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Closing the Gender Gap in DHM

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Abstract. Digital Human Modelling by Women (DHMW) is an international group of women and supporters with the main purpose of eliminating the gender gap, empowering women to exchange ideas, results, visions, and promote the women's participation in the STEM (science, technology, engineering, and math) and DHM fields. This study presents a demographic investigation of human factors and behaviors affecting women in the DHM field. A questionnaire composed of several items was set up to analyze the situation: demographic map of women in DHM (age, country, and level of education), the field of application, factors related to career progression, and correct instruments to change the current situation of underrepresentation. Our results show a gap of women working in the DHM field in the industry or research institutes (21% and 8% respectively). While, the 56% are involved in the Academic world, with a 30% PhD and 26% PostDoc level. Work-life-balance (WLB), career progress (CP), family-balance vs career (FB VS C), and work schedule flexibility (WSF) resulted lower in women of 30-34 and 35-39 years old. As a result, it is necessary to adopt strategies focus on support mentoring programs, career progress, childcare support, and flexible work schedule aiming to eliminate women inequality and stigmatization. This will open up borders in Academics, Industry, and Research education closing the gap in the DHM field.

Keywords. Women, STEM, DHM, DHMW, Modelling, Gender Balance

1. Introduction

Over the years, women in Europe and all over the world are increasingly pursuing jobs that have been traditionally considered for males. However, women continue to be underrepresented in the STEM field (science, technology, engineering, and math fields) [1], where men's employment is still very high covering over 80% [2].

Several studies have shown that although girls and boys perform similar in math and science, there continue to be factors and biases relating to a poor and lower achievements perception of girls [3-4]. The root of the lack of girls and women involved in STEM comes with biological factors, education policy, social and cultural context as well as early experience more than cognitive aptitudes or sex brain differences [3-5].

To overcome this situation, numerous studies propose strategies that highlight the need of reducing and breaking down the stereotyping [3], [5-7], and the challenges it supposes to the administrative, financial and cultural current environment [3], [8].

The European Commission's strategic plan for gender equality 2016-2019 points out to that. This report proposes four strategic areas for independence between gender: equal pay, equality in decision making, ending gender violence, and equality between

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the European Union's [8]. When moving to leadership positions this number is even lower [9]. In particular, the European University Association (EUA) analyzed the representation of female leaders in Europe's universities and found that only 15% of all rectors are female in 48 countries. Notably, 20 countries do not have any female rectors currently. Although the situation of female leaders is increasing yearly, there is still the gap.

Programs such as Hypatia chair were introduced in the University of Twente in the Netherlands for increasing the number of women in STEM to obtain academic top positions [10]. Dublin also approved a program to close the gender gap called "20 women only professor position" in 2020 [11]. Besides, the creation of tenure track policy resulted in increasing representation of women in senior academic positions but still this solution did not solve the problem in the transition from associate to full professor position. L'Oréal UNESCO for women in Science International programs recognize every year also women researchers around the world but apparently, highlighting again the existing gaps [12].

To confirm that, the study of Stefanie Jonson et al. [13] found that eliminating the gender information in funding application make more success for women passing from 18 to 30%. Understanding the current cause of underrepresentation and gender gap is important to open the borders and closing the gap [14]. For that, it is necessary to avoid discrimination for grant funding, journal reviewing, hiring female manager, researcher, and professor, and all this start from us. More dedicated and mentoring programs should grow up since primary school [15-16]. Together with that, stereotypes also need to be eliminated providing more role models. STEMinism campaigns are growing up but if these campaigns are promoted by only women the engagement will be more difficult [17-18]. To promote both gender engagement is necessary to build up an initiative where women are supported by also men looking into the role of "model" but also modelling.

In particular, Digital Human Modelling (DHM) is the "science of representing humans with their physical properties, characteristics, and behaviors in computerized virtual models" [19]. DHM is becoming an essential tool for the evolution of the society, going from a society 4.0 to a human-centred society 5.0 that aims to be much more smart, digital and address the well-being of the population [19]. In this evolution, it is important to ensure women are represented to the same degree as men.

DHM group started to promote the increment of women involved in the field by constituting an international group that aims to eliminate the gender gap, addressing the empowerment of women to exchange ideas, results, and visions in the multidisciplinary DHM and STEM field. This group entitled "Digital Human Modelling by Women" (DHMW) was born during the DHM Symposium 2017 [20], with the main purpose of increasing the women participation, reaching the gender balance by exploring the current barriers and issues that are affecting them, and constituting an essential "model" for women scientists that also inspires girls around the world. It constitutes a promising community of women and men that promotes sharing the feeling of struggling and engagement in improving the environment for women not only in the DHM area but STEM. Starting from the previous assumptions, this study presents a demographic investigation looking to human factors and behaviors that affects women in the DHM field.

2. Method

Twenty-three women, in the range of 18 and 67 years old, were investigated to study women's situation in the DHM field by using a questionnaire design form in GoogleDocs (Figure 1) [21]. The questionnaire (Table 1) admitted one or multiple responses, and is composed of several items that are addressed to:

1) create a demographics map of DHMW looking at their age, country(e.g. born, live/work today) and level of education;
2) explore the sectors and the field of application;
3) identify the factors and behaviors that affect their career progression, work and personal/family balance;
4) claim and find the instruments and the way for closing the gap.

The questionnaire was submitted to the DHMW group by email and shared in the LinkedIn social network group ("DHMW"). The responses were statistically elaborated by the authors in using the Statistical Package for Social Science, SPSS (IBM Corp., Armonk, NY, USA). The women involved were informed by a description of the research and all of them provided informed consent to be part of the study.

Figure 1. DHMW Survey.

Table 1. DHMW Questionnaire.

1	Gender
2	Age
3	Country of birth
4	Level of Education
5	Degree
6	Current work placement
7	Do you work in a country where you were born?
8	Did you move to another country for a non-professional reason?
9	If yes, why did you move?
10	Are you willing to move to another country in case you find an opportunity?
11	If you don't want to move, why?
12	Domain. If it is in academics (I am...)
	Domain. If it is in the industry (I am...)
13	Areas of practice/expertise
14	Topic
15	Areas of practice/expertise (software experience)
16	Which membership do you have?
17	Which DHM conferences did you attend?
18	Which networks do you use for work?
19	Projects Request Participation
20	Work-life balance (punctuation 0 to 10)
21	Do/did you find it difficult to find a job?
22	If you find/found it difficult, why?
23	Where do/did you search for jobs?
24	Career progress (punctuation 0 to 10)
25	Family balance VS Career (punctuation 0 to 10)
26	Work schedule flexibility (punctuation 0 to 10)
27	How many children do you have?
28	Parenthood flexibility (punctuation 0 to 10)
29	Do you get additional household support? (e.g. childcare, cleaning service,...)
30	What is the gender of your mentor?
31	Who is your mentor?
32	In which groups do you participate to promote specific populations?
33	Why is the participation useful?
34	Additional remarks?
35	Do you like to have a website (DHMW)?
36	Do you like the idea to have an association to share ideas, workshop, job, fellowship?

3. Results

The four different research objectives previously presented in the method were investigated, elaborated, and classified using the SPSS software.

3.1. Demographics

Data showed a geographical distribution that is limited in specific country areas where the DHMW number fluctuates from one to three (Figure 2).

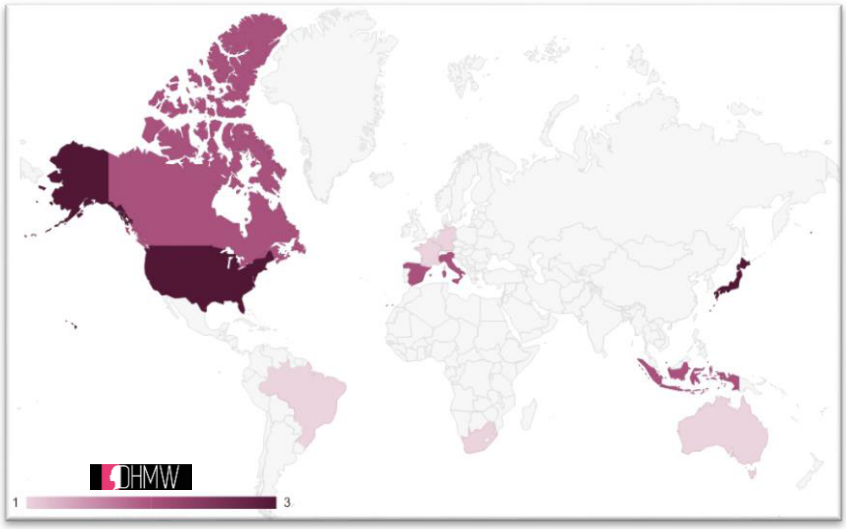

Figure 2. Map of DHMW population (light color represent lower density, dark color represent higher density) that participated in this study.

43% of DHMW participants are located in the European countries while 57% are not in the European zone. Within the EU zone, we can see that 17% of women are from France, 9% from Italy, 4% from Belgium, 9% from Spain and 4% from Germany. While from areas outside the EU, we have 4% of women participation in Australia, 4% in Brazil, 4% in South Africa, 14% in the United States, 13% in Japan, 9% in Indonesia, and 9% in Canada. Figure 3 shows the variation of the population considering the age distribution. The population of women has been classified by age groups of 18-24y, 25-29y, 30-34y, 35-39y, 40-54y, 55-67y. Age range values were established according to the academic's career structure. 48% of the women involved have ages between the 40-67 years. 22% age between 18-34 years while 30% between 35-39 years (Figure 3).

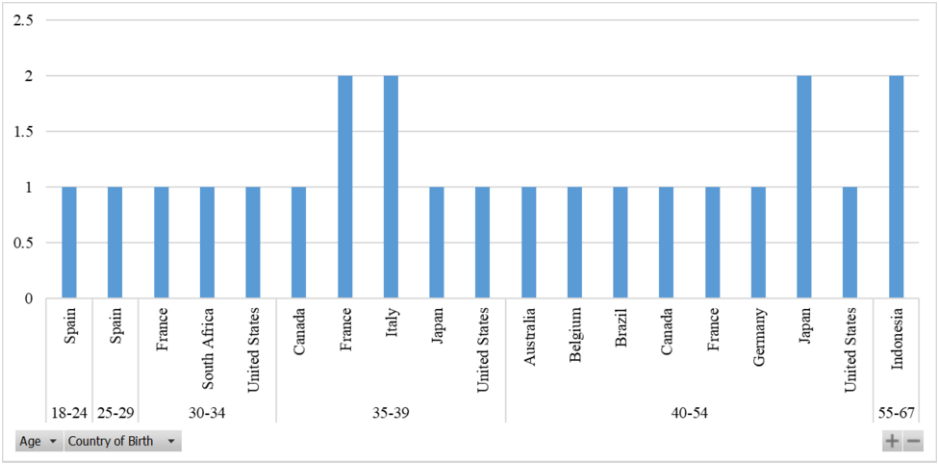

Figure 3. Age group distribution by country of birth of the DHMW population considered in this study.

3.2 Education, Career, Work-life balance

In terms of the level of education, 22% work in Industry, 9% in research institutes, and 56% in Academics (Figure 4).

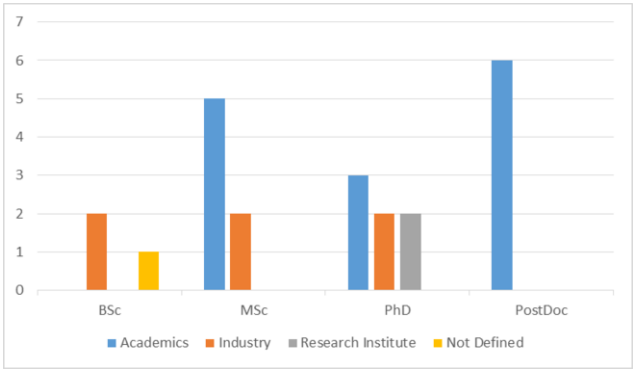

Figure 4. Number of DHMW per education level and workplace field considered in this study.

Seventy percent of them work in the country where they were born. From the overall population, 57% moved for their career (internship, job position, fellowship, change career), while 70% of them moved abroad for a non-professional reason (sabbatical year, family). Also, 52% of the women involved are willing to move to another country in case they find another opportunity. While 31% responded not because they do not like to do (16%) or they have family reasons (16%). Finally, 17% of women responded they cannot for reasons that are beyond their will (they mentioned family restriction). The women that responded they cannot for family reason are women that obtained rank as senior researchers, assistant or full professor.

61% did not find difficulties to get a job, while 39% found difficulties because there was no job in their countries (Italy, France, Spain, Belgium, and South Africa), the competitiveness of academics positions, and difficulties in their field.

Table 2. Age, Work-life balance (WLB), career progress (CP), family-balance vs career (FB VS C), work schedule flexibility (WSF) and number of child (NC) average score (0=low to 10=high) of the DHMW population that participated in this study.

Age	WLB	CP	FB VS C	WSF	NC
18-24	7	7	8	0	0
25-29	8	8	8	8	0
30-34	4.33	5.00	4.00	8.00	0
35-39	4.57	4.93	5.21	5.29	3.29
40-54	6.44	6.67	6.44	8.00	2.22
55-67	7.5	7.5	7.5	7.5	0
Mean	**6.31**	**6.52**	**6.53**	**6.13**	**0.92**
SD	**1.40**	**1.17**	**1.49**	**2.91**	**1.33**
Min	**4.33**	**4.93**	**4.00**	**0.00**	**0**
Max	**8.00**	**8.00**	**8.00**	**8.00**	**3.29**

Table 2 shows the average scores (from 0 meaning low to 10 meaning high) of every range of age regarding their work-life balance (WLB), career progress (CP), family balance vs career (FB vs C), and work schedule flexibility (WSF). It also shows the minimum, maximum, standard deviation and means scores of each aspect. Table 1 also describes the average number of children by age group, 57% of the women have at least one child. To this group, we asked also parenthood flexibility score (0=low to 10=high) obtaining an average of 6.36 for our population. 38% of them obtained also household support.

3.3 Area of expertise and the simulation tools in the different field of applications

DHM serves computer-based tools that simulate human-system interaction in a virtual environment applied in several fields such as rehabilitation, aerospace, medicine, space, forensic, automotive, elderly care, sports, orthopedics and robotics (Figure 5) [19]. These fields contain also areas of expertise such as virtual reality (VR), clothing, motion capturing, anthropometry, posture, mental/cognitive, musculoskeletal, standardization, and impact analysis (Figure 6).

From our analysis emerged that automotive and transportation are the main fields that are covered by our population, followed by robotics, elderly care, and then orthopedics. These results are followed by sport and military and successively clothing. Motion capturing and posture are the main areas of expertise with 43% each. These are followed by musculoskeletal and anthropometry and successively virtual reality, mental and cognitive modelling. Impact analysis covers only 8% of our population. This number becomes lower in the case of clothing and standardization.

Figure 7 shows the simulation tools used by our population in DHM as AnyBody [22], Biomechanics (e.g. kinematics data in Matlab,…), Blender [23], Delmia [24], Dhaiba [25], ESI [26], Gazebo simulator [27], HumanCad [28], IMMA [29], Jack [30], NetLogo [31], Opensim [32] and Posture (e.g. posturography).

Biomechanics is the most simulation tool used, followed by Jack, OpenSim, and Anybody. The field of application confirmed also the tools used by our population (Figure 7).

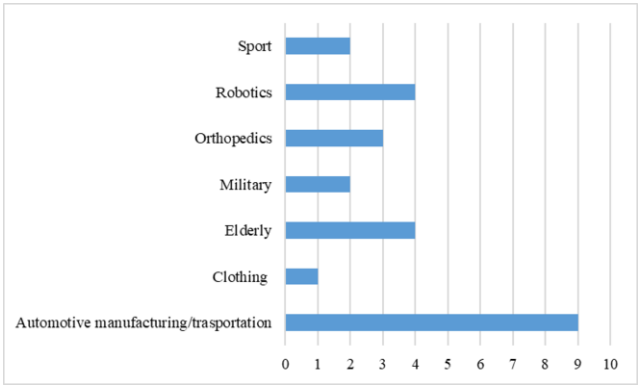

Figure 5. Number of DHMW for field application that participated in this study.

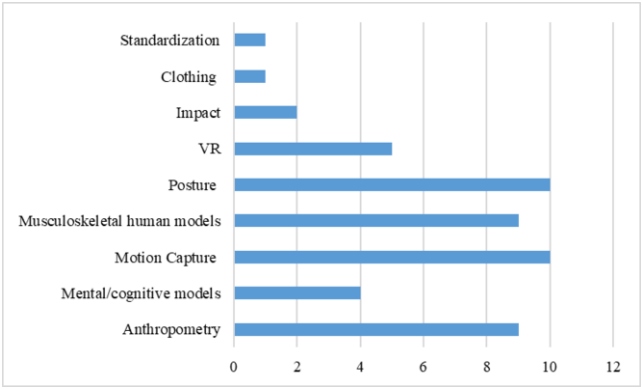

Figure 6. Number of DHMW in each area of expertise that participated in this study.

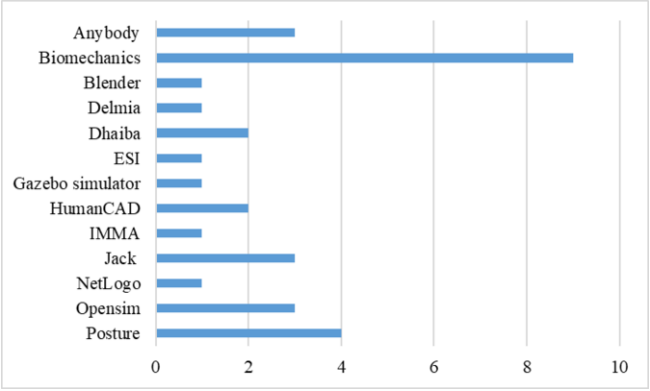

Figure 7. Number of DHMW that used the simulation tools considered in this study.

3.4 Network and conference participation

Networking and conference participation are also important for closing the gap. Figure 8 shows that DHM Symposium is the most specific congress in DHM with the majority of the participants with 52%. This is followed by the triennial International Conference

of Ergonomics (IEA) were also DHM group participates. 26% participates also at Applied Human Factors and Ergonomics (AHFE) that normally is held in the USA.

Finally, 4% follow the VPH Institute (Virtual Physiological Human) and the related conference in biomedicine.

The majority of the population use LinkedIn as a social network for sharing information, research, and job position (Figure 9). In terms of sharing research and papers, they prefer ResearchGate to Academia or Mendeley (Figure 9).

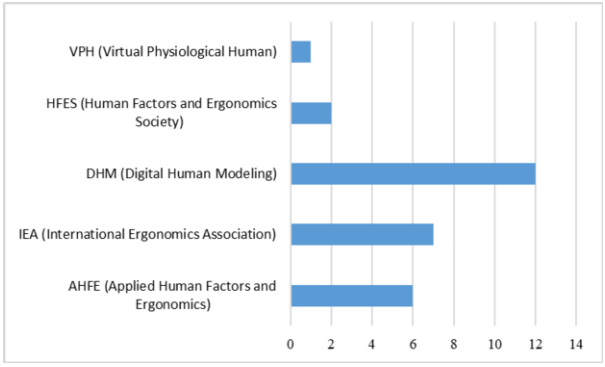

Figure 8. Number of DHMW that participate in each conference.

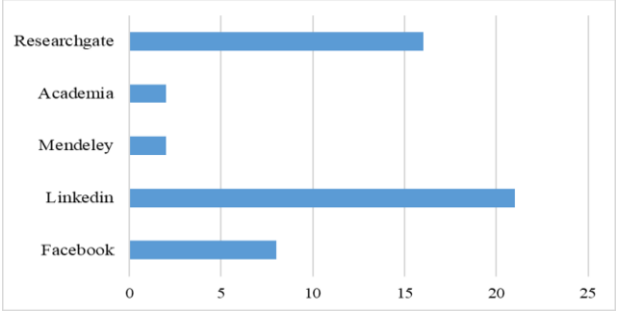

Figure 9. Number of DHMW that participate in each network.

4. Discussion

This paper aims to study the current situation of women involved in the DHM field. Different factors regarding age, nationality, experience, mobility, maternity, and career progression were taken into account to analyze in which order or how these aspects affect them and consequently try to find tools/solutions to improve it and close the gap.

A questionnaire form created using GoogleDocs was the used method in this study due to the easiness to spread by email or social network.

Results show a multicultural and a mixed-age environment of women working in the DHM area. Looking at their level of education and their workplace situation (Figure 4) is evident the gap of women working at the DHM field in the industry or research institutes (22% and 9% respectively). 56% are involved in the Academic world, with a 30% PhD and 26% PostDoc level. These numbers could mean the gender gap in Academia is smaller than in the industry, as some studies have also explained [11].

Another result to highlight is how work-life-balance (WLB), career progress (CP), family-balance vs career (FB VS C), and work schedule flexibility (WSF) decrease in the range of 30-34 and 35-39 years old when the number of child increase (Table 1).

Although 61% did not find difficulties getting a job, the remaining 39%, which is still a high number, found difficulties because there was no job in their countries. Also, from the entire population, 52% reported willing to move abroad in case of a career opportunity while 16% said they have family restrictions and 17% responded they cannot for reasons that are beyond their will. The women that responded they cannot for family reason are women that obtained rank as a senior researcher, assistant, or full professor, which correspond to the range of ages where the number of child increase. With these data, we could reflect again on how the maternity limit somehow the career progression of women in DHM. That points out the high importance of establishing strategies for the women's career progression and the equality between genders during parenthood.

Nowadays, social media as LinkedIn, ResearchGate, Mendeley (Figure 9) as well as conferences (Figure 8) are good tools or scenarios to expose and visualize the situation and promote the women's participation in both the DHM and the STEM fields.

5. Conclusion

This paper aims to study the current situation of women involved in the DHM field. Different factors regarding age, nationality, experience, mobility, maternity, and career progression were taken into account to analyze in which order or how these aspects affect them and consequently try to find tools/solutions to improve it and close the gap. Our results demonstrated that DHMW between 30 and 39 years old have a lower score of work-life-balance (WLB), career progress (CP), family-balance vs career (FB VS C), and work schedule flexibility (WSF) respect to the other age groups.

As a consequence, it is necessary to create and promoting strategies addressed to closing the gap for recreating gender balance. Mentoring programs, career progress aim to promoting female positions, childcare support, and flexible work schedule are necessary for closing the gap. The closing gap starts also from men putting more efforts to close it by promoting more women in STEM, opening borders in Academic, Industry and Research, and in this case in DHM.

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