearthing New Resources, 2007), separated into three sections focusing on young women and career expectations, the expectations

Figure 6: Proportion of female delegates attending Flotation, Comminution and Process Mineralogy conferences by sector



of female mining engineering and mineral processing students, and the retention of women in the mining industry. While considering the mining industry as a whole and Australia only, the report states that 18% of the workforce in the sector is female, with just 3% of on-site workers being women. The value of 18% is broadly in line with values of female mineral processing graduates and conference delegates, however it must be considered that this is for the Australian mining sector overall, including corporate and technical roles.

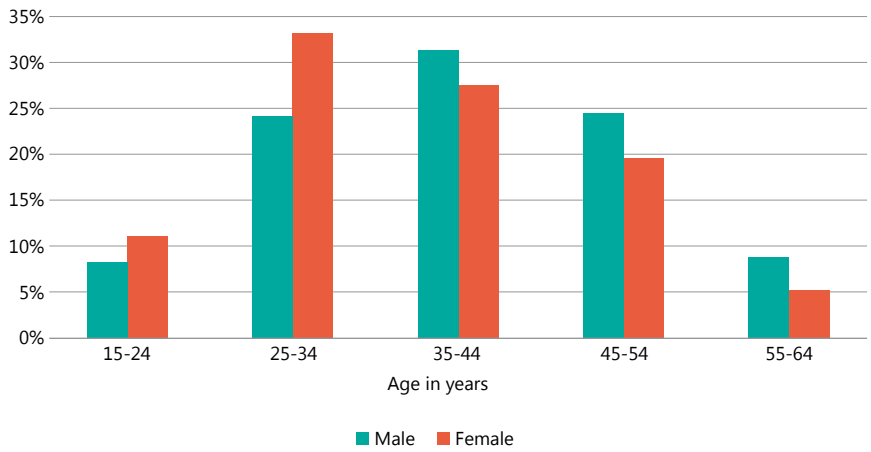
Of particular note in the report is the distribution of workers across age groupings, reproduced in Figure 7. Here, it can be seen that the 25-34 age group provides a third of the female mining sector employees, following which there is a significant drop-off. For men, on the other hand, there is a normal distribution of employees by age group, with the greatest contribution from the 35-44 age bracket. The differences in the distribution of female mining workers compared to male workers suggest that women attracted into the industry tend to leave beyond the age of 34. This is likely to be linked to caring responsibilities. The report suggests that lack of

flexible/part-time working and cultural behaviour are reasons behind this skewed distribution.

The data do, however, support the numbers presented in this study; while the proportion of female mineral processing graduates entering the industry is likely to be between 13.9% and 19.9%, the proportion representing industry at mineral processing conferences is around 11.5%. Academia has a higher fraction of women, at 18.8%, however there is variation in the discipline within mineral processing. In the positions of esteem, the numbers drop considerably to 5-8% according to the (relatively limited) information used here.

While it is beyond the scope of this study to suggest whether the numbers of women in the industry is problematic, or whether steps should be taken to address any issues raised, the data do highlight the need for discussion of this topic. In order to attract the next generation of skilled workers and innovators into mineral processing, we need to be attracting into and retaining a diverse range of people in the industry.

Figure 7: Distribution of age groups for male and female employees in the Australian mining industry (taken from Unearthing New Resources, 2007)



Summary and Conclusions

This study set out to establish the approximate number of women in the mineral processing industry, with the aim of stimulating discussion on the diversity of the industry as a whole, including the attraction and retention of women. Using available data from previous studies (the IMPC Commission on Human Resources and the Minerals Council of Australia report), in addition to delegate lists from selected mineral processing conferences, it has been shown that the proportion of women graduating from mineral processing degree programmes and entering the industry lies between 13.9% and 19.9%, while delegates at conferences comprised 18.8% women. The proportion of women from academia is greater than those representing industry at conferences across all disciplines within mineral processing, however there is a large degree of variation between the disciplines. These numbers are not reflected in the proportion of women in positions of esteem (e.g. Technical stream chairs, IMPC), however this study represents a snapshot in time. It might be assumed that this may change over time.

While this study did not set out to investigate the topic in any further depth, it is hoped that by increasing awareness of the diversity of the industry, we can seek to attract and retain the skilled workers and innovators that are required to meet the broad range of challenges this vital industry will face in the future.

Acknowledgements

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