

A Diversity Lens on the Last Decade of the FIE Conference: Role Models for the Engineering Community

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Abstract—Earlier studies have analyzed FIE and the community built around it, e.g. the origin, format, and future direction of the conference. We propose a new lens: that of diversity, with the motivation of identifying potential role models or the lack thereof. What is the evolution of the presence of diverse role models in FIE throughout the last decade? In this paper we analyze data containing the list of participants in the last 11 years of FIE. Since gender is not part of the registration form, we assume the gender of each participant based on the traditional gender assigned to their name. For the same reason, we use the traditional view of gender as binary. The results include the annual number of men and women attending the event, the attendees' roles in the conference divided by gender, the diversity in attendance based on the geographical location of the attendees' affiliations and the intersection with this aspect of the previous categories. We discuss future directions for the improvement of diversity in FIE and present possible expansions of this study.

Keywords— *FIE history; engineering education; diversity; gender; role models*

I. INTRODUCTION

The Frontiers in Education conference (hereafter FIE) and the community built around it have been the focus of earlier studies and discussions. Aspects such as the origin, format, and future direction of the event have been analyzed [1, 2, 3]. Studying a community is essential to contribute to its development, and to identify strengths and areas of improvement. An example of this line of research is Simon's work on Koli Calling [4]. In his bibliometric study, Simon examines different aspects and their evolution throughout the 15 years that comprised the life of the conference. He answers questions regarding who the people belonging to this community are, the ways in which they contribute, and the countries from which they come.

This paper builds on this idea of analyzing attendance to a conference throughout a substantial number of editions of the event. We, however, propose a new lens: that of gender, with a particular focus on diversity. The aforementioned studies and panel on FIE tackle diversity, including gender, but only from the perspective of how to improve it in engineering education (study programs, etc.), not as an internal look at FIE. During FIE 2016, we realized that the number of women attending the

conference seemed to us to be higher than the number we are used to seeing in other scientific gatherings in the area. We then became curious: What was the women-men ratio at FIE? Were there any differences between their roles and the men's at the event, e.g. the men tend to present papers and be in panels while the women tend to be just attending, or perhaps there are more female than male exhibitors? Given the efforts around the globe for gender equity in engineering, has there been an increase in female attendance and authors over the years?

The motivation behind this choice of approach was to identify potential role models - or the lack thereof - for the community, particularly for women. There are many examples in the literature addressing the role of role models for young girls and women to start and persist in their studies in engineering, e.g. in computer engineering [5, 6]. The same argument can be applied to women in the later stages of their professional career: while they may look for models with different traits and skills than they may have admired in their first years in the field, there is still a beneficial outcome in identifying strategies that have worked for professionals who have already achieved these women's desired goals.

Although succeeding without a role model is possible, their presence is a welcome kind of support. This is particularly true for underrepresented groups. Role models embody the reality that members of these groups can indeed have a career in engineering. If these members have internalized damaging stereotypes, learning about a role model can help them question these beliefs and look for ways to achieve their goals in engineering. For the same reason, these role models can spark the change of unconscious biases in members of majorities as well. While women may benefit more from a same-gender role model, men gain from female role models as well. Following a similar line of reasoning, it becomes apparent that the community as a whole will only benefit from increasing its diversity in terms of not only gender but also ethnicity, class, etc.

The availability of role models may be a challenge, especially in communities that are not as heterogeneous as desired. It may require a special effort to provide both students and professionals with a diverse range of role models, and particularly with the opportunity to see them in person and interact. However, the scientific community recognizes

conferences as a great platform for this kind of encounter, including this exchange of good practices and inspiration. It then becomes interesting to analyze: What is the evolution of the presence of potential female role models in FIE throughout the last decade?

As mentioned above, gender is only one of the dimensions that can be explored. We consider identity from an intersectional approach, i.e. a person as multiple identities together. The experiences and needs of a woman may vary depending on her ethnicity, cultural background, socioeconomic status, etc. In this case, given the data available through registration to the event, we were able to consider perspectives other than gender, such as the country of origin of the participant's affiliation and the role of the attendee in the conference.

II. BACKGROUND

In Simon's study of Koli Calling [4], the community built around the conference is analyzed. In particular, he takes a closer look at recurring participation through authorship. He claims that one of the characteristics of a community is that individuals come back to the event, as opposed to a different list of attendees and authors each year. Our study takes inspiration from Simon's, including his analysis of the countries in which the attendees work.

One of his motivations for this geographical analysis of Koli Calling is answering the question: can this event be considered an international conference, having always been held in the same country? The same question can be asked about Frontiers in Education. Having English as the conference language, an obvious choice for FIE, was one of the factors that led to Koli Calling expanding to an international audience.

FIE's history comprises over 40 years. The conference had its first edition in April 1971. Since then, there has been an edition of the event every year. Most editions have taken place in North America, primarily in the US. The few exceptions to this rule are 1974, when it was held in London; 1990, in Vienna and Budapest; and 2014, in Madrid, i.e. all the exceptions have been in European countries and the conference has not been held outside of these two continents. While FIE started with an attendance of approximately 100 participants, nearly all based in the US and male, today the average attendance is closer to 600, from about 20 nations and with women and minorities participating [1].

Jones presents FIE as a conference for those interested in engineering education as a profession, to evaluate their efficacy as faculty [2]. He also describes it as "a friendly venue for authors and attendees alike" [1]. While the atmosphere in the conference may be perceived in different ways by different attendees, there are some factors that may aid in increasing this feeling of inclusiveness. First-time attendees are given the option to add to their name tag a tag reflecting their first-timer status. The intention is for others to react to this tag by welcoming these attendees to the community, introducing them to the conference culture, etc. Other tags include the labels speaker/presenter, award receiver, program committee, etc. These tags may help attendees identify potential role models depending on the attendee's goals.

How do we define the term role model? It has been inconsistently used and loosely defined [7]. There are studies that point out how the different interpretations that individuals may give to the term, even when provided with a common definition, lead to confusion [8]. The definition has evolved and incorporated different characteristics that researchers believe make for an effective role model. According to Gibson, role models are "person(s) an individual perceives to be similar to some extent, and because of that similarity, the individual desires to emulate (or specifically avoid) aspects of that person's attributes or behaviors. Individuals attend to role models as possible exemplars of the professional skills and personal attributes needed to achieve desire". Gibson also defines the different stages in a professional career and how our search for role models varies depending on the stage in which we are at that moment [7]. This is yet another argument for providing a community with a wide range of role models, considering diversity from many different perspectives.

The individual's self-perceived likeness to the role model is significantly related to self-esteem, particularly for women [9]. College-age women who have role models have higher self-esteem than those who lack them. Women also rate their role models as more important than men do [10]. What are aspects that contribute to perceiving similarity between the individual and the role model? Profession and career choices are some of the possible connections, as are gender and background. In Lockwood's studies, women were more inspired by female than by male role models, while for men gender did not determine the impact of a role model [11]. But when the goal is to convey that women can also be successful in STEM fields, the gender of the role model may be less important than the extent to which they represent STEM stereotypes [12].

Lockwood and Kunda add the issue of attainability. Self-enhancement and inspiration from a role model may be provided if the person seeking this role model not only sees them as relevant for their goals or needs, but also if the role model's success seems attainable. Either we think that we have time to achieve similar success or that our abilities, given time, will improve. If this is not the case, the opposite effect may take place: self-deflation [13].

Notice that the definition states that a role model may display aspects to emulate or avoid. The former kind is a positive role model, while the latter is a negative role model. The motivation that these kinds of role models provide depend on the regulatory concerns of the individual: promotion-focused individuals, who prefer to strive for the pursue of desirable outcomes, are most inspired by positive role models, since they highlight strategies for achieving success; prevention-focused individuals, who prefer to strive for the avoidance of undesirable outcomes, are most motivated by negative role models, who highlight strategies for avoiding failure [14]. Culture also defines a preference for one or the other: individuals from collectivistic cultures, e.g. East Asian, who have a stronger prevention orientation, are most motivated by negative role models, while positive role models motivate more those individuals from individualistic cultures, e.g. Western Europe, who have a stronger promotion focus [15].

In this paper we are focusing on positive role models, which correspond to the traditional popular definition of the term role model. Increasing the number of these in the community is an endeavor already started by many organizations and institutions. Providing the community with a better understanding of what may function as a negative role model is also important, as a way of both raising awareness of what one may want to avoid as a professional in engineering and of catering to diverse needs in the community. While working on providing negative role models seems to us as less ethical (if considered as an active way of highlighting bad examples in the community), they may, however, organically join the community and be identified by those who seek this kind of role model.

Finding role models in engineering who are women may be more challenging depending on the geographical location, e.g. in computing education, the enrolment in the Western world tends to not be higher than 20% of women [16, 17, 18], while female enrolment is not an issue in some Asian countries, such as Saudi Arabia [19].

III. METHOD

We have analyzed the registration list for the last 11 years of FIE. The list included the following fields per attendee: first name, last name, contact company, contact state (if in the US), contact country (if other than the US), and Registration Type (author, exhibitor, or participant).

Due to the inclusion of the term participant as someone who attends the event but does not submit work or participate in an exhibit, hereafter we use attendee to refer to a person belonging to any of the registration types. An author is an attendee who submitted work, either alone or as part of a team of co-authors. Notice that this is not the same as a speaker, i.e. the person who presents the work at the event. In this collection of data, there are no records of who presented the paper, workshop, etc. at the conference. Gathering this information would be difficult as, even when presenters are listed, this may eventually change at the time of the presentation due to e.g. any reason preventing the original presenter from attending FIE, such as sickness.

Since gender is not part of the registration form, we used the first and last name fields to assume the gender of each participant based on the traditional gender assigned to their name. For the same reason, we use the traditional view of gender as binary, i.e. attendees were seen as either female or male. The final categories used to define gender were three: female, male, and unknown. Unknown comprises the subcategories unisex and missing. Unisex refers to the scenario where the name is traditionally assigned to both women and men, e.g. Kim, Robin, Masaki, and the last name does not reveal more information regarding gender, e.g. Icelandic last names have “daughter/son of” as a gender-dependent ending, women from the Czech Republic may change not only their last name but also include a special ending to it (“wife of”) to indicate that they are married. The unisex subcategory also includes the scenario where a short name has been used and it makes the name unisex, even though the original name is not, e.g. Sam for both Samantha and Samuel. “Missing” is the particular case of incomplete names, such as initials, or any other kind of incomplete data that made it impossible for us to see the full name and thus assign it a gender.

The authors come from and have lived in different European and English speaking countries, so their knowledge of the origin of names is primarily Western-focused. If the authors were not familiar with the origin of the name, native speakers from that background kindly assisted us. It was brought to our attention that names coming from other alphabets, e.g. Western representations of names of Chinese origin, may lose nuances during this adaptation. Thus, there is room for error in the interpretation of the gender associated to these names. If native speakers were not available, an online gender international checker was used instead. After these steps, there were still cases of unisex or unknown names. We aimed to solve this by (if the affiliation had been provided) looking for a public institutional webpage or a profile in a professional social/academic network such as LinkedIn or ResearchGate that might include pictures or references to the pronoun used by this attendee. In these cases, the gender we included in our analysis is then not the one assumed by the name but rather the gender that the attendee expresses e.g. through clothing or hairstyle (if from a picture) or the gender that their institution perceives for them (if the text was written by someone other than the attendee themselves). Unfortunately, this information was often not available for different reasons, e.g. the site did not include this kind of data, the person had possibly changed affiliation and was no longer listed as staff, there was more than one person with the same name and affiliation, the person did not have an online professional profile (more common among students), etc.

Notice that, for virtually every case we have included in our analysis, we are always relying on externally perceived gender (by someone other than the attendee themselves) rather than collecting data about the gender with which the attendee reports to identify. If reported, the results may have been different, e.g., we would have an extra category called “other” for those who do not see gender as binary.

Using the “Contact Country” field, we added a “Contact Continent” field to analyze the location of attendees. In the cases where the country had not been provided, we used the category “missing” to indicate missing information.

IV. RESULTS

Our results present, divided by year, the gender distribution in general attendance to the conference, among different registration types, and according to the geographical distribution based on the continent where the attendee’s affiliation is located. Each chart shows data for the last 11 years of FIE: from 2005 to 2016, both included.

The gender distribution in attendance to the conference is shown in Fig. 1 (according to number of attendees) and Fig. 2 (according to percentage of attendance). Gender parity, defined from 60% - 40% to 50% - 50%, is not reached. However, in these 11 years of FIE the percentage of female participation is never lower than 30%, and in the last 3 years the desired 40% is approximately reached.

We deepened the analysis and looked at the potential gender differences according to the roles that these attendees had in the conference, i.e. author, participant, or exhibitor. Fig. 3 shows this distribution of roles. For authorship, the registration type only reflects the fact that the attendee was an author or co-author.

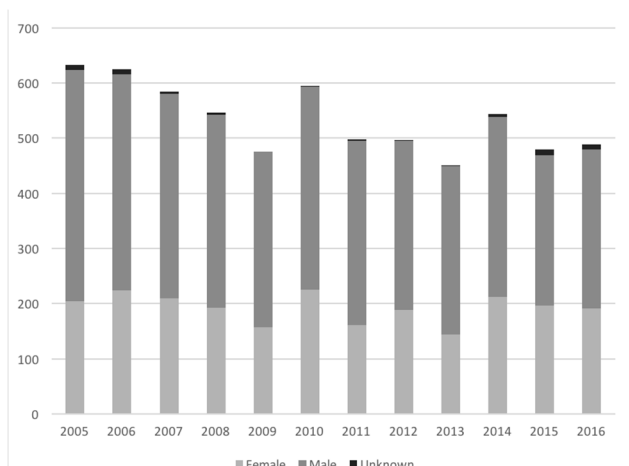


Fig. 1. All attendees (in total numbers) divided by gender

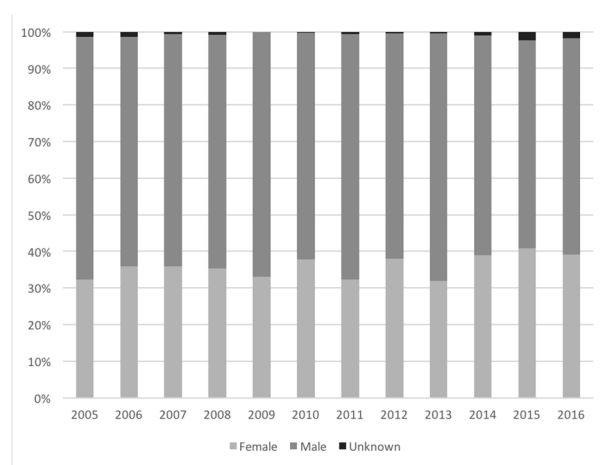


Fig. 2. All attendees (in percentages) divided by gender

Whether it was a first author, the presenter of the work, etc. is not included. Adding the gender perspective, Fig. 4 shows the distribution in authorship (female, male, or unknown) and how the ratios are similar to the ones in attendance.

We then studied each gender separately, to compare the ratio

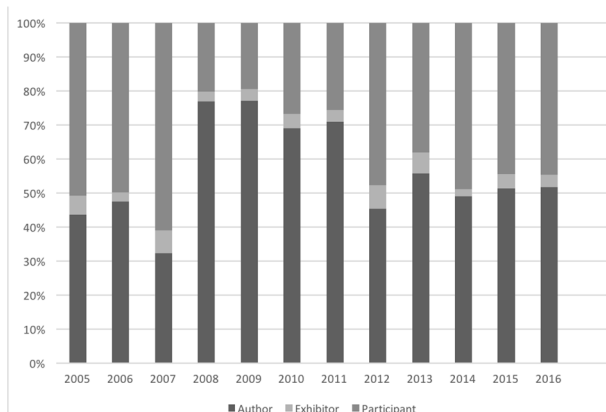


Fig. 3. All attendees divided by role

author-other role for women (Fig. 5) and for men (Fig. 6). Comparing these graphs, we see that they are very similar, i.e. there are no gender differences in authorship. However, for exhibitors Fig. 7 shows that gender parity is reached less often than in general attendance, and it is men who dominate when there is imbalance.

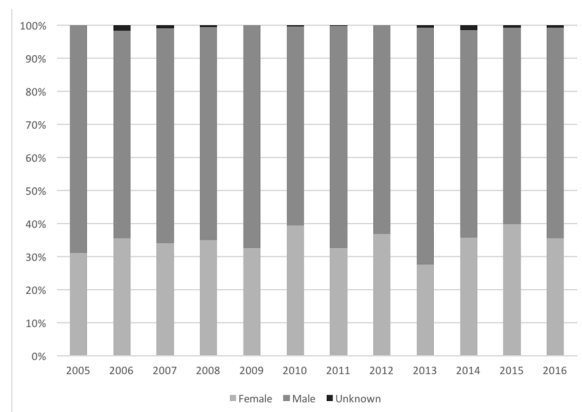


Fig. 4. All authors divided by gender

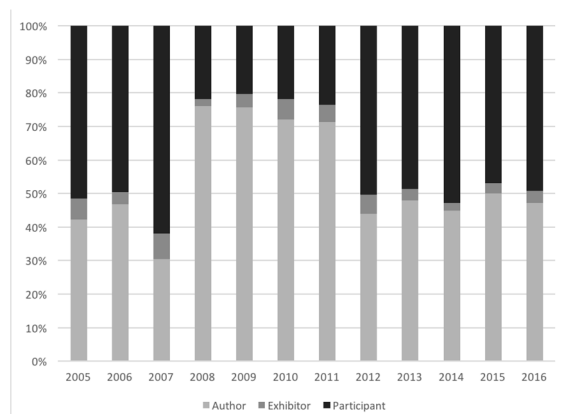


Fig. 5. Women divided by role

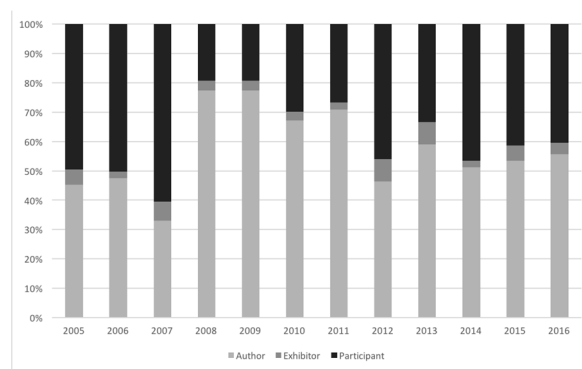


Fig. 6. Men divided by role

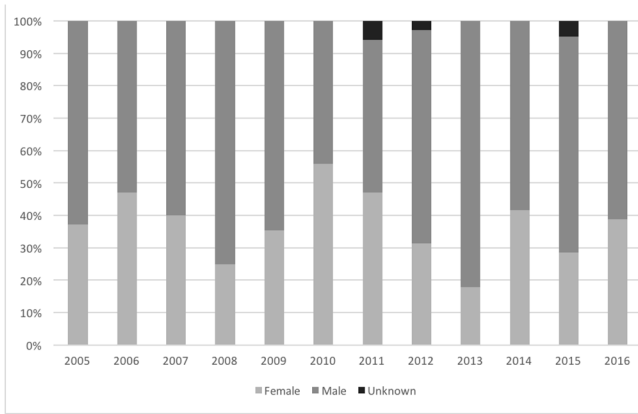


Fig. 7. Exhibitors divided by gender

Attendance can also be analyzed by the country where the attendee works. Here we have chosen a higher level of abstraction: Fig. 8 shows annual attendance by continent. North America is very heavily (95% as the minimum every year) represented by the US, as opposed to the representation of the continent by e.g. Canada, Mexico. North America clearly dominates participation. On the other side of the spectrum, participation from Africa is very low: only 9 attendees (4 of them in 2011) throughout the 11 analyzed years came from that continent. Oceania's participation is higher, but also too low to allow drawing conclusions. While Asia and South America have larger participation rates, and we comment on them, the percentages are still too low to be reliable.

Notice that FIE 2014 did not take place in North America - as all the other editions included in this analysis - but in Madrid, Spain. Thus, Fig. 8 shows a higher than usual European participation that year, i.e. 30% in 2014 compared to the average of less than 10%. In particular, the number of attendees located in Spain increased: from never exceeding 5% from 2005 to 2013 to reaching 12% in 2014. However, in proportion to other European participation Spanish attendance did not increase that year: instead, it seems to steadily increase from 2009 and then drop from 2012 (see Fig. 9 compares Spanish to other European attendance). The overall increase in European participation does

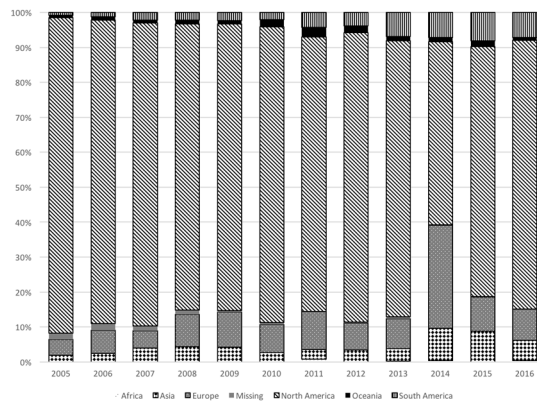


Fig. 8. Attendance by continent (represented alphabetically, from Africa represented at the bottom of the graph to South America represented at the top)

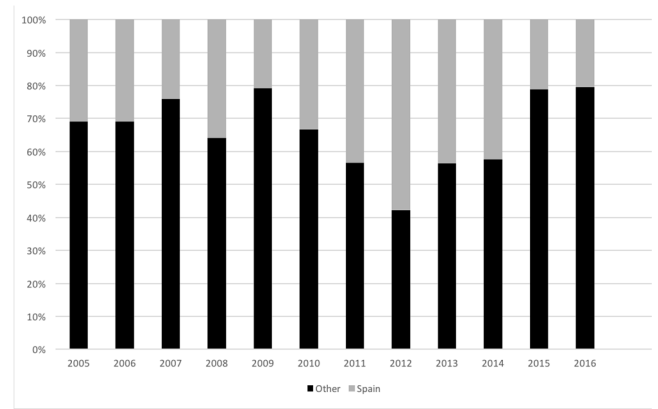


Fig. 9. Spanish VS Other European participation

not seem to continue in the following years either; it rather stays quite stable throughout the decade. For all the other editions of FIE included here, there seems to be an increase over time in participation from South America from 2013. Asian participation seems stable and slightly on the rise (particularly after the 2014 European edition), but not as clearly or certainly.

Is there gender parity regarding the location of attendees? Dividing by the continent of the location of their affiliation, we looked at how many women (Fig. 10) and men (Fig. 11) from each region attended FIE. From the 9 attendees from Africa, 2 were women. South America shows no significant differences in gender balance, while these are more pronounced in Asia. Studying the charts, 2014 is again a noticeable year. The number of European men compared to the North American men seems balanced, while European women are far fewer than their North American counterparts, i.e. in 2014 FIE seemed to attract more Europeans, particularly more men than women. From the perspective of North America, the location in Europe seemed to have less of an effect on the attendance of women than that of men. Notice, though, that this is only one year, so these observations need more support, i.e. there may be factors other than location affecting this difference.

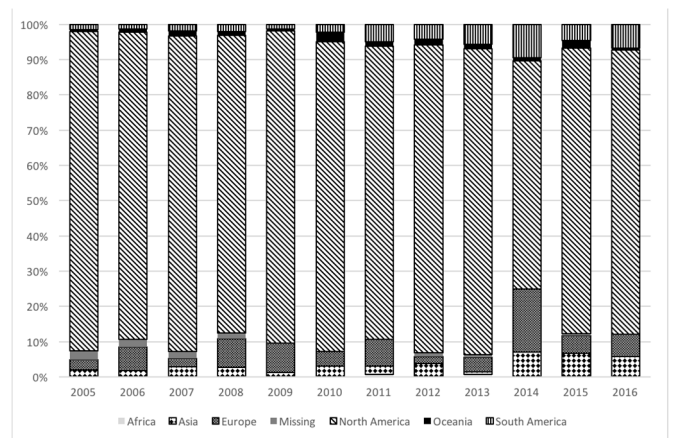


Fig. 10. Women divided by continent (represented alphabetically, from Africa represented at the bottom of the graph to South America represented at the top)

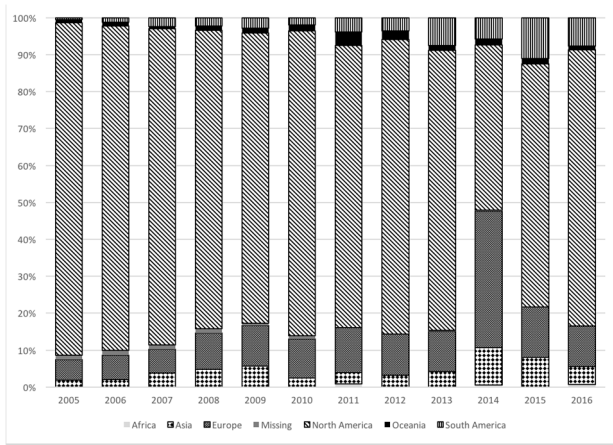


Fig. 11. Men divided by continent (represented as in Fig. 10)

Lastly, as before, we studied the differences according to the role in the conference. Fig. 12 shows authorship divided by continent. We then looked at the distribution of location in authorship for women (Fig. 13) and men (Fig. 14). South America has more male authors than female authors, as is the case with Europe (particularly in years such as 2007 and 2012 where female participation in authorship is very low, and 2014 with the most obvious disparity). For Asia the differences vary, with women dominating in some years while other editions have more male authors. Addressing again the case of the European edition in 2014 and how it increased the male European participation compare to the female one, we see that there is a balance in male authorship from Europe and North America, while North American women dominate over their European counterparts.

V. DISCUSSION

Female participation in FIE this last decade is higher than the female enrollment in engineering degrees in the countries represented by the majority of the attendees. Thus, our results do not reflect the current gender distribution in engineering: there are different percentages depending on the different branches, but gender parity is never reached. For the enrollment in some of these branches, e.g. in computing education, the percentages are significantly lower than the ones shown here. Notice that the

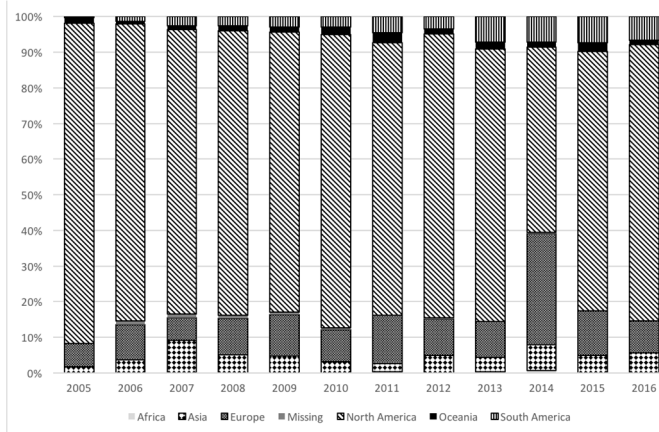


Fig. 12. Authors divided by continent (represented as in Fig. 10)

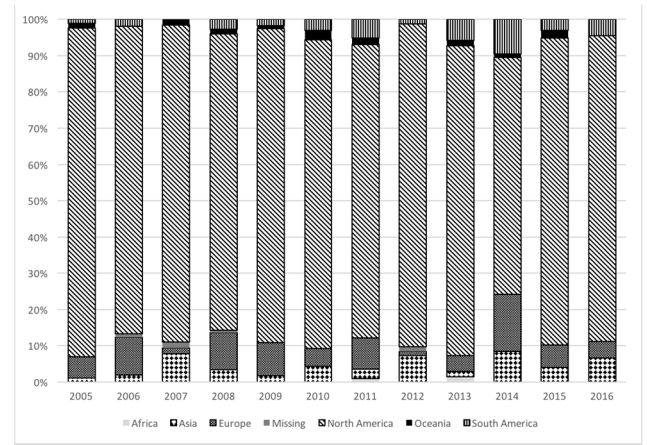


Fig. 13. Female authors divided by continent (represented as in Fig. 10)

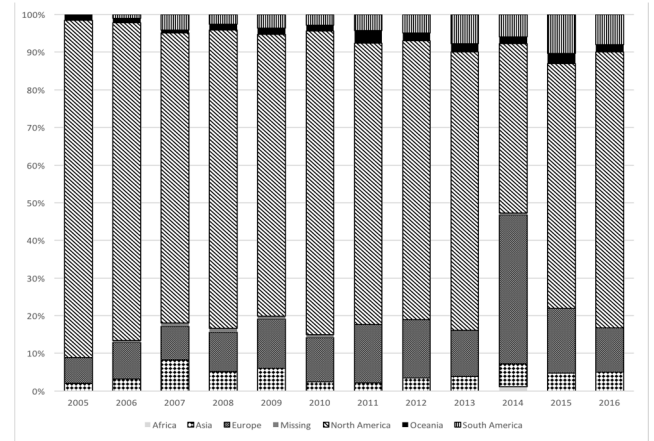


Fig. 14. Male authors divided by continent (represented as in Fig. 10)

gender ratio varies depending on the type of engineering. Thus, we are giving a view that includes mechanical engineering, computer engineering and others, even though their ratios are different. Since there was no trivial way of dividing the attendees according to this criterion, it is not possible to know whether the percentages of our results are influenced by e.g. a strong presence of a branch of engineering with higher presence of women than in other branches. It could also be argued that attendance from areas where lack of female enrollment is not a problem, e.g. Saudi Arabia, may contribute to the higher number of women in FIE. However, the number of female attendees from these areas is too low for it to affect in a significant way.

While we have studied gender based on names, attendees in FIE who may be looking for a role model will rely on the perceived gender (through the observation of e.g. clothing style and behavior) of the potential role model. This perceived gender may be different than that of the one assigned to the name, e.g. an attendee named Mary wearing traditionally masculine clothes and acting in traditionally masculine ways. We see this as an advantage, as these cases seem to be less common and thus their contribution to the diversity of the pool of role models is significant.

During our categorization of genders, we noticed that institutional websites may not include the gender of the

professional, be that through a picture or a description that includes pronouns. If gender matching is important for visitors of these websites who are - consciously or unconsciously - looking for a role model, they are not able to know the gender with certainty and thus an opportunity is lost. However, it can of course be argued that some professionals may prefer not to disclose their gender, or may not consider gender as binary. In the latter case, this could again be seen as an even better opportunity (as long as the person profiled on the website is comfortable with the disclosure of this information), as there is a larger lack of role models who identify with a gender that is not binary, i.e. not female or male.

Given the stereotype that men are more skilled in engineering, one expected result was that there would be more male authors (showcasing their work), while women may tend to be participants. But men and women seem to have very similar roles in the conference. So what is making female attendance lower, if their interests seem similar? Lack of resources, family duties, lack of institutional support...? Or does it simply reflect the pool of potential conference attendees? Studying the age of the attendees is one of the aspects that could throw some light in the reasons behind this difference.

In the case of exhibitors, given the traditional believe that women are more skilled in social interactions, we expected a higher number of women. The opposite result may come from the unconscious bias of perceiving men as more skilled in technical careers. Striving for gender parity should be one of the next goals in this area.

In terms of cultural diversity, there is certainly room for improvement for FIE. One approach that may contribute to more geographical diversity is holding the conference outside of the US more often. While we could analyze only one year that was not hold in North America (2014 in Spain), the changes in attendance not only from Europe but also from South America and Asia may signal that mobility is a problem for many not located in North America. A factor contributing to this lack of mobility may be the economic crisis still affecting some European countries.

The results show a lack of role models from some cultures, especially from an intersectional point of view, i.e. female Asian-located authors. There are individuals in engineering education with e.g. Asian background, who may or may not be located in Asia, who could benefit from this kind of role model. The same applies to other underrepresented groups in FIE. In the particular case of European female authors, further work needs to be done to study their lack of participation compared to that of their male counterparts.

When studying role models in this paper, we are using a Western perspective of the concept, as individuals in the Western world are more motivated by positive role models. However, the attendees of FIE come from a broad range of areas in the globe, and may have left their countries of origin to work abroad. Thus, it could be argued that there is a number of attendees who may not benefit from the proposed role models to the same extent as other attendees.

VI. FUTURE WORK

This study can be expanded by providing a deeper analysis of some the points it addresses, and by adding new perspectives.

A deeper analysis of authorship would be interesting: Are there gender differences in who tends to be first author? Or in who presents the paper at the conference (and, thus, gets more visibility)? If so, what can be done to improve the situation, e.g. should team of co-authors encourage women in their team to present (or at least revise the unconscious bias in the team to see if they are preventing women from presenting)? What is the visibility of other members of the team of authors at the conference, e.g. does the presenter introduce other co-authors in the room? This is important in order to increase the visibility of diverse authors as role models. Simon highlights the importance of collaboration in academic writing [20]. He also points out that authors who are part of a conference community bring in new authors by collaborating with them (by introducing them in their established team of co-authors) [4]. We add that gender parity in the team of co-authors is also important, and may contribute to more diversity through the described collaboration process. Studying then, as Simon does with authorship, the recurrent attendance of individuals to FIE may show whether there are opportunities to meet role models across the different editions or whether attendance tends to vary.

From a geographical perspective, since the US is a large country and the number of attendees coming from there is significant, it may be interesting to conduct a deeper analysis by state or even affiliation. Do some institutions send more women to FIE? Can others do better in this aspect? These results could contribute to an internal analysis of unconscious biases in industry and academia at an organizational level. Notice that a possible bias is to see education as a “soft” area of engineering, and thus associate it with women in a negative way. Therefore, a high number of female attendees may not necessarily mean a lack of biases.

Another dimension that could also be added to the analysis is the career stage of the attendee. This would be a difficult task, as some attendees belong to the academic world while others come from industry, and thus, their professional paths are different. The analysis could then differentiate between these two worlds. In the particular case of academia, we find it interesting to look at e.g. the number of female postdocs or junior researchers, since they could act as role models for the PhD students and other postdocs attending FIE.

An analysis similar to the one included in this paper could be conducted, this time of individuals linked to different parts of the organization of the conference in the last decade of FIE. Those in leadership and managerial positions offer yet another kind of role model to the community. For the same reason, FIE awards recipients could be examined from the perspective of diversity. Who is getting recognition in the community? How diverse is the pool of candidates?

Lastly, the results presented here could be compared to similar data from other conferences and events, i.e. how inclusive and diverse is FIE in comparison to other scientific gatherings of the same nature? What can the community learn from them, and vice versa?

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