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PROMOTION OF GENDER EQUALITY THROUGH CMAPTOOLS IN A SCIENCE EDUCATION CLASS WITH STUDENTS OF THE BACHELOR'S DEGREE IN PRIMARY EDUCATION (BDPE)

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Abstract. While the world has achieved some progress towards gender equality and women's empowerment, it is evident that there is still a shortage to achieve equality between men and women at the social and labour levels. According to the 2030 Agenda for Sustainable Development, 17 Sustainable Development Goals (SDG), were adopted to come into force since 1 January 2016. Among these objectives, the 4th (Ensure inclusive and quality education for all and promote lifelong learning) and the 5th (Achieve gender equality and empower all women and girls) were taken into account for designing an activity in the context of a Science education class of students of both sexes of the Bachelor's Degree in Primary education. Also, previous research (Sjoberg & Schreiner, 2005) showed evidence of the decrease in girls' interest for science and science related jobs or studies. Once the activity was implemented, results indicated students of BDPE enjoyed inquiring about scientific women who had to face difficulties and confront the society of the time, especially in professions considered more appropriate for men. They also created a concept map on each of the scientific woman selected by each group explaining why they had chosen her. These students, as future teachers, through activities in which they work on gender equality, will be the germ of an educational network, which can help in the achievement of the previously mentioned objectives.

Keywords*:* gender equality, science education, CmapTools, Bachelor's degree in primary education, concept mapping

1 Introduction

Even if some progress towards gender equality and women's empowerment is being achieved in the last decades, there is still a shortage to become equal in the social, economic and labour fields although this gap is greater in developing countries. The 2030 Agenda for Sustainable Development is a plan of action for people, planet and prosperity which seeks to strengthen universal peace in larger freedom (United Nations, 2015). In this Agenda, 17 Sustainable Development Goals (SDG) were adopted, containing 169 targets, which seed to realize the human rights of all and to achieve gender equality and the empowerment of all women and girls.

In the last 15 years, the international community has made a great effort to inspire and promote the participation of women and girls in science. Unfortunately, they continue to face barriers that prevent them from participating fully in this discipline. According to a study conducted in 14 countries, the probability of female students completing a bachelor's, master's and doctorate in some science-related subject is 18%, 8% and 2%, respectively, while the probability for male students is 37%, 18% and 6%. Although in the first world these percentages decrease, there is still a gender difference in terms of access to positions of greater responsibility (United Nations, 2015).

Other authors (Kenway & Gough, 1998) published an article with a focus in gender and science education, observing three distinct though not unrelated perspectives already mentioned in previous papers (Kaminski, 1982; Manthorpe, 1982). In the first place, the intellectual potential of girls was seen as a meaningful but untapped labour source for science and technology. The second perspective was concerned with equity and sought to identify and reform those factors which were seen to impede girls' achievement in science. The third focus was on the under-representation of women in science, arguing that the male nature of the practice of science was oppressive for women, hence their "science avoidance". Overall the emphasis was on research which could help getting more girls to study science and follow scientific careers (Kenway & Gough, 1998). For Butler (1983) many factors had been identified as contributing to the lack of girls and women in science courses and careers, among which she mentioned social factors (role models and sex role stereotyping), educational factors (enrollment patterns, parents/teachers expectations, classroom and extracurricular activities) and personal factors (spatial visualization).

More recent research (Sjoberg & Schreiner, 2005), focused on an international project called ROSE (Relevance Of Science Education), supported by the Research Council of Norway. It aimed to improve the theoretical understanding of the factors related to the relevance of the contents of science curricula in different cultural contexts. The theoretical foundations of the ROSE project assumed that scientific literacy and technology is necessary for the democratic participation of citizens in the techno-scientific decisions, personal autonomy and socio-economic development of the nations. Likewise, in ROSE it was argued that scientific education must also promote gender equity and cultural diversity (Acevedo, 2005). The population under study was that of students who were about to finish secondary education (15-16-year-old). Spain participated in the project, although only with students from the Autonomous Community of the Balearic Islands (Vázquez & Manassero, 2004). ROSE analyzed the information provided by the participating students about different factors that could influence the attitude towards science and the motivation to learn sciences (Sjøberg, Schreiner & Stefánsson, 2004), such as:

(i) Science and technology: the variety of related extracurricular personal experiences with science and technology
(ii) Trust in Science: interest in learning different science topics and technology in different social contexts (cultural, political, religious, linguistic, etc.)
(iii) Future and environment: the various points of view about school science derived from the previous experiences
(iv) Experience in school science: beliefs about the nature of science and perceptions about scientists
(v) Future work, plans and priorities: values, interests, aspirations, priorities and personal future expectations
(vi) Work in science and technology: own feelings regarding the multiple environmental challenges

Results showed in (i) there was a broad agreement about the importance of science, technology and research in all countries, although in rich countries, youth were more ambivalent than adults, especially, girls. In most countries there was relatively little confidence in what scientists say, the girls trusting even less than boys. In (ii) science was not believed to be neutral and objective, being again the girls the ones believing it even less than the boys. This opinion was more indecisive in the less developed countries (Acevedo, 2005). In (iii), in all countries, it was believed that more attention should be given to the protection of the environment (boys less than girls, especially in many developed countries). Also (girls more than boys) thought environmental problems should not be left to the experts alone. Girls believed more than boys, S&T could not solve all environmental problems, and this belief was higher in developed countries. In (iv) in developed countries, students liked less school science than other subjects, (girls liked it less than boys), whereas in developing countries, they believed school science shows exciting new jobs. In (v), boys and girls from all countries (boys less than girls) would like to work on something that is important and significant, appropriate to their attitudes and values. In all countries (more in less developed countries) girls like more than boys help others. The boys of the Nordic countries give less value to this aspect. In all countries, boys would like more than girls to work with machines and tools being girls very reluctant to this in developed countries. In (vi), students from developed countries (especially girls) did not want to be scientists. Girls from developed countries did not want to work in technology (especially in Japan and in the Nordic countries). The boys were less reluctant to this in developed countries (except in Japan) and favorable in less developed countries.

It is inside the 4th point of ROSE project (beliefs about the nature of science and perceptions about scientists) in which we considered to develop our didactic activity, as a germ to bloom in society, being conscious and humble enough about the possibilities of contributing to a little change in students' perception. For that, we assumed the 5th SDG (Sustainable Development Goal) of the 2030 Agenda (United Nations 2015), which tries to achieve gender equality and empower all women and girls, by designing a didactic activity in the context of a Science education class of students of both sexes of the BDPE. The didactic tool we decided to use was Concept Mapping through CmapTools (Cañas et al, 2004)), since it is a process of meaning-making and constitutes an advanced organizer (Willerman & Mac Harg, 1991). This implies taking a list of concepts, concept being a perceived regularity in events of objects or records of events or objects, designated by a label (Novak, 1998; Novak & Gowin, 1984; Cañas et al., 2000) and organize them in a graphical representation where concepts are linked by connectors, forming a proposition with absolute meaning by itself.

The general aim of this work was to contribute to the scope of this "equal opportunities" for girls and boys, by changing the current educational paradigm. For that, a didactic activity was designed for students of the BDPE, consisting in the inquiry of scientist women who faced difficulties to perform their professional careers and brought their knowledge, invention or discovery to humanity. This way, they could become references for the future girls who have to overcome preconceived ideas about science in most countries, as indicated by the ROSE project (Sjoberg & Schreiner, 2005).

2 Material and Methodology

In order to achieve full and equal access to and participation in science for women and girls, and further achieve gender equality and the empowerment of women and girls, the United Nations General Assembly adopted resolution A/RES/70/212 (Resolution adopted by the General Assembly of United Nations on 22 December 2012), declaring 11 February as the International Day of Women and Girls in Science. It is under this frame the following didactic activity (Table 1), was designed for a classroom of 62 Bachelor's Degree Primary Education students at the Universidad Pública de Navarra (Pamplona, Spain).

TITLE	**PRACTICAL ACTIVITY 3: "INTERNATIONAL DAY OF WOMEN AND GIRLS IN SCIENCE: FEBRUARY 11th "**
DESCRIPTION	Inquiry activity and oral exhibition by groups: February 11th is the International Day of Women and Girls in Science. According to the United Nations, science and gender equality are vital to achieve the Sustainable Development Goals, included in the 2030 Agenda (which includes the 17 Sustainable Development goals to transform our world). In the last 15 years, the international community has made a great effort to inspire and promote the participation of women and girls in science. Unfortunately, they continue to face barriers that prevent them from participating fully in this discipline. According to a study conducted in 14 countries, the probability of students completing a bachelor's, master's and doctorate in some science-related subject is 18%, 8% and 2%, respectively, while the probability for male students is 37%, 18% and 6%. Although in the first world these percentages decrease, there is still a gender difference in terms of access to positions of greater responsibility. To contribute to the scope of this "equal opportunity", the choice of a scientific woman or inventor who in your opinion has contributed to change the course of the world or whose contribution to science is significant, has been considered as a practical activity. Inquire about her life and work and reflect on what difficulties you have encountered or could find in her professional life according to the time she lived or lives. Justify the reason for your choice and if her contribution had its application in science or served to improve the welfare of humanity and in what sense.
SPACE	Ordinary classroom
TIME	A practical class of the subject "Teaching Natural Sciences", which belongs to the second course of BDPE.
RESOURCES: -HUMANS -MATERIALS	- Teacher and practical groups (15) - Mobile, laptop, internet, paper, pen, blackboard.
GROUPS	Medium groups (15)
ANNEXES	http://www.un.org/es/events/women-and-girls-in-science-day/ http://www.un.org/sustainabledevelopment/es/mdgs/
CROSS-CUTTING ISSUES	Integral education, Sustainable development Moral and civic education, Gender equality
EVALUATION	Teacher's rubric and rubric for peer evaluation. The final grade will be the average score obtained in both rubrics.

Table 1: This table represents the activity designed for commemorating the International Day of Women and Girls in Science.

As a tribute to all the scientist women who had made a relevant discovery for humanity, students in medium groups (15 groups in total), had to make the choice of a scientific woman or inventor who in their opinion had contributed to change the course of the world or whose contribution to science was significant. They had to inquire about her life and work and reflect on what difficulties she could have encountered or could find in her professional life according to the time and place she lived or lives. Later on, students had to justify the reasons for their choice and if the scientist's contribution had its application in science or served to improve the welfare of humanity and in what sense and if she had obtained recognition for it. Once this work was done, they had to select the relevant concepts and build a concept map about the scientist woman selected by using CmapTools, so that at the end, a Knowledge Model was built among all the students (González, 2008), including all the scientist women selected by the 15 groups.

2.1 Creation of the Knowledge Model "Women and Science" by all the Students' Groups

The fifteen students' medium groups selected scientist women, who made research in different fields such as astronomy (Jocelyn Bell and Vera Rubin), chemistry (Rosalind Franklin and Margarita Salas), physics (Katherine Johnson, Dorothy Vaughan, Mary Jackson and Lise Meitner), biology (Jane Goodall and Barbara Mc Clintock), and engineering (Hedy Lamarr, Elena García Armada and Mae Jemison). From all 13 scientists, only 2 were Spanish (15,4%) and only Rosalind Franklin, Jane Goodall and Katherine Johnson, Dorothy Vaughan and Mary Jackson were chosen by two groups. The methodology used for developing the Knowledge Model followed constructivism, and meaningful learning (Ausubel, 1968).

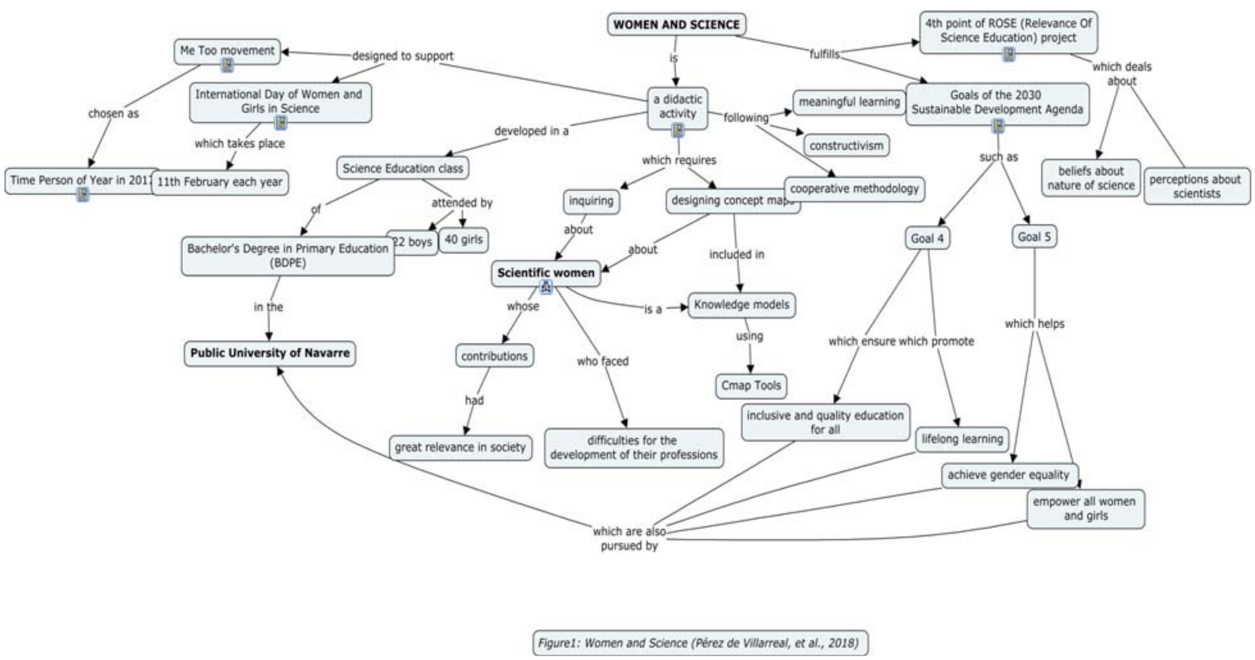

Figure 1. This concept map shows the activity "Women and Science" and it is the root map which is the interface for the rest of subordinate concept maps. Available at: http://cmap.unavarra.es/rid=1SG8PH1P2-1P905KL-1ST/ACTIVITY%20WOMEN%20AND%20SCIENCE.cmap

2.1.1 Rubric for coevaluation of the oral defense of the concept maps.

After working together and constructing their concept maps, students had to defend orally their selection emphasizing in some aspects, of the rubric such as:

- Selection of an interesting researcher
- Coherent and meaningful explanation about her life and work
- Proper oral expression, without errors
- Reflection on her work and the context in which she spent her life
- Application of her achievement

The coevaluation rubric, had four evaluation scores for each of the items mentioned above, like:

- Poor (1 point)
- Basic (2 points)
- Good (3 points)
- Excellent (4 points)

Each group evaluated the work of another group, so that at the end, we had the coevaluation score and the teacher's score and the final grade was the media obtained between both scores.

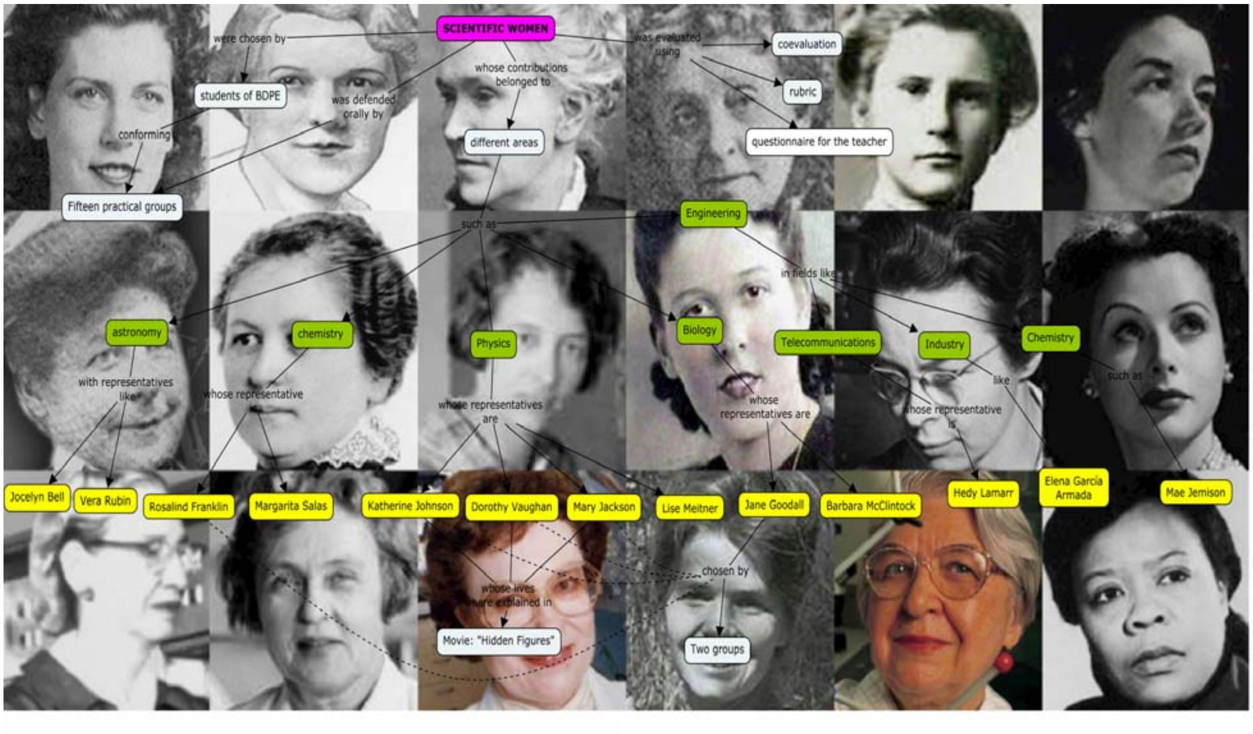

Figure 2: Scientific women. (Pérez de Villarreal et al., 2018)

Figure 2. This concept map shows "Scientific Women" chosen by the fifteen students' groups according to their preferences. Available at: http://cmap.unavarra.es/rid=1SG91XTZC-PB0HLQ-7TS/SCIENTIFIC%20WOMEN.cmap

2.2 Questionnaire for the Students.

2.2.1 Questions Asked to the Students.

For getting to know the usefulness of this activity and if the initial goals had been obtained, we designed a questionnaire with the following questions:
-Please, indicate your degree of agreement / disagreement with the following affirmations, where 4 = Completely agreement and 1 = completely in disagreement. There is a gap in equality between genders:

- when it comes to accessing science careers
- when entering the labour market
- at the time of accessing the highest paid academic, political and professional positions
- at the time of accessing professions related to the upbringing and care

-Practical activity 3 "Woman and Science", (in one scale from 0 to 4, being 4, Strongly agree and 0 very much in disagreement):

- Does it allow to give greater visibility to gender inequality in an educational and scientific context?
- Do you think that its didactic transposition in the school, as future teachers, will empower the girls to decrease the existing inequality?
- Does education have a relevant role to eliminate or alleviate gender inequality?
- As future teachers, what do you think could favor the elimination or reduction of existing inequality between genders?

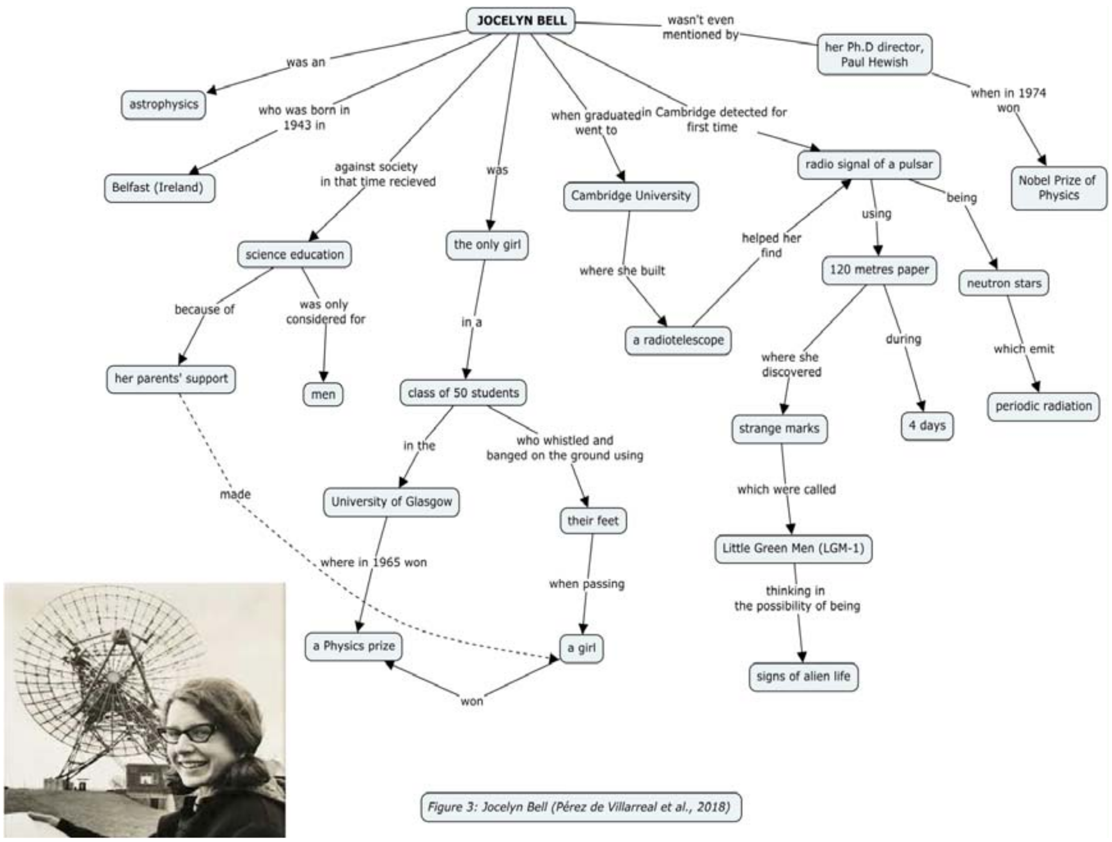

Figure 3: Jocelyn Bell (Pérez de Villarreal et al., 2018)

Figure 3. This concept map shows “Jocelyn Bell” as an example of scientist woman who had to face difficulties in the society of the time for becoming a recognized astrophysicist. Available at: http://cmap.unavarra.es/rid=1SGCGTRQR-75DJ0H-9HK/jocelyn%20bell.cmap

3 Results

3.1 Reflection on the Difficulties Selected Scientific Women faced during their Professional Career

According to 62 students of the BDPE, Katherine Johnson, Dorothy Vaughan and Mary Jackson (scientists in which the film “Hidden Figures” is based), were the ones deserving their most recognition (3 groups from 15, 20%); and later, Rosalind Franklin (discovery of the DNA structure) with 2 groups from 15 (13,3%); and Jane Goodall (wildlife preservation and discovery of use of tools by chimpanzees) with 2 groups from 15 (13,3%), as well. The other scientists were selected by only one group from 15 (6,7%). Only two of the selected women were Spanish (15,4%).

The graph in Figure 4 shows some difficulties, such as the society of the time in which it was not well seen women worked outside of their homes, especially in jobs considered appropriate for men, and maleness, were perceived as the most visible difficulties with a percentage of 23,26% each. Subsequently, the lack of recognition of society or of other colleagues (17,44%); later, race (11,63%) which implies Afro-American women had even more added difficulties for the development of their professional careers; after, the family support (5,81%) and the economic remuneration or project financing (5,81%); then the origin (4,65%) which refers to a humble origin or to belonging to ethnic communities such as the Jewish. War, exile and age, have the same percentage (2,33%), being particularly special age, because it deals about the lack of opportunities for scientific women once they reach retirement age. Finally, beauty (1,16%), which can be considered a gift, but in a labour context, it meant to put aside scientific dedication and exploit the gift, as it happened in the case of Hedy Lamarr.

GROUPS	SCIENTISTS	DIFFICULTIES											
		SOCIETY OF THE TIME	MALENESS	RACE	ORIGIN	FAMILY	WAR	EXILE	LACK OF RECOGNITION	BEAUTY	AGE	ECONOMICAL	SCORE
1	Jocelyn Bell	1	1		1				1				4
2	Hedy Lamarr	1	1		1		1	1		1			6
3, 13	Rosalind Franklin	2	2			2			2				8
4	Vera Rubin	1	1										2
5	Elena García Armada											1	1
15,9,6	Katherine Johnson	3	3	3					3				12
	Mary Jackson	3	3	3		3			3				15
	Dorothy Vaughan	3	3	3					3			1	13
7	Lise Meitner	1	1				1	1	1			1	6
8	Margarita Salas	1	1								1		3
12, 10	Jane Goodall	2	2		2				2			2	10
11	Barbara Mc Clintock	1	1								1		3
14	Mae Jemison	1	1	1									3
	TOTAL SCORE	20	20	10	4	5	2	2	15	1	2	5	86
	PERCENTAGE	23,26%	23,26%	11,63%	4,65%	5,81%	2,33%	2,33%	17,44%	1,16%	2,33%	5,81%	100%

Table 2: Table showing the difficulties students assumed for each of their selected scientific women.

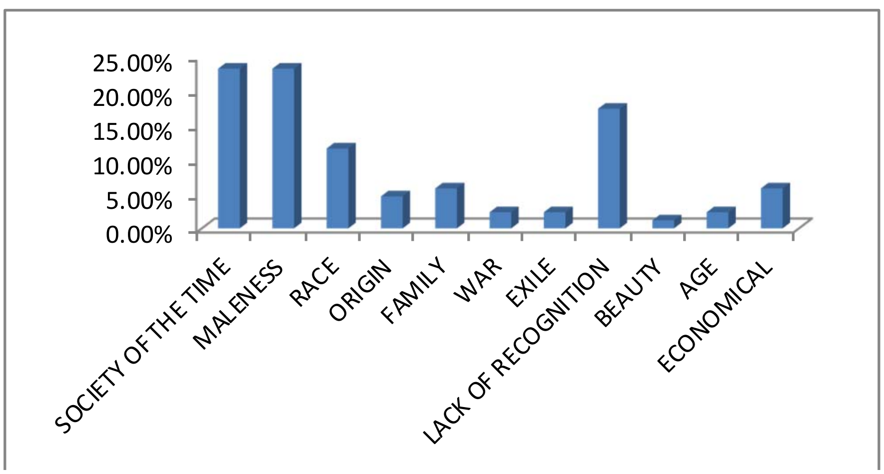

Figure 4: Graphic showing the percentages of each of the difficulties perceived by the students of BDPE.

3.2 Questionnaire for the Students

The survey was answered by 39% of the students, being 80% women and 20% men. From them, 84% were aged between 20-23 years old, 4% between 27-30, and 12% more than 30 years old. Of the total of students, 40% received science training in high school, 12% training in humanities and 48% in social sciences. Pre-Grade training had been high school in most cases (79%), whereas the rest had received job training (8%) and 13% had taken another degree or bachelor's degree.

When it came to answer if students considered there was a gap in equality between genders: once accessing science careers, 67% agreed, whereas 2% did not agree and 2% did not answer; when entering the labour market, 72% considered there was a gap, 24% there was not, and 4 % did not answer; at the time of accessing the highest paid academic, political and professional positions, 67% agreed in the gap, 29% did not agree and 4% did not answer; at the time of accessing professions related to the upbringing and care, 80% agreed in the existence of the gap, whereas 16% did not and 4% did not answer.

As an evaluation for the Practical activity 3 “Woman and Science”, and to check if the initial goals had been obtained, we posed some questions (see 2.2.1) getting the following results: 100% of the students surveyed considered this activity allowed giving greater visibility to gender inequality in an educational and scientific context (answering 64% as excellent, 24%, good and 12% adequate) ; again, 100% deemed its didactic transposition in the school, as future teachers, would help empowering the girls and therefore, decreasing the existing inequality (answering 64% as excellent, 32% good, and 4% adequate); last, but not less important, again 100 % of the surveyed students considered education had a relevant role to eliminate or alleviate gender inequality (answering 92% as excellent, 4% good and 4% adequate).

4 Discussion

Although the function of role models has been questioned in improving attitudes toward or in increasing the number of women in science, many studies suggest it has a positive effect and it is suggested it should be included in the science curriculum. In addition, universities such as Stanford University and / or Massachusetts Institute of Technology (MIT) have successfully used undergraduate women in science and engineering to recruit high school girls to those fields. Perhaps, the most effective role models for science classes are women or girls only a few stages ahead of one's students and girls might form science clubs at both the elementary and junior high levels to encourage those in the lower grades. This way, social perceptions of acceptance and belonging could be fostered and perhaps the negative attitudes developed between age 9 and 13 (Butler, 1983) and observed also in 15 (Sjoberg & Schreiner, 2005) could be ameliorated. During the early high school years, girls should have the opportunity to speak with both collegiate undergraduate and graduate women in science as well as professional female scientists and engineers. Conscious efforts may be needed in the beginning, but -as students, teachers, counselors and administrators practice these strategies, they will become routine. The recognition of inequalities in science classrooms and the implementation of remedial instructional and curricular strategies is a critical first step in improving the science education for women. Science teachers as well as educators of science teachers, should be cognizant of these strategies.

The design of Knowledge models and the use of concept maps for improving gender equality, is a quite novel methodology in BDPE. In this study, it was selected, because they are powerful tools for promoting meaningful learning (Novak, 1998; Ausubel, 1968), and since students of BDPE are going to become teachers of primary education, they are going to be relevant links of the chain which will spread the conceptual change needed for empowering girls and making them feel curious about science and capable of developing science related careers. School is the very first step for starting the change.

When we asked students as future teachers, if what they thought could favor the elimination or reduction of existing inequality between genders, they answered wisely:

> “*Promote the same aspirations, skills and values in children. End those roles of gender difference, sometimes even without realizing it, and which are transmitted to each other (good behavior, different ways of expressing themselves, attitudes that are tolerated in boys and not in girls and vice versa, etc.). Highlight the important role that many pioneering women have carried out in different aspects of culture and knowledge (science, art ...). Promote a language that is less and less sexist. I believe that in the small and sometimes imperceptible moments of the educational community it lies the difference and change occurs.*”

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