

Monitoring the Effects of the October 10-11 Solar Storm at Mid-Latitudes Using a GNSS SDR Receiver

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Article

Assessing Gender Gaps in Educational Provision, Research and Employment Opportunities in the Transport Sector at the European Level

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Abstract: Serious gaps are found when evaluating the recognition and inclusion of gender aspects in transport strategies, research and innovation. Similar issues can be spotted in the transport labor market, where only 22% of workers are women at the European level. The roots of these limitations are in the low participation of women in Science, Technology, Engineering and Maths (STEM) studies and, therefore, in the traditionally male-dominated transport field occupations. Stemming from the European project TIInnGO, the current paper proposes a descriptive analysis to evaluate the gender gaps in educational provision and research in ten European countries. Specific indicators, such as percentages in the gender composition or the presence of university courses dealing with mobility and transport, have been defined and their availability in different countries is verified. In addition, a desktop review of practices for encouraging and supporting women in STEM studies is operated, underlying characteristics such as the kind of initiative, the methods and tools used, the target group or the type of promoter. The results of this activity show that a wide network of associations and mentoring operates in various European nations, mostly targeting secondary school students, trying to make females aware of their potentialities in a deeply gender-biased field like the STEM one.

Keywords: gender issues; STEM culture; H2020; smart mobility; women in transport

1. Women in Transport

The European Commission underlines the importance of changing European transport to meet the ambition of a safe, efficient, technologically advanced, sustainable and accessible transport system [1]. Moreover, the concept of equality between women and men is a core value of the European Union, which provided a large body of legislation intending to promote gender equality in various areas (equal pay, work-life balance, health and safety at work, social security, access to goods and services, and protection from human trafficking, gender-based violence and other forms of gender-based crime) [2]. However, the relevance of this topic has a worldwide dimension, also thanks to the 17 United Nations' Sustainable Development Goals (SDGs), which include the gender-specific Goal 5 [3]. Gender equality "does not mean that women and men will become the same but that women's and men's rights, responsibilities and opportunities will not depend on whether they are born female or male" [4]. Although wealth and income inequality are topics currently debated at academic and policy level, gender inequality remains mostly on the margins despite the fact that it can cause serious adverse effects on the welfare of women and a country's development [5]. On the whole, this theme is very up to date in various fields, such as gender discrimination against working women [6] or subjective well-being [7]. A consistent part of the literature focuses on the gender gap in science and in STEM (Science, Technology, Engineering and Mathematics) disciplines at university [8] or college level [9]

down to pre-schoolers [10]. However, the debate on the transport careers of women is still a rather niche topic, with some recent examples coming from Japan [11] or India [12].

The presence of women in the transport industry is not simply desirable to reach certain gender equality, but it is expected because they can be a true source of innovation and creativity in new services. This sector is, in fact, in need of all talents in order to meet the pressing challenges of climate change, urbanization, growing population etc. At both European and national levels, there are still severe gaps when it comes to the recognition and inclusion of gender aspects in transport strategies, research and innovation. On the whole, women's issues in transport is a relatively new topic even if research on that, and mainly on equality and women, started in the early 1980s. A recent review showed that European regulations considered women and transport issues since the beginning of the 21st century, but also that the funding of relevant European research projects began about 20 years ago [13]. Several reasons can explain the underrepresentation of women in the transport sector: "difficulty to find a work-life balance in shift work, lack of appropriate working environment and equipment, lack of training and life-long learning opportunities or inadequate targeted recruitment, persistence of stereotypes, harassment, and bullying" [13].

Many reasons can give rise to the absence of women in certain careers and can find different interpretations in many theories: human capital, discrimination, the social construction of gender and the work organization models [14]. According to the intersection of these contents, women seem more influenced by the possibility of combining work and family while choosing a profession. Moreover, a potential job would be more appealing among females if it appears suitable for their personal characteristics and interests or when it guarantees a major transference. These professional choices seem motivated by positive opinions on their social utility [14]. On the whole, it is rather known that educational and professional preference feel the effect of suggestions and models that people internalize during their life, commonly in socialization and education processes taking place in the family and school environment. This aspect seems to reflect more on women: they appear to be affected by long-lasting prejudices towards certain jobs that are supposed to be more suited to men [14].

Similar issues can be spotted in the transport labor market, where women comprise only 22% of workers in Europe [15]. Nowadays, when talking about transport, it is necessary to focus on a buzzword of the 21st century: smart mobility (SM). This is a concept involving four main contents: vehicle technology, intelligent transport systems, data and new mobility services [16]. It is usually associated to smart city initiatives because they are considered to be a winning urban strategy using technology to increase the quality of life in urban space, both improving the environmental quality and delivering better services to the citizens [17]. The smart city can be described as "a city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of activities of self-decisive, independent and aware citizens" [18]. Smart mobility, although just one component of a smart city, is seen as a means of delivering key benefits such as reducing pollution, traffic congestion, noise pollution and transfer costs, while at the same time increasing transport safety and improving transfer speed [19]. On the whole, gender has been marginal in smart cities research, while smart mobility could open interesting opportunities for social inequity reduction [20].

The spread of the knowledge on the innovations connected with the SM framework is somewhat related to the kind of studies reinforcing them, namely the ownership of STEM skills. Therefore, the starting point to address gender gaps in the transport sector is necessarily an analysis of gender-related educational issues in the above-mentioned sectors. This paper aims to explore the gender imbalances in the educational provision at European level in STEM education (especially in the transport sector and smart mobility). Data collection is an important step which is necessary to deepen the knowledge of the current situation in different countries. Our attention will focus on two main kinds of information. Firstly, we will define specific indicators investigating staff and students' distribution in educational institutions, possibly dealing with transport and SM, and their availability. These data can help to understand the level of awareness on the topic at the educational level in

different countries. Once this aspect is assessed, it is interesting to investigate which are possible initiatives that could be proposed to increase the number of women interested in those studies. So, we will propose a desktop review of practices already available in EU countries, underlining their main characteristics, such as the kind of initiative, the methods and tools used, the target group or the type of promoter. The results obtained will help in deepening the discussion on how it is possible to improve gender imbalances in STEM education and R&D.

2. The TInnGO Project and Smart Mobility

TInnGO (Transport Innovation Gender Observatory, <http://www.tinngo.eu/>) is a European Project funded under the H2020 programme aimed at creating a framework and a mechanism for a sustainable game change in European transport, through a transformative strategy to achieve a gender and diversity sensitive smart mobility [21]. It fits inside this framework to provide a solid awareness of the barriers in both transport and in the labor market, and to develop and apply new models of knowledge production for the transport and smart mobility sectors. Its approach will make use of qualitative, quantitative and design research methods in multiple locations by combining hands-on knowledge, concrete actions and best practices to develop gender- and diversity-sensitive smart mobility solutions, which fit local conditions. The central objectives of TInnGO can be spelt out in four specific and integrated targets: gender smart mobility, knowledge production and data modelling, guidelines for gender action plans and policy strategies development. Moreover, the project will work for the creation of 10 national hubs and associated 'ideas factories' (TInnGIdLabs) covering Sweden/Denmark, the UK, Spain, Portugal, Italy, Greece, France, Germany, Romania, Lithuania and the Baltic states: each hub will address issues of local importance in gender and diversity sensitive smart mobility.

As previously mentioned, smart mobility is based on the development of new technologies and the use of innovations in the field of transport. So, it is interesting to evaluate the position of women not only as final users [22–24] but also as "provider" of such contents. In other words, the investigation of the opportunities for women's employment and education in this new field is another crucial issue that is addressed by the TInnGO project and presenting related activities is within the scope of the current paper. Although the smart mobility concept includes a rather vast domain of aspects such as urban mobility, citizen's engagement and participatory design, the present work aims at focusing on the contents more related to the term 'smart' which can be commonly associated to traditionally male-dominated STEM subjects such as computing, engineering, manufacturing and planning. Usually, all these subjects are coupled with a fractured and gender-biased transport ecosystem (embracing education, employment, operation, data collection and innovation) that severely impedes the ability of smart mobility to deliver equitable transport.

While demand for STEM professionals and associate professionals is expected to grow by around 8% by 2025, much higher than the average 3% growth forecast for all occupations, women's participation in STEM studies, in particular in engineering, remains low in most EU countries: in 2012, graduates in STEM-related subjects accounted for 12.6% of female graduates as compared with a share of 37.5% among male graduates. [25]. As shown in by the Danish Technological Institute [26], computing and engineering are the two STEM disciplines which are heavily male-dominated, with more than 80% male graduates in both disciplines in 2012 in the EU, while life science—the third-largest STEM discipline—is dominated by women. The remaining three STEM disciplines (physical science, mathematics and statistics, manufacturing and processing) have a fairly equal participation rate of males and females. The gender gap in STEM disciplines has many facets, including a form of horizontal segregation that favors the presence of men or women in some sectors and excludes them in others [14]. Women are commonly not so present in technical-scientific jobs, although they attend scientific high schools. However, a series of mechanisms linked to specific systems of expectations and identity definitions seem to influence the work choices of women, who tend to exclude themselves from occupations in the IT, technical and scientific sectors.

As previously observed, smart mobility is mainly connected with the former group of subjects and, so, it is a deeply gender-biased domain. Many elements contribute to this figure, including barriers to the participation of women in STEM which take the form of stereotypes, social norms and cultural practices, welfare policies, family backgrounds and the absence of women role models, and limited access to networks, information, funding or institutional support. As depicted in [25], recruitment difficulties have been experienced in many EU member states concerning STEM skilled labor, mainly pertaining to technological jobs in the field of engineering and ICT, which is connected to an insufficient number of graduates and a lack of experienced staff. At the same time, underrepresentation of women persists in most of those domains. The TInnGO project aims at analyzing both the current situation and issues in the field of education and employment of women in the mobility sector.

3. Methods of Data Collection

The first step we propose to deepen the knowledge of the current situation in different countries involves a data collection procedure. We wanted to investigate the availability of information on staff and students' distribution in universities and secondary schools in the EU countries of TInnGO hubs. The aid of people belonging to these hubs has been fundamental for the data gathering mainly because almost all the material collected was only available in the local language. We implemented a specific survey asking each hub to focus on a selection of about 10 STEM universities (possibly dealing with the transport and smart mobility field, both in teaching and for research) and 10 secondary schools covering STEM subjects. These institutions were supposed to be chosen in such a way that they could be considered sufficiently representative of the situation in the country related to gender issues in STEM education.

We defined a set of specific indicators that allowed us to compare the level of awareness in the different countries. Some of these indicators can be commonly found in documents and reports providing an overview of the STEM studies and occupations [25,26] or on gender equality in research and innovation [2]. However, the current research aimed at focusing on indicators more specifically targeting the smart mobility field, whenever possible, in a gender-sensitive way. The investigated aspects are connected to the composition of personnel in the selected institutions, both in the administrative staff (up to the governing bodies) and for people employed in teaching and/or research. Moreover, the gender percentages of students are collected at all levels of education, from secondary schools up to post-university courses, when available. Our interest in transport and SM requires us to focus on specific courses of study dealing with these topics, whenever data are accessible. In this regard, some peculiar indicators have been defined, such as those dealing with the composition of associations and students' teams or the gender of winners of grants and scholarships.

In addition, information was collected on each indicator to understand whether its value is either publicly available, or collected but not available, or not collected, considering both the national level (i.e., aggregated values for the entire educational system), and the universities or schools within the selected sample. The availability of raw data was one of the first issues to be tackled: in fact, it was not easy to search for this kind of information. However, these numbers can help in understanding the female interest and participation in STEM studies, and they can be exploited to evaluate the effectiveness of practices proposed for encouraging and supporting women in the transport sector education.

The above set of indicators can help in assessing the gender balance situation related to education in the subjects related to smart mobility. It is, then, important to understand if some specific actions have been taken to reach a good balance or if some initiatives are underway to enhance it. So, the second part of the data collection was based on the identification of best practices for encouraging and supporting women engaged in STEM education at the European level in the TInnGO countries, either on a teaching/research or on a student side. The aim was to focus on actions that are specifically targeted at the transport educational sector (e.g., transport engineering, transport planning, vehicle design, etc.), if possible.

Common practices for encouraging and supporting women in STEM can be quite different, including the way subjects are taught, the implementation of student-centred and problem-based approaches, the change of learning cultures, or the promotion of gender balance through association, communication campaigns and awards. A desktop review of best practices was then implemented to analyze common and peculiar features and procedures in some selected European countries. Also in this case, a proper survey was proposed to the researchers belonging to the different project hubs to access data available only in the national language. The main information that all hubs collected to compare the practices included: the title of the action, its type, the geographical level (national or local), if the initiative was in progress or concluded, the start and end years, who was the promoter, who was the funder, the target group, the type of source for the information, the method used to support and encourage women in STEM and the main results if already available.

4. Analysis of the Results

4.1. Indicators Availability

The rows of Tables 1 and 2 present the indicators that the hubs had to analyze, respectively referring to staff (Table 1) and students in universities and secondary schools (Table 2). The columns of the two tables cover the level of availability of each indicator, while each cell lists the hubs where a specific indicator has a given level of availability. The options in the columns are not mutually exclusive, since an indicator could be available for some schools but not for others, or available both as an aggregate result at the national level and for some specific institutions, but not for all.

Table 1. Indicators referring to staff in university and secondary school.

Indicators	Publicly Available		Not Collected		Collected but not Publicly Available	
	At National Level	At University/School Level	At National Level	At University/School Level	At National Level	At University/School Level
Gender staff composition in universities, irrespective of the covered role	FR, GE, IT, PO, RO, SP, UK	FR, GE, IT, RO, DE, SP	DE	BS, RO		
Gender staff composition in secondary schools, irrespective of the covered role	FR, GE, PO, RO, SP, GR, UK	FR, IT, RO, DE	DE	BS		
Gender staff composition in universities, only considering the personnel employed in teaching and/or research	FR, GE, IT, PO, RO, SP, GR, UK	FR, GE, IT, RO, DE, SP	DE	BS, RO		
Gender composition in universities, only considering the personnel employed in teaching and/or research in the transport and smart mobility fields	FR	FR, IT, RO, UK	GE, IT, PO, DE, SP	GE, RO, DE, SP		PO
Gender composition of the university governing bodies (e.g., head or management roles)	FR, IT, UK	FR, GE, IT, RO	GE, PO, DE, SP	BS, RO, DE, SP		PO
Number of university courses dealing with transport or smart mobility	FR	FR, IT, PO, RO, SP, UK	GE, IT, DE	GE, DE		RO
Number of ongoing national and international research projects dealing with transport and smart mobility in which the university is involved		FR, IT, PO, RO, DE, SP	GE, IT, DE	GE, UK		RO
Gender composition of the research teams involved in projects related to transport and smart mobility		RO, DE, SP	FR, GE, IT, PO, DE	GE, IT, PO, UK		RO

NB: BS, Lithuania and Baltic States; DE, Denmark; FR, France; GE, Germany; GR, Greece; IT, Italy; PO, Portugal; RO, Romania; UK, United Kingdom; SP, Spain.

Table 2. Indicators referring to students in university and secondary school.

Indicators	Publicly Available		Not Collected		Collected but not Publicly Available	
	At National Level	At University/School Level	At National Level	At University/School Level	At National Level	At University/School Level
Gender composition—secondary school students	FR, GE, PO, RO, DE, SP, GR, IT	BS, IT, RO		BS, DE		FR, RO
Gender composition—students taking part in university admission tests	FR	FR, DE, RO	GE, PO, DE	BS, GE, PO, RO		IT, SP
Gender composition—first year students (university)	FR, GE, IT, SP	FR, GE, IT, DE, SP, RO	PO	BS, PO, RO		
Gender composition—first year students (university) in subject related to transport and smart mobility	FR	DE, RO	GE, IT, DE	GE, IT, RO		FR, SP, RO
Gender composition—university students (all levels)	BS, FR, GE, IT, PO, SP, RO	FR, GE, IT, SP	DE	BS, DE		
Gender composition—Bachelor’s degrees	FR, GE, IT, PO, SP, RO	FR, GE, IT, SP	DE	BS, DE		
Gender composition—Bachelor’s degrees in transport and smart mobility	FR	IT	GE, PO, DE, SP	GE, DE, SP, RO		FR, RO
Gender composition—Master’s level students	FR, GE, IT, SP	FR, GE, IT, SP, RO	PO, DE	BS, DE, RO		
Gender composition—Master’s level students in transport and smart mobility	FR	FR, GE, RO	GE, IT, PO, DE, SP	IT, DE, SP		RO
Gender composition—Master’s degrees	FR, GE, IT, SP, RO	FR, GE, IT, SP	PO, DE	BS, DE		
Gender composition—Master’s degrees in transport and smart mobility	FR	FR	GE, IT, PO, DE, SP	GE, IT, DE, SP, RO		RO
Gender composition—post-master students excluding PhD	FR, SP	FR, IT, SP	PO, DE	BS, DE		PO
Gender composition—post-master students in transport and smart mobility excluding PhD		IT	GE, PO, DE	GE, DE	FR	FR, PO
Gender composition—PhD students	FR, GE, SP, RO, IT	FR, GE, IT, DE, RO	PO, DE	BS, RO		
Gender composition—PhD students in transport and smart mobility	FR	IT, RO	GE, PO, DE	GE, DE, RO		FR, SP, RO
Gender composition - Erasmus students	FR, IT, SP	FR, RO	DE	BS, DE, RO		IT
Gender composition - Winners of grants/scholarship	FR	FR	GE, IT, DE	BS, IT, DE, RO		SP, RO
Number of grants/scholarships specifically designed for women			GE, IT, DE	DE	FR	SP
Number of grants/scholarships in transport and smart mobility	FR	FR	GE, IT, DE	DE, RO		SP
Number of students involved in associations and teams dealing with transport and smart mobility	FR	FR, IT	GE, IT, DE	GE, DE, RO		SP, RO

NB: BS, Lithuania and Baltic States; DE, Denmark; FR, France; GE, Germany; GR, Greece; IT, Italy; PO, Portugal; RO, Romania; UK, United Kingdom; SP, Spain.

The count of how many hubs fall into each cell in Tables 1 and 2 demonstrates how the availability of data differs across TInnGO countries. Such a result is undoubtedly influenced by the possibility of accessing specific academic databases, while another rather strong barrier lies in the fact that most of the information is available only in the relevant national language. All these factors do not allow a straightforward comparative analysis of the situation at the European level. However, some trends can be noticed in order to assess the level of imbalance in the education provision in the considered European countries and derive some benchmark values. One analysis that will be proposed in the subsequent phases of the project is to compare the presence of women in technical universities at the national level with the above-mentioned European benchmark to gain a better trend knowledge. The investigation can be twofold, including an analysis both at the staff and at the student level.

Some preliminary studies were already carried out. For example, the comparison of gender staff composition, irrespective of the covered role, on a selection of universities in Germany, Spain and Italy demonstrated that the percentage of women is commonly lower than the national average in those dealing with more technical degree courses, namely engineering schools. These values decrease even more when considering only the personnel employed in teaching and/or research, due to

the considerable presence of women covering administrative roles in those institutes. Numerically speaking, the average percentage of females in the whole staff in German universities is equal to 43.8%, with this number decreasing to 39% when considering only those involved in teaching and/or research. The latter value is similar to the Italian one (40%), but in this nation, instead, the former indicator rises to 47%.

Some other analyses can be carried out on the students’ datasets at the national level. For instance, Figure 1 shows some data for Italy. The chart on the left reveals that three universities dealing only with technical courses, namely POLIBA, POLIMI and POLITO, have a female presence lower than the average. In fact, the other institutions also offer other kinds of study, like the humanistic ones, that usually attract more women. The chart also shows the trends of women’s presence at three different stages of the university career, namely first year, at master’s graduation and as PhD students. Given the focus of this research on transport and smart mobility, Figure 1b shows the percentages of females who got master’s degrees in courses related to those topics, whenever those data are available: the presence of males is always sharper, but equality is not so far off in some cases.

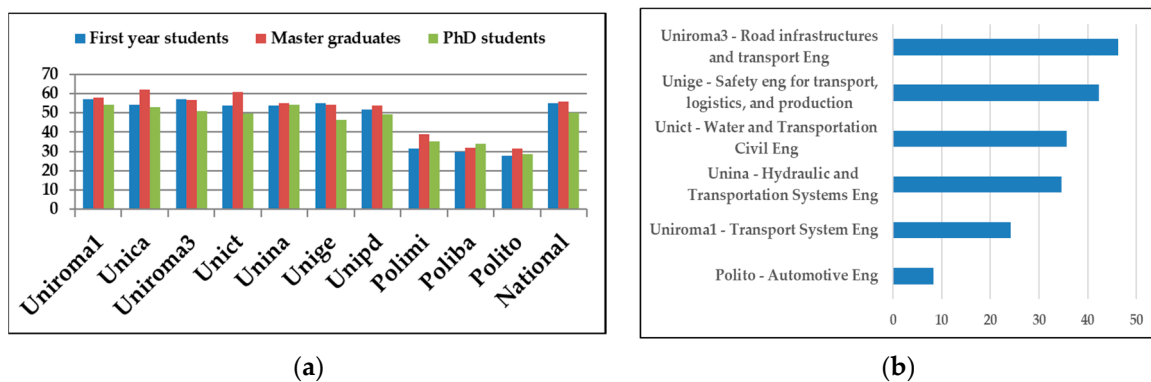


Figure 1. (a) Percentages of female students in 10 Italian universities; (b) percentages of females graduating in transport and smart mobility (SM) master’s degrees.

4.2. Desktop Review of Practices

In general, a difficulty emerged in the procedure described in the previous section, especially about finding specific and relevant initiatives in the field of transport. Surely this aspect is not favorable for the promotion of gender balance in this sector since the visibility of the initiative itself should be a peculiar element. The desktop review proposed is useful to define a base framework of European practices, by categorizing them through their main features that are reported in the first two columns of Table 3.

In this initial phase, 26 initiatives were considered from nine hubs. As shown in Table 3, actions to involve women in STEM and transport sector widely differ and a comparison could be inefficient, but an overview is nevertheless reported. Furthermore, the availability of information was not homogeneous in different countries. Consequently, the number of useful practices for the desktop review is currently not comparable among the nations. It is essential to underline that more than one option is acceptable per category: the tools used can be both workshops and hackathon, for instance.

Table 3. Cross-tabulation of the number of reviewed European practices for encouraging and supporting women in Science, Technology, Engineering and Maths (STEM): practice characteristics by country.

		Country								
		IT	DE	UK	GR	GE	PO	SP	RO	BS
Kind of practice	Association/network	2	1	1	0	2	1	0	0	3
	Mentorship/courses	2	0	1	0	0	0	0	1	3
	Communication campaign/events	3	1	1	3	1	0	1	0	4
	Awards/scholarship	1	0	0	0	0	0	0	1	0
Promoter	Regional/National/EU policy	1	0	1	2	1	1	1	1	2
	School/University	3	2	1	0	2	0	0	0	1
	STEM Company	2	0	1	0	2	0	0	2	2
	Association/NGO	0	1	0	1	0	0	0	1	5
Funding	Project funding/EU funding	1	1	0	1	0	0	0	0	2
	Financed by the company	1	0	2	0	1	0	0	1	4
	Public/national funding/University funding	2	0	0	3	0	1	1	0	1
	Donations/fees	0	0	0	0	0	0	0	0	2
Target groups	Primary school students	1	0	0	1	0	0	1	0	1
	Secondary school students	3	1	2	2	2	0	1	1	4
	University students	3	0	1	0	2	1	0	0	3
	PhD students	0	0	0	0	1	1	0	1	0
	Researchers/ PhD	0	0	0	0	1	0	0	1	0
	Educational staff	0	0	0	3	0	0	0	0	0
	Women in general/selected women categories	0	1	0	0	0	0	0	0	4
Implementation methods and tools	Workshops/conferences	1	2	2	3	2	0	1	0	8
	Games/hackathon/camp	3	1	0	0	0	0	0	0	1
	Social network campaign/dissemination materials	1	0	0	1	0	0	0	0	1
	Mentoring	3	1	1	1	2	0	0	1	4
	Awards/internship	1	0	1	0	0	0	0	1	1
Transport-specific	Yes	1	0	1	0	0	0	0	0	0
	No	3	2	1	3	2	1	1	2	10

NB: BS, Lithuania and Baltic States; DE, Denmark; GE, Germany; GR, Greece; IT, Italy; PO, Portugal; RO, Romania; UK, United Kingdom; SP, Spain.

The overall view reported in Figure 2 shows that the kind of practice that is generally more widespread is the communication campaign (43%) followed by the association (30%): probably the former type of approach raised recently because of the ever-increasing diffusion of social networks as a useful communication tool. As regards the promoter of initiatives, the situation is quite balanced, with 28% of practices proposed by regional/national/EU policies, 25% by schools or universities, 25% by STEM companies and finally a 22% by associations or NGOs. In addition, funding to promote the initiatives is coming in a balanced way from both the public and private sectors. This means that STEM companies are interested in practices to encourage and support women in their fields too.

The desktop review demonstrates that the most used implementation method is the organization of workshops or conferences (43%), but also the mentoring approach is widespread (30%). Finally, interesting results concern the target group to which the initiative is addressed: secondary school girls (37%) are the primary beneficiaries of this type of activity. In fact, as shown by the findings of a survey presented by the Italian association “STEM by Woman”, girls (like all students) make decisions about their future typically in those years. Therefore, this is the moment when the initiatives may become more effective [14].

Although many of the actions are recent and still ongoing, impressive outcomes have sometimes emerged. For instance, a Danish communication campaign, addressed to secondary school students and made up of workshops, mentoring and camps, increased the female students admitted at the IT University of Copenhagen (ITU) from 25% to 34% in the period 2016–2018 (<https://en.itu.dk/about-itu/gender-diversity-among-students>). In the United Kingdom, just one event was proposed by an association which aims to inspire and support young women into those careers (<https://stemettes.org/about-us/>), after which 95% of attendees reported an increased interest in STEM. A communication

campaign proposed by an Italian technical university through a mentoring approach and targeted scholarships contributed to improving the percentage of women enrolled from 15.8% to 19.3% between 2001 and 2007 (<https://laboratoriopolito.org/file/47>).

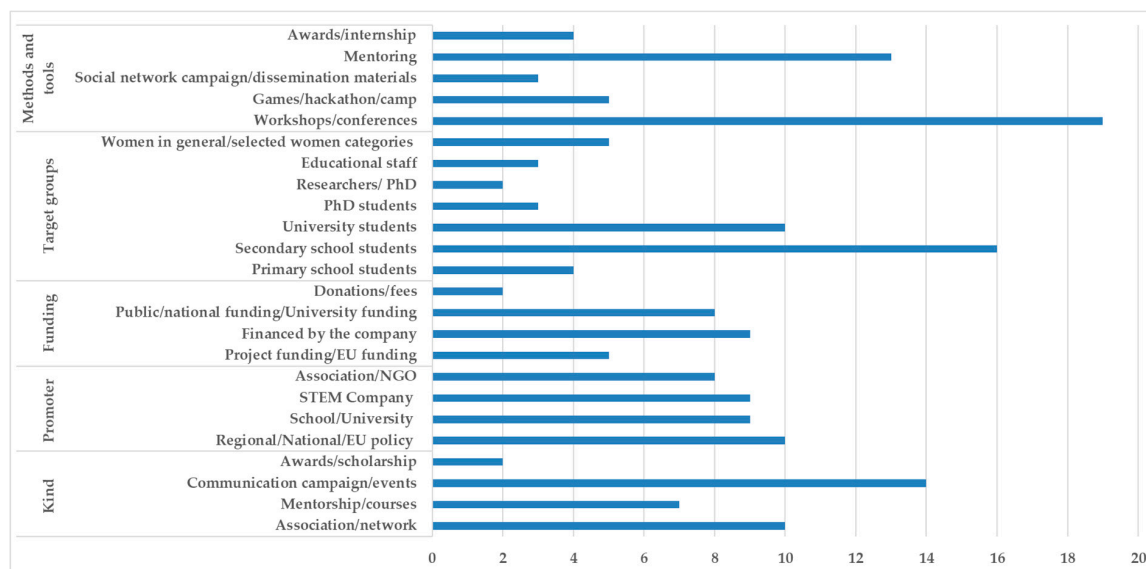


Figure 2. Overall view of collected information on European practices for encouraging and supporting women in STEM.

5. Discussion and Conclusions

This paper presented the activities conducted at European level aimed at evaluating the imbalances in educational provision in the STEM domain, given the strong link with the smart mobility and transport framework. Some difficulties had to be faced: numbers are not always easily accessible, especially from outside the academic context. As showed in Section 4.2, more information can be found while searching for specific initiatives aiming to increase the interest of women towards STEM disciplines at both the academic and secondary school levels. For example, the effectiveness of campaigns proposed by technical universities for promoting this kind of study among secondary female students could be inferred by the increase in the percentage of women enrolled over the years, as emerged from some of the past European practices reviewed in Section 4.2.

Currently, European universities rarely offer study courses focused on smart mobility, as emerged in Section 4.1 of this paper. As a consequence, it has been necessary to extend the study to the STEM world with a focus on the transport sector, given the correlation between gender gaps in STEM and gender gaps in smart mobility. Furthermore, as discussed in Section 4.2, the practices for encouraging and supporting women in transport and Smart Mobility sectors are often included in more general solutions proposed by STEM studies.

A vast network of associations and mentoring can be found operating in various European nations. In essence, most of them organize workshops and communication campaigns trying to make female aware of their potentialities in a deeply gender-biased field like the STEM one. Unfortunately, a low number of initiatives are explicitly focusing on bringing the women closer to the transport sector, and this is undoubtedly a domain where the TInnGO project can give a contribution by supplying new knowledge and suggesting specific ways to address this issue.

Most of the initiatives are directed at secondary school students to show women's potentialities in technical universities and propose the experiences of successful women operating in commonly male-dominated jobs, such as, for example, within the smart mobility sector. In these cases, the mentoring approach can involve either female university students or working women. In the first case, the goal is to present the experiences of female students in courses characterized by a vast majority

of boys, highlighting both problems and satisfactions. The meetings with working women have the intent, instead, of highlighting the persistence of the gender gap and its effects in the many areas of professional life, with differences in the entry into the labor market, barriers during career paths, conflicts between working times, family obligations, and careers. However, these women can be seen as a living example of how it is possible to face these issues, demonstrating their ways of overcoming those barriers. Some activities are also proposed in primary schools, commonly to show that girls hold technical capacities too. In fact, recent research showed that that gendered notions of brilliance are acquired early (at six years of age) and have an immediate effect on children's interests [27].

One of the fundamental points is the combined work of educational institutions (mainly universities, but also secondary schools) and companies to explain the potentialities of female students in the technical disciplines and fighting some stereotypes that would keep women far from some male-dominated labor ambits. Overcoming the gender gap in the STEM would produce advantages both in terms of equity and efficiency. In 1999, Katy Matzui, an analyst at Goldman Sachs, coined the term "Womenomics" to indicate to the business world a new strategy that would enhance the female component as a resource and not as a constraint for the development of companies [14]. An increased number of women entering the labor market would produce an increase in the economy with benefits that could be perceived by the whole population [28]. This aspect is necessary for an era like the current one, which is characterized by a broad technological change through the development of new products and processes. Design of the technology and the organization addressed only to the male component of the population would produce the risk of not exploiting the innovation and the creative proposal that the other half of the population would bring [14].

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References

1. European Commission WHITE PAPER—Roadmap to a Single European Transport Area towards a competitive and resource efficient transport system. *COM 2011, 2011*, 144.
2. European Commission. *She Figures 2018*; Publication Office for the European Union: Luxembourg, 2019.
3. Razavi, S. The 2030 Agenda: Challenges of implementation to attain gender equality and women's rights. *Gend. Dev.* **2016**, *24*, 25–41. [[CrossRef](#)]
4. European Commission. *One Hundred Words for Equality: A Glossary of Terms on Equality between Women and Men*; Office for Official Publications of the European Communities: Luxembourg, 1998.
5. Agarwal, B. The challenge of gender inequality. *Econ. Politica* **2018**, *35*, 3–12. [[CrossRef](#)]
6. Verniers, C.; Vala, J. Justifying gender discrimination in the workplace: The mediating role of motherhood myths. *PLoS ONE* **2018**, *13*, e0190657.
7. Meisenberg, G.; Woodley, M.A. Gender Differences in Subjective Well-Being and Their Relationships with Gender Equality. *J. Happiness Stud.* **2015**, *16*, 1539–1555. [[CrossRef](#)]
8. Holman, L.; Stuart-Fox, D.; Hauser, C.E. The gender gap in science: How long until women are equally represented? *PLoS Biol.* **2018**, *16*, e2004956. [[CrossRef](#)] [[PubMed](#)]
9. Stoet, G.; Geary, D.C. The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education. *Psychol. Sci.* **2018**, *29*, 581–593. [[CrossRef](#)] [[PubMed](#)]
10. Bakker, M.; Torbeyns, J.; Wijns, N.; Verschaffel, L.; De Smedt, B. Gender equality in 4- to 5-year-old preschoolers' early numerical competencies. *Dev. Sci.* **2019**, *22*, e12718. [[CrossRef](#)] [[PubMed](#)]

11. Kitada, M.; Harada, J. Progress or regress on gender equality: The case study of selected transport STEM careers and their vocational education and training in Japan. *Transp. Res. Interdiscip. Perspect.* **2019**, *1*, 100009. [CrossRef]
12. Varghese, S.; Kumari, K.T. Women Empowerment and Job Satisfaction among Women Conductors in Transport Sector with Special Reference to BMTC, Bangalore. *Sumedha J. Manag.* **2017**, *6*, 47–53.
13. Ortega Hortelano, A.; Grosso, M.; Haq, G.; Tsakalidis, A.; Gkoumas, K.; van Balen, M.; Pekár, F. *Women in European Transport with a Focus on Research and Innovation—An Overview of Women’s Issues in Transport Based on the Transport Research and Innovation Monitoring and Information System (TRIMIS)*; Publications Office of the European Union: Luxembourg, 2019.
14. Berra, M.; Cavalletto, G.M. *Scienza e Tecnologia: Superare il Gender gap. Un’indagine a Torino*; Ledizioni: Milano, Italy, 2019.
15. DG MOVE, Transport in the European Union: Current Trends and Issues. Available online: <https://ec.europa.eu/transport/sites/transport/files/2019-transport-in-the-eu-current-trends-and-issues.pdf> (accessed on 16 April 2020).
16. Jeekel, H. Social Sustainability and Smart Mobility: Exploring the relationship. *Transp. Res. Procedia* **2017**, *25*, 4296–4310. [CrossRef]
17. Hall, P. Creative cities and economic development. *Urban Stud.* **2000**, *37*, 633–649. [CrossRef]
18. Giffinger, R.; Fertner, C.; Kramar, H.; Kalasek, R.; Pichler-Milanovic, N.; Meijers, E. Smart cities Ranking of European medium-sized cities. Final Report. *Cent. Reg. Sci. Vienna UT*. Available online: http://www.smartcities.eu/download/smart_cities_final_report.pdf (accessed on 16 April 2020).
19. Bencardino, M.; Greco, I. Smart communities. Social innovation at the service of the smart cities. *TeMA J. Land Use Mobil. Environ.* **2014**. [CrossRef]
20. Staricco, L. Smart Mobility: Opportunità e condizioni. *J. Land Use Mobil. Environ.* **2013**, *3*, 289–354.
21. Woodcock, A.; Levin, L.; Pirra, M.; Schöne, C.; Sanvicente, E.S. Gender-related contemporary challenges in the transport ecosystem and women’s mobility needs TIInnGO. In Proceedings of the Transport Research Arena, Helsinki, Finland, 27–30 April 2020 (Conference canceled).
22. Hohenberger, C.; Spörrle, M.; Welpe, I.M. How and why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups. *Transp. Res. Part A Policy Pract.* **2016**, *94*, 374–385. [CrossRef]
23. Singh, Y.J. Is smart mobility also gender-smart? *Gend. Stud.* **2019**, 1–15. [CrossRef]
24. Duchène, C. Gender and Transport, International Transport Forum Discussion Paper. Available online: <https://www.itf-oecd.org/sites/default/files/docs/dp201111.pdf> (accessed on 16 April 2020).
25. Caprile, M.; Palmén, R.; Sanz, P.; Dente, G. Encouraging STEM Studies. Labour Market Situation and Comparison of Practices Targeted at Young People in Different Member States. Available online: [https://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU\(2015\)542199_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf) (accessed on 16 April 2020).
26. Danish technological Institute. *Does the EU need more STEM Graduates?* 2015; Available online: <https://op.europa.eu/en/publication-detail/-/publication/60500ed6-cbd5-11e5-a4b5-01aa75ed71a1/language-en> (accessed on 16 April 2020).
27. Bian, L.; Leslie, S.J.; Cimpian, A. Gender stereotypes about intellectual ability emerge early and influence children’s interests. *Science* **2017**, *355*, 389–391. [CrossRef] [PubMed]
28. Del Boca, D.; Mencarini, L.; Pasqua, S. *Valorizzare le donne conviene. Ruoli di Genere nell’economia Italiana*; Il Mulino: Bologna, Italy, 2012.

