WIA-EUROPE
WHITE PAPER

STEM EDUCATION IN EUROPE

Inclusively inspiring and enabling more young people to pursue aerospace and STEM

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WOMEN IN AEROSPACE EUROPE
Empowering all Women, in Space and on Earth

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WIA-EUROPE WORKING GROUPS & WHITE PAPERS

Looking into the future, in Europe seven million job openings are forecast for the entire STEM field by 2025 as well as an exponential growth for the aerospace industry in the decades to come. Despite the abundant career opportunities, the aerospace sector is currently facing a significant occupation shortage, which calls for a comprehensive set of actions on the part of the different actors involved.

As a strategic sector, to safeguard future economic and social well-being, our industry needs to invest in their human resources at all career levels: from expanding the potential talent pool and attracting new early career talent to retaining the existing workforce and increasing the number of highly skilled women in the C-Suite, not just as a diversity initiative, but as a strategic priority to improve business performance.

Since its foundation in 2009, Women in Aerospace Europe (WIA-Europe) has been committed to tackling these challenges by fostering inclusive representation for women across the European aerospace sector, giving visibility to outstanding women, motivating girls to get interested in science, and communicating the key role that space plays in our daily lives.

For more than a decade now we have been organising events, trainings, grants and awards, bringing together individuals and organisations from across our industry to network and share experiences through our local groups. WIA-Europe has gained high-level support from its corporate members and a growing individual membership base fully devoted to spreading such values as equality and inclusion, with no distinction of race, religion, gender, background or culture.

Adding to our range of initiatives, we have launched the WIA-Europe Working Groups, consisting of individual members and representatives of corporate members and partners, in order to work on key topics related to the objectives of our association and to give recommendations on effective actions, which are published as White Paper series available to all WIA-Europe members.

Focussing on some of the most acute questions, WIA-Europe has established the first three WIA-E Working Groups: “Skills Gap in the Aerospace Sector”, “Increasing the number of women in C-Suite roles” and “STEM Education in Europe”. The Working Groups have evaluated the current landscape and collected insights and strategies, based on the review of existing reports and research studies. This research was supplemented by personal experiences and recommendations of WIA-Europe members at all career levels, which have been recorded through surveys and personal interviews.

Following the publication of the first White Papers we will review the recommendations and together with the Working Group assess their implementation within the current scope of WIA-Europe activities.

We would like to acknowledge the excellent work done by the members of each Working Group, and say a very big thank you to all the members of our network who have contributed their with time and expertise by participating in surveys and interviews.

Thanks to your contribution, we are able to share tools to progress on these acute challenges.

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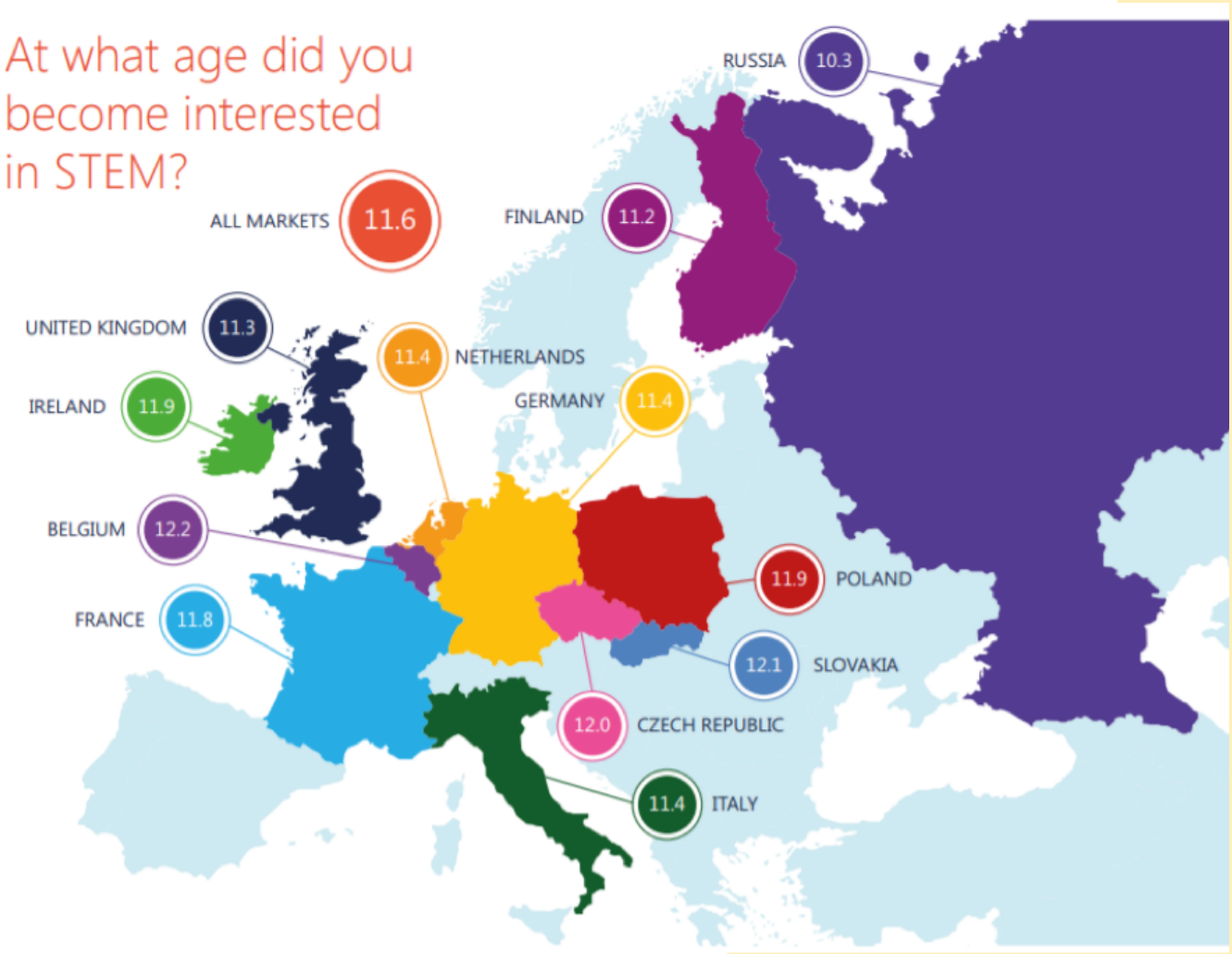
CONTENTS

1 INTRODUCTION

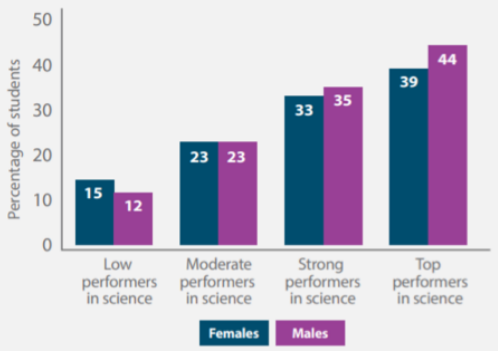
STEM (Science, Technology, Engineering and Mathematics) comprises the main areas of study and skills on which scientific and technological industries, including the aerospace sector, lay their foundations.

In recent decades, institutions and governments have identified a more than consolidated tendency: a very low uptake of STEM studies throughout the whole education process, especially in the case of girls (WISE 2020, APPG on Diversity and Inclusion in STEM 2020, UNICEF 2020, UNESCO 2017, Microsoft 2017).



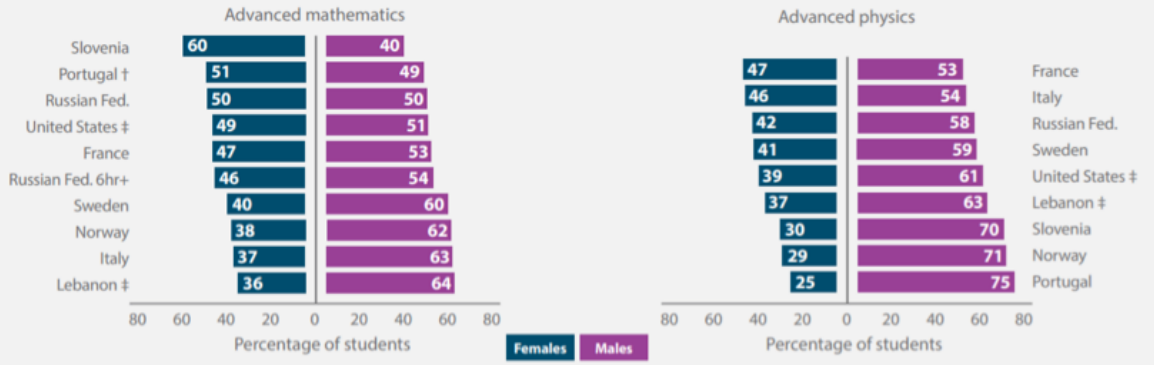
From a very early age, a significant amount of STEM potential is being lost, which leads to slower scientific and technological progress in the industry. This reality not only affects these particular industries but it also burdens our society considerably, preventing it from: reaching Sustainable Development Goals, generating problem-solving, innovative and critical thinking citizens with 21st century skills, preparing the next generation for jobs that don't yet exist, creating inclusive and diverse teams of people, interconnecting cultures, and more (OECD 2018).

Figure 9: Percentage of students who expect to work in science-related occupations and their level of proficiency in science, 15-year-olds



Girls' and boys' career expectations are affected by their level of proficiency in science.
35 OECD countries. Data source: PISA 2015 (OECD countries)[17]

igure 3: Percentage of students that take advanced courses in mathematics and physics, by sex, Grade 12



More boys than girls take advanced courses in mathematics and physics in secondary education in Grade 12.
Note: † Met guidelines for sample participation rates only after replacement schools were included, ‡ Did not satisfy guidelines for sample participation rates. The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.
9 countries. Data source: TIMSS Advanced 2015[18]

In this white paper, a brief analysis of STEM education across Europe is presented, supported by case studies and accompanied by current state-of-the-art research from a variety of sources, incorporating the knowledge and experience from academic researchers and practitioners in education. A concise summary of the main issues, transverse across European countries, and recommendations to address them effectively by the different actors involved are provided.

Which factors have the biggest impact on girls' interest in STEM?

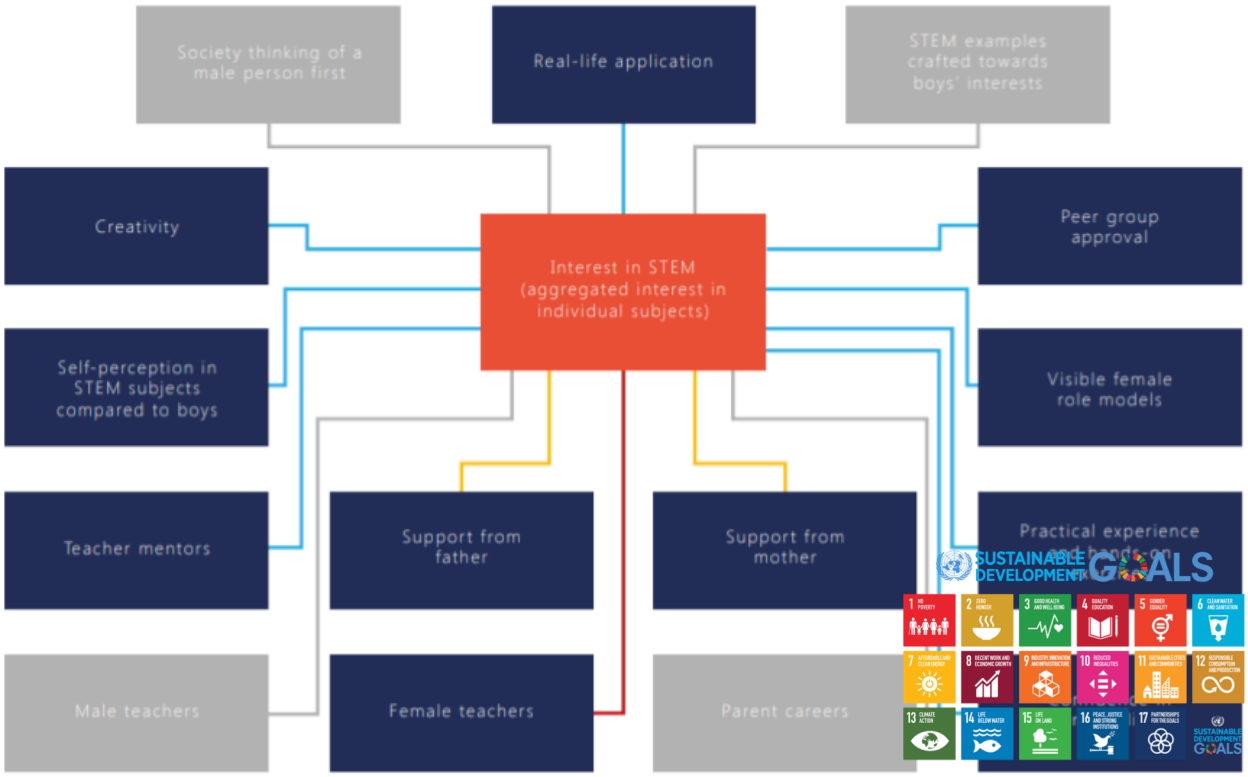
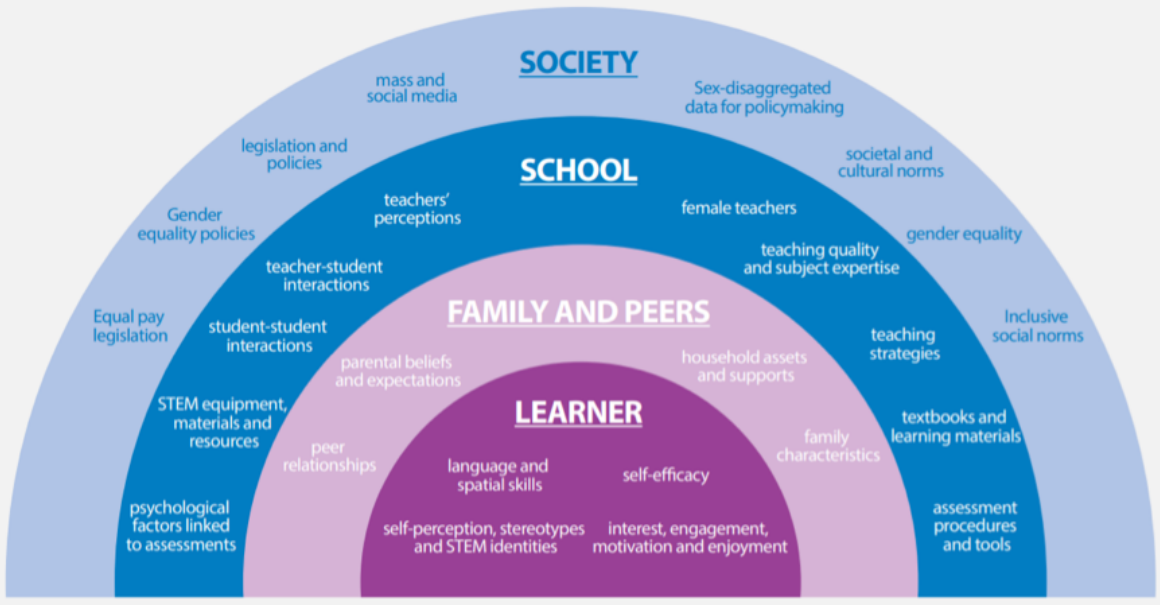


Figure 36: Ecological framework of factors influencing girls' and women's participation, achievement and progression in STEM studies



In particular, this white paper:

- Focuses on the weakest spots: early inspiration, retention of young women, the contribution and influence of peers/family, the perception of women in STEM careers, and the importance of European coordination.

- Delivers: a plentiful set of recommendations to address each weakness, emphasising the role of the aerospace sector and the contribution that organisations such as WIA-Europe can make to society, both locally and at a European level, in order to encourage young people, especially girls, to pursue pathways into STEM.

2 UNDERSTANDING AND DEVELOPING THE STEM EDUCATION LANDSCAPE

In this section, the overarching issues that this working group has identified to be common across European countries are presented. Research and insights are summarised that draw on the concept of science capital and similar ideas: the knowledge, attitudes, experiences and contacts people have with science and relating this to people's aspirations (Archer et al. 2013, MINT Forum 2021, Comunidad de Madrid 2019). Example solutions are discussed from case studies; potential ways forward that could be adopted or built upon more widely to provide young people opportunities to build their science capital, empowering them and, as a result, address inequality in STEM in order to make it appealing and accessible to everyone. The current situation regarding each theme is outlined, encompassing what is already well-known, what has been proven to work effectively, what doesn't work and why, progressing into what needs to be improved in future and how this can be achieved.

The working group acknowledges that there are additional or more complex issues pertaining to specific countries; the objective of this white paper is to focus on common underlying themes, for which activities by WIA-Europe and the aerospace sector can have the greatest impact. Best efforts have been made to incorporate and represent perspectives across all of Europe. The working group benefited from the perspectives of the ESA Education Office, who support a network of space education resources offices across 18 countries.

2.1 INSPIRING CHILDREN

Gender roles and stereotypes influence the configuration of STEM interests as well as the perceived ability in this field; it is no surprise that fewer women than men feel attracted to the world of science and technology.

Studies such as Aspires 2 (Archer et al. 2020) have confirmed that dominant educational and social representations of science (e.g. through science education, the media and in everyday life), the association of science with 'cleverness' and 'masculinity' and the worry for particularly young women that they might not be 'clever enough' to continue with STEM subjects such as physics, can be very influential in shaping whether young people go on to form science aspirations or consider themselves 'suited' to science. Research shows that already in primary school, girls and boys develop their personal attitude towards science (positive or negative) and decide if science is for them or not. Furthermore, though most young people have high aspirations for their future and career, in general they do not aspire to be scientists. This scenario is not down to a poor view of science or scientists. In fact, the majority of 10-14-year olds in the study had very positive views of science, but they did not aspire to be scientists.

To analyse this problem, the ASPIRES researchers coined the term 'Science Capital' which refers to someone's science-related qualifications, understanding, knowledge, interest and social contacts (e.g. knowing someone who works in a science-related job). The researchers found that students with low science capital are unlikely to aspire to a science-related career by the age of 10 and this is unlikely to change as they progress through school. Stereotypes have a very big influence on young girls' motivation to pursue STEM careers. In relation to this topic, the researchers also highlighted the reduced number of girls studying physics in post-16 courses in the UK. As students progress through their secondary school education, the study showed that careers provision in the UK is 'patchy' and 'patterned' particularly in terms of social inequalities and is often not reaching those most in need of it: girls, ethnic minorities, working class and lower attaining students. Students aspiring to careers in science are least likely to get work experience in it.

The OECD's International Early Learning and Child Well-being Study (OECD 2021) asked over 4,000 children what they wanted to do or be when they grow up. They discovered that gender is more strongly related to children's future aspirations than family socioeconomic background, including parents' education levels or occupations.

It has been proven that the awareness that you are a boy or a girl is already prevalent

between the ages of two and three. In the next two years, between the ages of four and six, they learn that they will be a woman or a man when they grow up. At that age, children already have a knowledge of what results are appropriate for each sex according to the culture to which they belong; at five years old they possess a whole constellation of stereotypes.

Lin Bian, Sarah-Jane Leslie and Andrei Cimpian, from the universities of Illinois, New York and Princeton have published the findings of their study on the self-perception of intelligence and brilliance in six-year-old boys and girls and the influence on their configuration of interests and skills. The study detected a turning point between the ages of five and six. At five years old, boys and girls associate brilliance with their own gender in a similar measure. At six and seven years old, girls associating brilliance with their own gender are significantly fewer than boys. Thus, the stereotype that equates men with brilliance is already internalised at the age of six. The stereotype that associates women with being kind or nice seems to develop along the same trajectory.

The threat of stereotyping affects performance and influences how girls and boys approach mathematics and any other STEM discipline associated with more stereotyped 'intelligence' or intellectual brilliance. Many children's societies run campaigns against stereotypes because it affects their wellbeing and future (The Children's Society 2021).

When they go to school, it is often the first time they encounter an environment that challenges their ideas of the world and schools are the most influential environment outside of home. There is a need to create an encouraging, inclusive environment that values education and equality, which can then challenge the beliefs children learned from home. "Unstereotyping" becomes a foundation of equal opportunity (UNICEF 2020).

It is very important that parents create an environment that encourages contact with different vocations without gender relation. To create this environment, children have to be exposed to toys and experiences free of gender or other (often unconscious) bias.

The Institution of Engineering and Technology in the UK has researched how toys linked to STEM are three times more likely to be marketed at boys than girls (IET 2016). Different types of toys contribute to the development and training of skills and abilities. Puzzles, construction toys or those related to science, among others, contribute to the development of science-related skills, engineering or mathematics. Research shows that girls have an interest in these STEM-related activities and that the toy field is a strategic place to begin to change perceptions of opportunities within this area.

CASE STUDY: "HAUS DER KLEINEN FORSCHER" (LITTLE SCIENTISTS' HOUSE)

The non-profit "Haus der kleinen Forscher" is Germany's largest early childhood education initiative in the STEM domains. With an accompanying focus on Education for Sustainable Development, the aim of the programme is to strengthen children for the future, provide them with important skills, and enable them to act in a sustainable way. Together with its local network partners, the foundation provides a nationwide continuing professional development programme that supports staff at early childhood education and care centres, after-school centres, and primary schools to facilitate children's learning, inquiry and exploration between the ages of three and ten (Kleine Forscher 2021). The pedagogic approach incorporates modern research in developmental psychology and didactics.

It is already demonstrated that initiatives that provide accredited training and facilitate implementation of best practices are fundamental to make great progress in tackling the issues across Europe outlined in this topic, and should be reinforced.

Another solution would be to take a Science Capital Teaching Approach in the classroom (Godec et al. 2017). The approach uses the existing curriculum, does not require a new set of teaching materials but instead encourages a change in teaching mindset. The idea is to broaden what counts as science in the classroom; personalise and make science relevant to the children and their communities; elicit, value and link knowledge and experiences that students are bringing from outside school to their study of science; and build the science capital dimensions to show them science is in everything we do.

2.2 RETAINING YOUNG WOMEN AND UNDERREPRESENTED COMMUNITIES

The uptake of STEM subjects at secondary school and university is lower amongst young women and minoritised groups, and the dropout rate persists into working life in the aerospace sector. It is a longstanding issue that educators, governments and organisations have been aware of, yet despite various interventions being implemented across Europe, the situation has not significantly changed (Macdonald 2014, WISE 2020, SEA 2020, Walker et al. 2010, IAU 2021, Microsoft 2017, Gatsby 2017, DfE 2019, IOP 2020). The issue: interest in space is not enough.

Whilst young people are acquiring an interest in STEM and space, they need to be supported on their journey through school and university into their careers, with fair access to opportunities that continually enrich their development. Studies show young people do see the relevance of STEM and space science to their lives but these positive perceptions do not convert into an appreciation of viable future career options, nor are they necessarily prevalent across all countries e.g. the international Our Space Our Future study of secondary students found 70.7% said they space science is interesting and would like to learn about it but only 41.2% said they would like a job related to space science (DeWitt et al. 2018, Leverment et al. 2019, Our Space Our Future 2021, Accenture 2017). The lack of awareness of job roles and societal benefits is a particular barrier in the aerospace sector, which, similar to physical sciences and engineering, is male-dominated.

Many outreach resources and activities from education supporters exist that aim to address these points. However, they may not be well known, they can require teacher training, the formal education frameworks don't have capacity for them, too much choice of one-off initiatives can be misleading, or the content can be gender-biased for example.

A particular issue in the UK that has been well-evidenced is the lack of awareness of engineering and the broad range of jobs in this field, including spacecraft engineering. Multiple studies have concluded that gender is a main factor in engineering aspirations and the consequential imbalance in working life (IMechE 2017, Engineering UK 2020, Moote et al. 2018).

Partnerships between schools and STEM centres or industry organisations can be the key to enacting change, encouraging more young people to pursue careers in STEM and the aerospace sector. The quality and the impact of existing resources, including careers

education, can be maximised and maintained according to regulated standards in order to raise aspirations amongst young people of all backgrounds and reduce inequity (APPG on Diversity and Inclusion in STEM 2020). One example is the Gatsby Benchmarks for career guidance in England with specific support for employers (STEM Learning and the CEC 2021). As a reference, ESA Education's Teach with Space and ESERO classroom resources (the former in English and the latter in national European languages) are co-developed with didactics experts, national education specialists and teachers. Content is tailored to curricula and incorporates the inspirational space context, and the resources are disseminated through established national networks. Another initiative is the CESAR Space Science Experience, where students can experience a real Space Experience, guided by Space Experts, in class and/or at the European Space Astronomy Center (ESAC).

Partnerships also provide pupils and university students with valuable exposure to role modelling and careers from schemes including mentoring and work experience (STEM Learning 2017, Kelly et al. 2019). The UK Space Agency has been running and funding Space Placements in Industry (SPIN) in the UK since 2013 and connects university students with organisations to gain hands-on experience through a paid work placement. Not only does this give students first-hand experience of working in the sector, and the opportunity to find out what skills employers really want, but around a third of the students are offered full-time employment by the organisation after their placement, and another third complete their degree and then join the organisation. This is an incredibly popular scheme with over 3.5 thousand applicants for the 60 or so placements on offer in 2021. Similar approaches are offered by ESA as internships for under-graduate and graduate students.

Mentoring has been proven valuable for every student, and especially for women in STEM careers, at university and in secondary school (e.g. Alta mentoring by the Royal Aeronautical Society's Women in Aviation and Aerospace Committee, Inspiring Girls). At school, girls need role models; the WISE "My Skills My Life" is a tried and tested resource that allows girls to find out their personality types and matches them with role models to explore STEM careers. Initiatives are most effective when they are recurring interactions with women working in STEM. These interactions inform them of Uthe relevance to their daily lives and raise their awareness of career options, improve academic attainment and attitudes towards education to overall raise their STEM capital (science capital can be applied particularly to "SEM": Science, Engineering, Mathematics), boost confidence and empower young women to make their own informed choices by having an opportunity to see themselves in these future careers, therefore removing some current barriers preventing them from pursuing STEM (Mansell 2014, Kashefpakdel et al. 2019, STEM Women 2020, Science Grrl 2014, Stemettes 2020a, Stemettes 2020b, Moote et al. 2019).

CASE STUDY: IMPACT OF MENTORING FOR RAL SPACE EMPLOYEES

RAL Space, a department of the Science and Technology Facilities Council, part of the UK Research and Innovation, is a gold corporate member of WIA-E with 21 members and champions diversity in the space industry (RAL Space 2020a). RAL Space also has an impactful outreach and engagement programme (RAL Space 2020b), made possible by some 70 STEM ambassadors who volunteer to support events and activities that inspire the next generation. To investigate how they have succeeded in this, how STEM professionals can enact change, how WIA-Europe can support them and address the lack of female mentors in these fields, nine interviews were conducted with women (seven of whom are WIA-Europe members) about their experiences of mentoring within and outside of RAL Space, what influenced them to join the aerospace sector and how they could help inspire the next generation.

- 90% have had a mentor during their career or at university. Both formal mentoring schemes and informal connections were beneficial, particularly to: discover different perspectives across the wider organisation, learn about opportunities for career development and leadership qualities, identify personal strengths and weaknesses, improve communication and soft skills, and receive specialist guidance for attaining professional qualifications. A couple commented on the value of having had both female and male mentors.
  - "I could get an overview for example, five or ten years down the line, what is important in one's career."
  - "It was just so helpful knowing there was somebody who would listen."

- 90% have had mentees including school students for work experience or early career professionals. 75% of those said the main benefit of being a mentor was being able to reflect on their own achievements and progression. Sustainability was highlighted; having had a mentor encouraged some to become one themselves and helped them anticipate what support their mentees needed.

  - “It reminded me how much I love my subject and why I was doing it in the first place.”
  - “I don't think there's a better feeling than watching someone grow and develop and lifting someone up.”

- None reported negative experiences, however 90% commented that potential pitfalls are incompatibility, unclear expectations or the required time commitment.

- Motivations that were prevalent for becoming a mentor included: wanting to help young people make their own informed choices, wanting to help young professionals reach their potential, develop leadership skills, wanting to share their own experiences especially relating to professional qualifications or to raising awareness of their job role and how young women can do the same.
  - “My mum did exactly the same engineering course [at university] but about 30 years before me, and it was the same percentage of female engineers as 30 years before and nothing had changed.”
  - “As a woman and as someone from an ethnic minority, you don't see that diversity in the space industry in those senior roles. I'm in a leadership role; I need to make myself more visible. I've got nieces, I want them to see women and other girls like them in those kinds of roles so that they can say “I can do that too”.

- 100% agree that training from a professional body is valuable for mentors to: understand expectations, learn tips or activities to initiate discussions at the beginning, set goals with mentees, learn how to listen and interact to develop the relationship, and specifically how to interact effectively when supporting school students. A useful example is STEM Learning’s guidance on mentoring for ambassadors (STEM Learning 2021).

- 67% didn’t have and wish they’d had the opportunity to interact with a STEM professional when they were at school, either through mentoring or careers talks.

- "I would have really appreciated to actually talk to somebody in the engineering industry when I was at school. In hindsight I probably would have preferred doing an engineering degree although I loved doing physics."
- "What I struggled with a lot growing up and even through university was: I knew I wanted to work in space but where did I fit?"
- "There was that of perception of you had to be careful who you trusted with your aspirations, because [some teachers] weren't supportive."

- 100% would take part in a mentoring programme for schools, especially if facilitated formally by local existing networks and targeted at female students aged ~13 when they are making choices for the first time about their own education pathway. All would be interested to take part in group mentoring, to encourage peer-to-peer dialogue but with flexibility to support students with less confidence who prefer to share their thoughts individually. All could commit a minimum of a one hour session per term for a year. A few commented on the importance of hands-on experiences and the value of instead taking part in team projects with an external supervisor, and a couple are keen to engage teachers as part of a programme for a more sustainable impact.

- 90% said their parents or family were a key influencer on their career aspirations. 50% of those said it was because their parents worked in STEM and the other 50% said their family did not work in STEM but that they were very supportive, open-minded and valued education. A couple also reported watching TV and documentaries as an important factor that attracted them to the aerospace industry.

Teachers are also key role models and influencers for young people; education supporters can engage teachers to have a broader, sustainable impact. To increase the uptake of STEM and retain future generations who will need new 21st century skills, teachers need to receive ongoing accredited professional development training, which will address their reported lack of knowledge or confidence in these subjects particularly in the first stages of education. In countries such as Spain, teachers have reported themselves the need for a deeper training in STEM areas at primary school level that enables them to encourage younger children to pursue their scientific objectives later on in their education process. Moreover, it further motivates them in their work and can help improve their standing in a position of respect in society. In particular, in Madrid, Valencia and the Canary Island, teachers organizations join the CESAR Teacher workshops to provide teachersfrom primary and secondary level, vocation training, special education and Universities with state-of-the-art training in Space subjects as well as credits for their participation in them.

Teachers can be trained to use pedagogical approaches that are most effective in these subjects. "'School science education must reflect science as it is practiced' [...] one goal of science education is 'to prepare students who understand the modes of reasoning of scientific inquiry and can use them.'" (ERIC 1993). Inquiry based learning is a more active approach than traditional teaching methods that brings many benefits and empowers students to pose their own questions and investigations – teachers and students learn together through the process. Examples of certified teacher trainings that place this methodology at the centre and have been successful in building teachers' confidence, using space as the inspirational context, are ESA Education's: international (e.g. the e-technology lab teacher training sessions) and national (ESERO) teacher trainings, the CESAR teacher training, and the joint ESA/NUCLIO Galileo Teacher Training Programme (GTTP). These promote hands-on learning and teamwork in the classroom through activities with assigned roles that match STEM professions. To educate teachers on such professions, lasting partnerships with industry or education supporters are vital. Professionals can provide valuable insights about their careers for students and teachers alike. For example, the 2021 GTTP included a workshop on space careers and demonstrated the impact of storytelling; the recorded sessions could later be used by teachers back in their classrooms. The historic context of careers and stories surrounding scientific discoveries can also be incorporated to provide role models, such as Vera Rubin, Henrietta Swan Leavitt and Jocelyn Bell-Burnell (ESA 2020). Implementing these projects in schools and having a meaningful impact is more likely to be achieved with a whole-school approach. Collaborative partnerships with specific schools allow the activities to be tailored to their needs (Leverment et al. 2019, Our Space Our Future 2021).

The greatest benefit to all countries lies in promoting existing STEM education resources that are of high quality, promote hands-on and inquiry-based learning, and are accessible to diverse audiences, and enabling industry to support formal education providers. This is namely seeking local partnerships, providing training and encouraging employees to take part in schools and public engagement, including supporting careers talks, workplace experiences and mentoring starting earlier in secondary school, and involving teachers throughout by complementing their curricula teaching.

2.3 ENGAGING FAMILIES AND LOCAL COMMUNITIES

Children spend the first three years of their lives nearly exclusively in their family. This is the place where they learn how society functions. They adopt their parents' belief systems, including inherent gender stereotypes. Girls' participation, progression and achievement in STEM education is, as a result, highly influenced by their families and peers especially in the first steps of their education. Therefore, the role of parents in creating a supportive environment that encourages contact with different vocations is crucial for young girls to develop an interest and pursue a career in STEM, regardless of socioeconomic status, ethnicity, or the parents' own level of education.

Students of engineering and other scientific or technological branches usually have a supportive family environment. Having relatives in the children's environment who are involved in STEM careers has been shown to influence girls' pursuit of STEM studies (Tan et al. 2013). These relatives are more easily acquainted with opportunities, activities and knowledge in the STEM field and can act as role models. On the contrary, families who are not acquainted with STEM education will find it more difficult to encourage girls to pursue STEM careers. Occasionally, materials and activities at schools are not enough to spark and maintain interest in STEM careers. As a result, access to other learning materials and instructional support, preparation of activities outside the classroom (camps, courses) motivated by family members could be very beneficial.

While toys directly linked to STEM are indeed beneficial for children, other activities promoting skills for these fields, such as spatial understanding or mathematical reasoning can help parents encourage their older children and teenagers. Some studies have resulted in the necessity to create other experiences such as Fab labs and makerspaces to serve as spaces for informal peer learning and, in addition, many of these spaces operate through working groups in those who establish a common theme and all participate in the creation process and learning (García Sáez 2016).

Depending on the country, the bodies mostly responsible for after school and extracurricular activities should be approached. Existing resources about STEM activities for groups and individual children, parents and clubs, need to be shared widely and used more. Sponsored activities can provide equal opportunities for all children, regardless of background. Formal education venues should be more involved in countering common misconceptions: schools, universities and other centres of STEM (such as museums and activity centres) can provide parents with information about STEM educational opportunities and careers, and connect them to educational advisors who can counter common misconceptions. Moreover, such organisations could be more involved in promoting parent-child dialogue: providing parents with materials through brochures and websites which focus on the usefulness of STEM courses, organising activities in which the parents are also involved, and giving recommendations on materials, books and games to families. One example of this are the ESA Open Days.

Community centres such as churches are already very involved in local communities and are usually experienced in helping those in need. They already have established networks. Girl-focused STEM education campaigns can be incorporated within these existing networks of literacy and child-wellbeing programs. In addition, they could promote career days, involving relatives, science fairs and competitions to engage local communities, and guidance for parents on how to recognise their children's achievements.

Libraries can be an easy and inexpensive way for entertainment and furthering education, accessible to families of all backgrounds. Parents reading to children has considerable benefits; reading inclusive STEM books to children would increase the benefits and children reading should see themselves represented in their book. Local libraries need the budget to stock these books. Since their budgets are usually council-mandated and often low, grants and donations can modernise the children's literature section and bring more diversity into it. In the same way, museums can contribute with special expositions or displays, combinations of children-parent activities, ideally adapting themselves to the local community and supporting schools in the same areas to consolidate children’s learning.

CASE STUDY:
SCIENCE AND ENGINEERING CAREERS CHALLENGE

In the UK, over 1 million young people aged 5 - 18 are members of Girlguiding or Scouts (The Scout Association 2020, The Guide Association 2020). It is a well-established community network and provides an opportunity for children and teenagers to develop skills and competencies outside of the school environment. They earn badges in recognition of their achievements and members of the community including parents are often involved as volunteers to support activities.

In 2020, the Science and Technology Facilities Council (STFC), of which RAL Space is a department, funded the Science and Engineering Careers Challenge for Girlguiding and Scouts. The challenge is to complete six activities; each one involves tasks and skills that are used in a particular job role such as a mechanical engineer or a physicist. RAL Space partnered with local groups to help develop the activities and trained 16 staff ambassadors to deliver workshops for groups with limited access to STEM resources. There is a choice of fun hands-on activities, such as a coding game and making edible Mars rovers, and the challenge pack provides guidance for group leaders to run sessions, as well as information about careers and profiles from real people in those roles at STFC. The activities can be adapted for online meetings and were designed to be accessible to groups located in areas of low socioeconomic status, requiring inexpensive resources, and the groups receive badges at no cost to them.

12,200 young people have completed the challenge, as of September 2021:

- Over 93% were female
- 70% were 10 years old or younger
- 30% were from the most deprived areas, as measured by the indices of deprivation (National Statistics UK Gov. 2019)

The evaluation showed that 98% enjoyed taking part, 97% had a better understanding of what scientists and engineers do, and 64% were more likely to consider pursuing STEM when they're older.

"The girls loved learning about jobs they didn't know they could do, realising this could be them in the future."

"Our girls were given the challenges to do at home during lockdown. Many did more than was asked and got their dads involved which was lovely."

"Our girls have thoroughly enjoyed learning what scientific careers are out there and have enjoyed the practical elements of the challenge. Doing these challenges at home has also involved parents who have been very complimentary on the contents too."

The project has been successful in engaging young people but also adult leaders in local communities. It has provided hands-on experiences, raised their awareness of STEM careers, reinforced the perception that anyone can become a scientist or engineer and educated leaders on the importance of STEM for society, equipping them with knowledge of why and how they should encourage young people to pursue STEM. The project received additional funding in 2021 to continue awarding badges and reach as many groups as possible.

WIA-Europe can become the ambassador and promoter of initiatives and connect local or national societies to create a backing to bring forward ideas in international forums and leverage against policy makers and stakeholders towards greater inclusivity.

2.4 PERCEPTIONS OF WOMEN IN STEM

Stereotypes about women and their perceived inability to deal with quantitative and analytical problems have played a great role in preventing young women from pursuing studies and careers in STEM fields. In 1983, social scientist David Chambers published the results of a study designed to investigate children's perceptions and stereotypical views by asking them to draw a scientist (Chambers 1983). Out of more than 4,800 drawings collected in the US, only 28 represented a female scientist. All of them were drawn by girls. No boys drew a woman. Since then, the Draw-A-Scientist test has been repeated over the years and, although drawings are now more gender diverse, children are still more likely to draw scientists as men especially when they grow older, suggesting the influence of dominant social norms depicting STEM as male-oriented domains is a substantial, persistent problem (Miller et al. 2018).

Gender biases also apply to women who are scientists themselves and speak publicly about their work or research. As highlighted in a study by McKinnon and O'Connell (McKinnon et al. 2020), female scientists who communicate on their professional activities are likely to be labelled as "know-it-all", "bossy", and "emotional", indicating that women are judged more on personality rather than on the quality of their research. Female professionals are perceived and generally described differently in their work. The "Heidi/Howard" study from 2003 showcases the likeability vs. success issue (Sandberg 2015). The more successful women are, the less likable they are perceived to be because they are breaking traditional roles. There is also the notion that in order to be a successful woman in STEM, you cannot take a career break to raise a family, for example, which deters women from pursuing STEM. Personal likeability and connections are important in the STEM-world to win grants, foster cooperation and advance in the field. It is one of the factors that causes the "leaky pipeline"; the persistent dropout of women from STEM.

Clearly, gender stereotypes in science, technology and innovation fields remain hard to shift and are perpetuated by media coverage and representation choices. Women in STEM are underrepresented in all fields. A recent study published by the Geena Davis Institute (Geena Davis Inst. 2018) found that, in movies, TV and streaming content screened between 2007 and 2017, less than 15% of actors playing leading roles in STEM were women. While female STEM characters are relatively rare on entertainment media, showing women scientists on television may help promote girls' interest in STEM, as illustrated in that same study. In fact, more than 80% of the girls interviewed said that watching female STEM characters is important to influence their choice to go into STEM. Female science teachers are still the minority and even in current school literature, traditional gender roles dominate in text and images.

Stereotypes of women pervade all areas of life, public and private. These underlying negative influences have to be addressed to remove the barriers between girls and STEM, particularly because they cause poor self-perception with fewer young women than men considering themselves "intelligent" (Kelly et al. 2019). They are an expression of the inequality of genders our societies still firmly hold. Deeply held biases must be recognised and acknowledged as to how they might affect our behaviour and judgement, before there is a fundamental step towards higher diversity in STEM fields. Equal participation, indistinguishable perception and diverse representation of all genders and groups in STEM will be an expression of a truly equal society.

In the meantime, it is fundamental to promote women's visibility in STEM fields and counter misconceptions and stereotypes with structured role modelling and girl-focussed STEM programs. Women working in STEM can talk to the next generation about their career paths and emphasise that there is no single linear path, and that personal as well as professional aspirations can be upheld. Increasing inclusive representation in the media, especially in children's shows and advertisement, would help reach girls from all walks of life, penetrate into their homes and bridge between educational teachings and real-life applications.

The STEM industry needs to realise the potential they are wasting by not engaging all children fairly. They could partner with organisations like WIA-E to produce targeted campaigns about women in STEM and STEM as a fun subject with introductory tasks and job examples for children's TV, social media and websites (RAL Space 2021, ESERO-UK 2021). This would increase diverse visibility and put aerospace on the map as a viable future to pursue, made known to children early on as many other industries are doing already.

2.5 CONNECTING EUROPE

European countries all feature different education systems, including STEM education, at all levels. The ESERO project and other relevant experiences in Europe (EUSchoolnet/Scientix) strive to provide a response to the different national curriculum realities, which vary in the subjects taught in: the didactics methodologies adopted, the tools made available to teaching and learning, and the resources invested in formal education. Whilst the cited initiatives and many more invest enormously in cross-fertilisation and active exchange of best practices across European borders, the implementation of innovative STEM education initiatives encounters different systemic issues or particular barriers in each country.

A perspective of evolution which foresees a future generation truly enabled to succeed in tackling societal and environmental challenges, in building a sustainable future based on the intelligent use of sciences for the benefit of all, and on an active and responsible citizenship, requires in this particular historical moment a collective effort.

One very sensitive way to approach the issue would be to advocate for a common European STEM education framework. The transversal, coordinated, supported, synchronised availability of a common, innovative formal teaching and learning framework in Europe, built around a long-term, inclusive vision, would provide an incredible boost to the adoption of innovative and inclusive STEM education, could build on synergies as efficiently as never before, could lead to long-term resource optimization for each country, and would facilitate the creation of generations of citizens grown around common values - innovation, sustainability, inclusiveness, equal opportunities, collaboration. This would eventually represent a powerful response to the urgent need of a (newly) highly qualified STEM workforce in Europe.

The ambassadorship of virtuous STEM education initiatives in all possible national and international forums, and an active advocacy for a higher European coordination in policies and initiatives - ideally a common European STEM education framework - will help engaging relevant stakeholders and education actors and possibly trigger a (r)evolutionary change for STEM education at large scale in Europe.

3 RECOMMENDATIONS

3.1 FORMAL EDUCATION PROVIDERS: SCHOOLS AND GOVERNMENTS

- **Help early years teachers to create an environment that encourages contact with different vocations without bias such as gender relation.**

Provide children with exposure to toys and experiences free of bias that promote skills relevant for STEM and critical thinking.

- **Provide and enable educators to undertake continuing professional development programmes across Europe.**

Improve availability and accessibility to teacher training with sponsored programmes, and improve the quality of provision, including unconscious bias training, using a Science Capital Teaching Approach to empower students to see the relevance of science to their lives, and raise awareness of existing STEM resources such as ESA's Teach with Space and hands-on learning. Support pedagogical staff in early years education and care centres, facilitating exploration and inquiry skills and development of children between the ages of three and ten. For example, enhance collaboration with national ESEROs for STEM teacher trainings using space as a context for teaching and learning.

- **Build partnerships to improve STEM and aerospace careers education and engage pupils with ongoing active support**

Incorporate careers education in core learning programmes. Raise awareness of existing support and encourage partnerships for pupils to connect with industry professionals through career talks, supervising team projects, and mentoring. Provide support from primary school level through to secondary school level, to expose young people to role models and opportunities to see themselves in STEM jobs and make informed choices. Ensure programmes reach underserved audiences by partnering with relevant charities or social enterprises. Evaluate progress to maintain high quality career guidance for people from all backgrounds; the Gatsby Benchmarks set out statutory standards for the UK government and are implemented with targeted resources and funding.

3.2 EDUCATION SUPPORTERS: STEM CENTRES, INDUSTRY AND ORGANISATIONS

- **Engage families and communities effectively to raise awareness and aspirations.**

Tailor support for underprivileged communities; create environments for young children to interact with toys free of gender bias and establish STEM-related skills; promote sustained dialogue about activities between children and key influencers (family and peers) by involving parents in activities and supplying follow-up resources.

- **Build partnerships with local community organisations.**

Museums, libraries, science centres and community groups can connect with industry to complement formal education, provide resources and maximise their impact by working alongside didactics experts to strengthen messages, raise awareness of careers, provide workplace experiences and encourage employees to take part in mentoring school students.

- **Connect with the media to improve visibility and perceptions of women in aerospace.**

Deliver media campaigns through local, national and international outlets, both digital and analogue formats to reach broad audiences. Develop resources for community groups and schools that counter misconceptions, and provide information about enrichment opportunities for learning about the aerospace sector and connecting with STEM professionals or advisors.

3.3 WOMEN IN AEROSPACE EUROPE

- **Promote existing school and community outreach initiatives that address inequality in STEM and raise awareness of space-related studies and careers.**

Promote collections of existing credible resources and teacher training across Europe and how groups in specific countries can find further relevant information.

- **Enable members to support education initiatives; provide training or toolkits to take part in outreach, role modelling and mentoring**

Enable individual and corporate members to participate and support projects, by establishing partnerships to maximise their impact and sustain an efficient use of resources, such as time to provide mentoring. Promote existing guidance and national networks to facilitate these programmes.

- **Create working group(s) to ease knowledge exchange of STEM education across Europe and provide a network for advocacy initiatives.**

Evolve future working group(s) to focus on addressing the retention of young women in STEM and devise methods for sharing best practices and advocating for a coordinated STEM education framework across Europe.

- **Deliver a media campaign to address misconceptions about women working in aerospace.**

Collate profiles from members to display on the website, social media and as downloadable materials aimed at school and family audiences. Although it has not been addressed in detail in this paper, exploring how to involve male colleagues and co-workers when breaking down these misconceptions, and how they can support powerful women roles from inside the industry itself, remains a vital way ahead in STEM to strive for equality.

4 CONCLUSION

In accordance with the wealth of research and interventions, it is clear that young people need structured support in order to pursue STEM in their future. The declining uptake, especially amongst girls, and the consequences are well known but not to all underrepresented communities; it is still necessary to communicate this message across Europe to reach key stakeholders, educators and policymakers who influence young people's journeys.

WIA-Europe can have a significant role to connect and influence partners internationally, especially to undertake the recommended actions listed in 3.3. The working group could be consolidated into a consultant tool for stakeholders, enabling active promotion of high-quality initiatives and participation with local groups to engage educators and industry locally. The impact is invaluable to inspire and retain young people in STEM during their schooling and mentor them into and throughout career paths in the aerospace sector.

It is advised that the scope of the subsequent working groups should focus on coordinating and delivering the recommended actions with members, in particular expanding existing media campaigns to target younger audiences, planning suitable methods for promoting existing resources, and seeking connections for advocacy of coordinated programmes and training. It would be beneficial to cooperate with the other existing working groups to understand the wider picture and the role of education in laying foundations to address the skills gap and increasing the number of women in senior roles in aerospace.

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