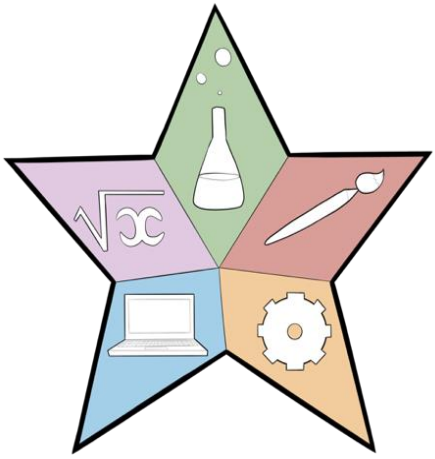

STEAM Stars

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Intellectual Output 4:

A2. European policies analysis report

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Contents

Introduction

This document provides an overview of the national and European policies in teaching STEAM education for gifted students. To do so, we have reviewed the different national policies devoted to gifted education established in the five partner countries. In addition, we will consider the main trends of public education policies within Europe in favour of STEM/STEAM, which can lead to outlined potential solutions to the STEM/STEAM challenges. The output of this policy report will guide the development of the report *Guidelines to Promote Transparency and Recognition of Teaching STEAM Education for Gifted Students*.

1. General context

Recent studies conclude that there is a need to improve existing education policies in order to provide an inclusive education framework for gifted children and to understand that the essence is not only to agree on differences but to stimulate the individuality and diversity of the gifted at all levels (Ninkov, 2020). Currently, most gifted children spend the majority of their time in mainstream classrooms, without access to challenging coursework or teachers knowledgeable about the special learning needs of our most highly able learners.

Within this context, STEAM education has enormous potential to provide more challenging and motivating exercises to gifted and talented students. Georgette Yakman, a teacher and researcher credited with developing the STEAM educational framework, defined it as "Science and Technology, interpreted through Engineering and the Arts, all based in a language of Mathematics" (Yakman, 2008). This idea of adding the arts to STEM has recently gained a lot of momentum. The "A" in STEAM does not only represent the visual arts, but is a broad term that includes liberal arts, language arts, social studies, physical arts, and fine arts and music. It is about applying creative thinking to STEM projects, and sparking students' imagination and creativity through the arts. Studies show that a quality STEAM education programme is engaging, motivating, student-centred, innovative, collaborative, and employs real-world applications.

In this respect, the long-term goal of gifted education is to enable more gifted individuals to become creative producers in adulthood and achieve at the highest levels within their fields (Ulger & Çepni, 2020). Thus, STEAM education paired with gifted and talented education with a focus on practical learning could create opportunities in talent development: STEAM lessons have the potential to develop deep thinking, as well as the creativity and visual-spatial skills that are necessary in the STEM disciplines. Therefore, the existing STEAM initiatives provide helpful information about the curriculum and activities needed in gifted and talented education and create opportunities for rigorous and high-order education (Ulger & Çepni, 2020).

However, despite significant interest in STEAM, it can be challenging for teachers to integrate these practices into their teaching within institutional curricula, and particularly into the teaching addressed to gifted students. As a result, we could not find European policies specifically related to teaching STEAM education for gifted students, and consequently we have focused on collecting the existing European policies within each area separately: 1) gifted education; and 2) STEAM education.

2. Gifted education policies in Europe

Legislation on education in the EU Member States takes into account the existence of students with high abilities; however, there is variation when it comes to considering whether or not these students require specific measures for educational care.

Overall, care for highly able students tends to be dominated by out-of-school activities in the context of non-formal education, rather than activities within the curriculum or mainstream educational establishment during school hours. Thus, specific competitions for particular talents (science, technology, sports, music, etc.) tend to be more common than initiatives providing care for high abilities in general (EESC, 2013). Most European countries provide support for their gifted children with the help of various organisations.

Within this context, while the legislation of almost all Member States includes some educational measures relating to students with high abilities, the range of responses is highly diverse (EESC, 2013):

- Some countries provides for general educational measures for all students without distinguishing highly gifted or talented students from the rest, excellence being sought among all students.
- Most countries establish mixed-ability groups while aiming to provide care for all students within each group. A lot of countries divide students into groups depending on their abilities and academic performance, whereas some only do so for sporting or artistic abilities.
- Most of the EU countries allow for increasing flexibility or fast-tracking (i.e. the possibility for a student to move up to a school level above their age group) but there is no uniform criterion for implementation.
- All Member States liaise with private associations of professionals that provide extracurricular educational activities to foster the abilities of particularly gifted students. Activities are also promoted by or in collaboration with relevant education authorities in some countries.
- Regarding specific teacher training for gifted education, only half of the EU Member States offer this within their ongoing teacher training plans. When it comes to diagnosing and caring for highly gifted children, there is a lot of potential for improvement in teacher training, both initial and ongoing.

Therefore, what we find is that most gifted children spend the majority of their time in mainstream classrooms without access to challenging coursework, and that many teachers lack knowledge about the special learning needs of these highly able learners. There is thus much room for improvement in educational practices and activities aimed at these young people, something that is underlined by the scarcity of targeted teacher training in this area. This is the reality in countries such as the UK, Ireland, Spain, The Netherlands and Turkey.

National policies devoted to gifted education

In the following sections we will summarise the different national policies devoted to gifted education established in the STEAM Stars project's partner countries.

United Kingdom

The approach to gifted education in the United Kingdom is inclusive and holistic. However, there are some differences between the constituent countries of the UK. In England the terms "gifted" and "talented" are used and 5-10% of students in every school are considered to be gifted or talented. In Wales the terms "more able" and "talented" are used and up to 20% of students are considered to be more able and talented. Scotland uses the term "able" and also covers the inclusive approach (Reid & Boettger, 2015). The "English model" prefers the integrated approach to gifted education in which gifted children spend most of their time with the regular school group (especially in the age 5-11) with a small amount of cross-school and out-of-school opportunities.

Each school recognises differences among their students and plans curricula which meet the needs of individuals. This means that schools plan to meet the needs of the gifted as well as the least able children. Dividing a class into groups depending on their ability is one method of managing this. Among 14-19 year-olds the emphasis is on developing personal paths in order to satisfy personal requirements. Schools provide optimum matches between children's needs and opportunities. Every teacher in this integrated education must be a teacher of the gifted, and each teacher has the power to decide who is gifted (Reid & Boettger, 2015). The government's goal was to improve talented education in all schools, and by 2007 all English schools were required to have a gifted policy and a coordinator.

In 2020 a briefing paper from the House of Commons Library in the UK Parliament was produced entitled **Support for More Able and Talented Children in Schools (UK)**, which provided an analysis of support provided for gifted children in the UK. It includes evaluations of school strategies and performance, together with other statistics across all four countries in the UK.

Several organisations have been created in the UK to support gifted children. The **National Association for Gifted Children** was established in 1967 to support the social, emotional and learning needs of children with high learning potential of all ages and backgrounds (Potential Plus UK, 2014). The **National Association for Able Children in Education (NACE)** was established in 1983 to support, guide and train teachers to obtain the best results from able learners in everyday classrooms. In 2002 the **National Academy for Gifted and Talented Youth (NAGTY)** was established at the University of Warwick to help deliver the Government's programme for gifted and talented learners, in particular by developing, promoting and supporting educational opportunities for gifted and talented children up to the age of 19 (Reid & Boettger, 2015).

In 2008 a government policy for supporting the gifted was issued under **the National Programme for Gifted and Talented Education (DCSF, 2008)**, which encouraged schools in identifying learners in secondary education (11-19 years old) who are gifted and talented relative to their peers in their own group and school. Schools place a greater emphasis on a variety of abilities, such as artistic and athletic capabilities, and ability rather than achievement, so underachievers are discovered. According to **Potential Plus UK (2014)**, new teaching standards introduced in 2012 expect schools to identify and support gifted children (Reid & Boettger, 2015).

Ireland

In Ireland the most recent general education legislation (the **Education Act 2008**) included 'giftedness' as part of the definition of the term 'SEN' ('Special Educational Needs'). However, this legislation did not provide any specific indication on how gifted students could be supported and was not followed by any policy or implementation measures. It simply suggested that students with special educational needs should, like all children, receive an education appropriate to their needs and abilities. In contrast, the most recent special needs education legislation (the **Education for Persons with Special Educational Needs Act 2004**) did not mention or apply to gifted students. This reflects the fact that giftedness is not included with special needs education for administrative or resource allocation purposes (D'Alessio, 2009).

When reviewing the Eurydice report (2006), it seems to emerge that most European countries, such as Ireland, consider 'giftedness' not only in relation to a limited interpretation of intelligence (such as IQ) but also in relation to other abilities and talents. These include the performing arts, sports, entrepreneurial skills, motivation, problem solving, leadership, team working, creativity, and also socio-emotional skills (D'Alessio, 2009).

The main strategy for meeting the needs of gifted learners at secondary school age is a differentiated school system where these students are 'streamed' or put into similar ability groups. In secondary schools in Ireland, students may be placed in ability groupings that are often related to the 'higher' and 'ordinary' levels associated with the state examinations for which they are being prepared (D'Alessio, 2009).

Regarding teaching practices, recently published draft guidelines for teachers of exceptionally able students recommend a broad approach to identification, which may include formal psychometric assessment but also allows for identification by parents, teachers, peers, or self-identification (D'Alessio, 2009). Teacher education specifically addresses the needs of gifted learners; this is part of an integrated approach to diversity in education and is mandatory within initial teacher training. When considering identification criteria other forms of assessment, such as teachers' recommendations, student interviews and parental nominations, along with diagnostic procedures, have been considered in Ireland (D'Alessio, 2009).

With regard to financing, Ireland does not allocate any resource specifically targeted to gifted learners. Counselling services are part of the general education system which addresses the needs of all students, including gifted learners. In addition, Ireland has a special support service and resource centre, the **Centre for Talented Youth**, which specifically addresses the needs of gifted learners (D'Alessio, 2009).

The Netherlands

Education in the Netherlands is traditionally less focused on gifted or profoundly gifted and talented students. The common belief is that these students will learn anyway and do not need any additional aid or guidance, and if the learning outcomes are disappointing, the alleged giftedness of the student is questioned (De Boer et al., 2013).

In 2000, the Department of Education, Culture, and Science established a National High Ability Information Center. The purpose of this centre was to provide the government with information about developments and issues in primary and secondary education regarding appropriate education for highly gifted students (De Boer et al., 2013).

Since 2009, appropriate education for gifted and outstanding students has become an important issue on the political agenda. Until 2009, considerations of what methods of teaching were appropriate for gifted students had only been an educational issue. The educational policies of "dealing with differences" and "personalised learning", along with pressure from parents, mandated a differentiated focus for these students. For example, the government has promoted a focus on outstanding students in broad-based, heterogeneous schools, and that focus has ultimately benefited all students. In this regard, the Department of Education has given preference to an inclusive approach over a segregated approach (De Boer et al., 2013).

The importance of the implementation of a curriculum that suits the capabilities of gifted students is now recognised by most schools. Studies have shown that many schools are aware of the presence of gifted students within their student population and strive for a curriculum that matches the capabilities of these students (De Boer et al., 2013).

In the summer of 2011, the Dutch Minister of Education, Culture, and Science presented a letter to the Cabinet, containing the policy objectives for the education of talented, gifted, and highly gifted students. Action plans for primary, secondary, and higher education, in addition to the development of teacher skills, specific measures were announced, which should lead to better education and opportunities for developing the potential of these students.

Regarding funding, in the Netherlands schools are autonomous bodies and can choose how to use their extra budget to meet the requirements of gifted learners. Dutch schools receive general funding and can use that according to the needs of their students. In cases where children are both gifted and also have serious psychological disorders or problems, for example autism or ADHD, care is provided through school-based policies or through the healthcare system. Moreover, a new funding scheme has now been enacted (2009-2011) that allows primary Dutch schools to get funding to stimulate innovative approaches to supporting excellence by providing more challenging education in primary schools (D'Alessio, 2009).

Spain

In Spain, gifted students were included in the category of Special Educational Needs (SEN) until 2006 when a new legislation which differentiated between SEN students and 'gifted' students was passed (**Organic Law of Education**, 2006). This new legislation identified three main groups of students requiring extra support: those with special educational needs, those with high intellectual capacity and those who enter the education system late. Apparently, gifted students are not included within the general category of SEN because the latter is usually associated with a lack or a difficulty in learning, whilst giftedness is usually associated with issues concerning intelligence and learning potential (e.g., cognitive, social, physical) (D'Alessio, 2009).

Spain includes an official legislative definition for gifted learners within its policy. The Eurydice report (2006) indicates that Spain, among other European countries, considers giftedness in relation to a variety of talents and abilities, not just in terms of IQ or other measures of intelligence (D'Alessio, 2009).

Class sharing with upper grades, curriculum adaptation, and class skipping are all options in Spanish schools, but they are rarely employed. There is a growing interest in provisions for gifted children such as adapting the curriculum or skipping classes, but specific school actions for the gifted are still rare. Schools hold competitions for gifted students on a regular basis. Despite the fact that it is a legal requirement to identify talented children, there are no criteria, processes, or testing devices in place to do so. There is also a lack of attention given to teacher training for gifted education. Even though the school legislation recognises gifted children, their education has been generally neglected (Reid & Boettger, 2015).

Turkey

Despite the fact that the Turkish educational system has addressed the learning and support needs of exceptional students in a number of ways, the country's gifted education regulations are sparse. During the second half of the 20th century, the Turkish educational system underwent major changes and there were modifications to educational strategies, policies, and processes that cover special education. The **Turkish Ministry of Education (MOE)** attempted to develop several regulations to improve special education in Turkey and in the 1960s, some low-profile efforts were made to establish gifted and talented programs (Mammadov, 2015).

In 1960, the first school programme for gifted education was created in Ankara at the elementary school level. It was named ***özel sınıf ve türde¸s yetenek sınıfları*** (special class and homogenous talent classes), and gifted students selected from various elementary schools were grouped within the programme. The education of students with special needs, including gifted students, began in 1961 under a specialised strategy plan established by the newly approved constitution. This development strategy aimed to establish new institutions for all special needs students. However, in the following years, the MOE terminated the implementation of this programme (Mammadov, 2015).

In 1991, the MOE organised a **National Congress for Special Education** where gifted students were defined and accepted as a group who are in need of special education. As a result, during the 1990s, there was a significant expansion in the number of special schools established. The MOE instituted special education departments, and the government raised the annual grant for special education teachers. Gifted education, however, remained a challenging sector, with a scarcity of institutions and services for gifted students. Since the early 2000s, civil society organisations have pushed the government to take action in determining national policy and developing required programmes for talented children's education. With the first countrywide congress on gifted education in 2004, the first real effort to prepare a comprehensive strategy plan for the education of gifted children was undertaken: the **First Congress on Turkish Talented Students (FCTTS)**. The second congress was held in 2009. During these intervening years, various reports, papers and assessment documents were presented to address the development of gifted education (Mammadov, 2015).

3. STEAM education policies in Europe

According to the **Scientix Observatory** in 2015, 22% of 15-year-olds in Europe underachieve in mathematics while 17% underachieve in science, meaning that underachievement remains above the EU's Education and Training 2020 benchmark of 15%. Also, most EU countries continue to face a low number of students interested in studying or pursuing a career in the STEM/STEAM field.

Therefore, European countries are lagging behind in mathematics and science and, despite efforts since 2012, little progress appears to have been made. To address these issues, the European Commission launched the **"New Skills Agenda"** initiative to focus on improving the quality and relevance of STEM/STEAM skills development, to promote STEM/STEAM studies and careers and to support teachers' professional development. Initiatives like this are supplemented in some countries by a global approach to deal with STEM/STEAM issues at the national level.

In the following sections, we will provide the main trends of public education policies carried out in the different partner countries in favour of STEM/STEAM that can lead to outlined potential solutions to the STEM/STEAM challenges (European Schoolnet, 2018).

National policies devoted to STEM/STEAM education

All partner countries (UK, Ireland, the Netherlands, Spain, and Turkey) have or are developing strategies to improve teaching and learning and the uptake of STEM/STEAM studies and careers.

The Netherlands and the **UK (Scotland and Northern Ireland)** have a national strategy or dedicated action plan devoted to STEM/STEAM education, while **Spain**, **Turkey** and **UK (England and Wales)** combine with other general education strategies within which STEM/STEAM education issues are highlighted. As for **Ireland**, rather than having global strategies dealing with STEM/STEAM education more holistically, it has specific strategies dealing with improving the profile, quality and interest in technology studies and careers in particular. Each national strategy is described below:

United Kingdom

Within the United Kingdom, the devolved governments of England, Scotland, Wales and Northern Ireland take slightly different approaches to their STEM/STEAM strategy. There is no single overarching strategic document for the United Kingdom. However, STEM/STEAM education has been and remains a priority for the United Kingdom: the goal for the country's STEM/STEAM sectors was to recruit or train an additional 180,000 engineers, scientists and technicians per year by 2020 to maintain the United Kingdom's future competitiveness in the global economy.

STEM/STEAM subjects in schools and colleges have received clear, particular and continuous support from the government of the United Kingdom and the devolved administrations for the last 10 years. The adoption of the term STEM/STEAM in United Kingdom public policy was brought together with the publication of the government's **Science and Innovation Investment Framework 2004-2014**. The **Council for Science and Technology** is in place to support and inform the STEM/STEAM agenda advising the Prime Minister on the strategic policies and framework for sustaining and developing STEM/STEAM in the United Kingdom and promoting international co-operation in the field.

Ireland

In 2014, the Irish **Minister for Jobs, Enterprise and Innovation** and the **Minister for Education and Skills** published the **ICT Skills Action Plan 2014**. This Plan aimed to meet 74% of industry demands for ICT professionals domestically by 2018 (up from 45% in 2011 and 60% in 2014). In order to meet this target, the Minister for Jobs, Enterprise and Innovation announced a series of reforms aimed at dramatically increasing the availability of graduates and the Minister for Education and Skills outlined further reforms aimed at ensuring that there is a strong ICT talent pool and promoting Ireland as a centre for high-level ICT skills.

The Netherlands

The Netherlands has had a STEM/STEAM education strategy in place since 2004, starting with the **Delta Plan Science and Technology (2004-2010)** which aimed to tackle the country's shortage of scientists and engineers in the years to come. A key element of the Delta plan was the **Platform Bèta Techniek** (Dutch National STEM Platform, PTvT) which coordinates and supports the implementation of the Dutch national STEM/STEAM strategies (currently: Technology Pact). The Platform was originally established in 2004 by three Ministries: the Ministry of Education, Culture, and Science, the Ministry of Economic Affairs and Climate Policy, and the Ministry of Social Affairs and Employment.

The Platform was later combined in 2019 with the TechniekTalent.nu organisation, which is funded by eight technical industry associations (branches). Through a wide range of national and regional programmes that cover the entire education chain (from primary education to the labour market), PTvT addresses current and future bottlenecks in STEM/STEAM, such as teacher shortages and the impact of technology in the health sector. PTvT is also co-founder of the EU STEM/STEAM Coalition, a Europe-wide network of like-minded national STEM/STEAM platforms.

To continue this holistic approach a **Master Plan** was published in November 2009 in a response to the Manifesto **'Room for Talent! Room for Science and Technology!'** (November, 2008). It outlined a strategy for implementing the Manifesto's goals during the period 2011-2016 and aimed to offer all children aged 2-14 the opportunity to develop their talents for investigation, reasoning and problem solving. Since 2013 the overarching STEM/STEAM education strategy is formed by the **Technology Pact**, a targeted strategy focused specifically on technology studies and careers and developing technology skills for future STEM/STEAM professionals.

Spain

Spain also has no dedicated STEM/STEAM education strategy in place; however, the country has specific STEM/STEAM education requirements highlighted in the **Organic Law 8/2013** on the improvement of educational quality, knows as the **'LOMCE'**. The LOMCE is currently being implemented in each of the different educational stages, with each Autonomous Community being responsible for developing its own regulations. This Law places special emphasis on the need to improve science teaching, as justified by the inadequate results of Spanish students in the mathematical and scientific PISA 2009 tests, which were below the average for OECD countries.

It should also be noted that Spain's Federal Ministry of **Education, Culture and Sport** has formal agreements with a number of scientific bodies at a national level for the development of a scientific culture in schools. These scientific entities include: the Confederation of Scientific Societies of Spain, the Scientific Research Council (CSIC), the Royal Spanish Societies of Mathematics, Physics and Chemistry, and the National Association of Chemists of Spain.

Turkey

Although Turkey does not have its own specific STEM/STEAM education strategy, it follows the guidelines given for STEM/STEAM education in schools in the **National Science, Technology and Innovation Strategy (2011-2016)** produced by **TUBİTAK (the Science and Technological Research Council of Turkey)**. According to this strategy, the Ministry of Education provides support to STEM/STEAM education through the organisation of Science Fairs for primary and secondary schools, the encouragement of young people to study Space Sciences, the foundation of science centres in all provinces and the improvement of science, technology and design, and mathematics curricula at primary and secondary level.

STEM/STEAM-related in-service teacher education initiatives

All partner countries have recently developed or are currently developing STEM/STEAM -related professional development initiatives, some of these implemented at central level, and others provided by teacher training agencies, universities and private organisations.

Education Scotland (the national body in Scotland for supporting quality and improvement in learning and teaching) has run a large number of networking support events, training events and courses and materials for teachers on the national educational intranet, **Glow**. For instance, Education Scotland organised 12 events bringing teachers from all local authorities together to co-develop classroom resources, including for STEM/STEAM teaching. Since April 2014, four sets of professional learning materials have been uploaded in the Glow online community, bringing the total number of resources available to 3,000.

Meanwhile, in England, the government funds professional development in science and mathematics and a number of science, technology, engineering and mathematics professional bodies and subject associations also offer professional development opportunities. However, England reports that it is witnessing a move away from a national and regional delivery model for continuous professional development in science education, to a school-led model.

For its part, Ireland provides ICT-focused professional development courses, specifically a full in-service teacher education programme for Design and Communication Graphics, delivered by the **Professional Development Service for Teachers (PDST)**. The programme involves blended support through online components and then follow-up face-to-face support.

Especially relevant is the **Dutch STEM/STEAM Teacher Academy** in the Netherlands, which provides professional development in cooperation with industry. This initiative was launched in 2014 and is run by the **Platform Bèta Techniek**. The Academy provides initial and in-service teacher education through the provision of internships, master classes and courses organised in cooperation with industry. The activities of the STEM/STEAM Teacher Academy are available to all secondary education STEM/STEAM teachers throughout the Netherlands.

In Spain, there are several institutions providing professional development for STEM/STEAM teachers. **INTEF (National Institute of Educational Technologies and Teacher Training)** offers in-service teacher training for STEM/STEAM teachers annually through its summer courses. It also organises congresses and working days with the objective to spread, deepen and exchange knowledge and skills in different subjects and on various educational topics.

In Turkey, the **Ministry of National Education's Directorate General for Teacher Education and Development** has designed standard training programmes for in-service science teachers with the aim of training teachers about new teaching approaches in science teaching and how to effectively use innovative science and mathematics materials in lessons. A similar programme has been designed for in-service mathematics teachers.

Regarding evaluations of teachers' continuous professional development, in the United Kingdom there are a large number of evaluation reports on the impact of the continuous professional development provided by the **National Science Learning Centre and National Science Learning Network**. Ireland is also committed to the ongoing evaluation of the teacher training it provides for Maths, Science and Technology subjects, as well as Physics, Chemistry, Agricultural Science, and Biology, delivered by the **Professional Development Service for Teachers (PDST)**.

Online professional development for STEM/STEAM teachers

With the generalisation of Internet capabilities and the digital economy, new teaching methodologies are emerging which tend to be used throughout Europe. Based on this, all partner countries, with the exception of Turkey, now offer or plan to offer online professional development for STEM/STEAM teachers, demonstrating the growing popularity and accepted use of this method of training. The format of online professional development offered by different countries ranges from short one-off webinars to activities on e-learning platforms (such as Moodle) to full Massive Open Online Courses (MOOCs). Often these courses specifically aim to support teachers in the pedagogical use of ICT in STEM/STEAM, as well as other areas of teaching and learning.

United Kingdom (England)

In England, the **National Science Learning Centre** has ten years of experience of running STEM/STEAM specific webinars for teachers across a range of systems, including Adobe Connect, Livestream and Google Hangouts on Air. Regarding MOOC courses on STEM/STEAM teaching, England is increasingly experimenting and developing these. While there is interest in the possibilities around using MOOCs in the education of 11 to 19-year-olds, current developments in the United Kingdom, as in other countries, focus on MOOCs for teachers. The National Science Learning Centre recently piloted MOOCs on two different platforms. The first pilot was deployed on the **Canvas Network platform** and was focused on managing behaviour for learning, and specifically addressed the issue from the perspective of STEM/STEAM teachers. The second pilot was run on the **FutureLearn platform** and was focused on Assessment for Learning in STEM/STEAM teaching.

Ireland

In Ireland, the Irish organisation **T4** is a full-time support service under the auspices of the **Teacher Education Section** within the **Department of Education and Science**. The main goal of T4 is to prepare and support teachers to implement revised syllabuses in Architectural Technology, Design and Communication Graphics and Engineering Technology, and the new subject Technology, at Leaving Certificate level. T4 provides continued professional development in CAD software, which includes an online component that must be distance learned and completed for teachers to qualify for face-to-face support.

The Netherlands

In the Netherlands, the Dutch **STEM Teacher Academy** was launched in 2014 in order to meet the objectives set in the Dutch National Technology Pact and several programmes of the Dutch government which aimed to attract more people to teach STEM subjects and to do so in a more engaging way. Overall, the programme involved 227 companies and 814 teachers, which resulted in nearly 100% geographical coverage. Additionally, the STEM Teacher Academy inspired the inclusion of teachers' internships in the curriculum of teacher training programmes at eight universities of applied science.

Other online resources include **TeachSTEM**, an initiative developed under the ARTIFEX project in 2020 whose aim was to provide support and resources for STEM teachers to improve their practices and methodologies.

The **VO-HO Netwerken** (Secondary-Higher Education Networks) were set up in 2004 as part of the Deltaplan Bèta Techniek (Dutch national STEM strategy). The main goals of the networks are the professional development of secondary education teachers and principals, the continuing innovation of courses and curricula and the improvement of the connection between secondary education (VO) and higher education (HO). The Networks cover 361 (pre-university) secondary schools (60% of the total), 22 universities of applied sciences and 12 research universities. Together they reach more than 35.000 students and 3.800 teachers annually.

Spain

In Spain, there is a wide range of online training provided by **INTEF**, which range from courses on mobile learning and augmented reality to digital storytelling for teachers, and courses dedicated to the effective use of open educational resources in Mathematics and Science. The **National Centre for Curricular Development in Non-proprietary Systems (CeDeC)** also provides numerous applications and digital resources for STEM/STEAM teachers to use in their classrooms. The materials provided promote the design and development of digital educational materials using open-source software. Regarding MOOC courses on STEM/STEAM teaching, a new model of teacher training intends to develop massive training opportunities based on open and social learning through activities that generate interaction, aggregated production, shared knowledge, and the building of professional networks. Courses are offered in the form of MOOCs, NOOCs (Nano Online Open Courses) and SPOOCs (Self-Paced Open Online Courses).

In addition to the new teaching methodologies for teachers, a pool of innovative material is available either online (for virtual material) or in universities and sciences centres. It helps teachers to develop new teaching methodologies for their courses and content to promote STEM/STEAM education. In the EU, the **T³ Europe Network** of mathematics and STEM/STEAM teachers offers educators free access to peer reviewed, curriculum-related resources and webinars (www.t3europe.eu).

Furthermore, beyond traditional training, some countries are proposing alternative ways of increasing the skills of STEM/STEAM teachers where the logic is reversed. The aim is not to train teachers so that they can better teach STEM/STEAM afterwards but to encourage them to do STEM/STEAM projects with their students and support experts, to develop their pedagogical STEM skills on the job. The advantages are accelerated development of targeted skills and more motivated teachers, who acquire the right skills at the right time in the right place.

"STEM/STEAM Commons" by NGOs and private companies

NGOs and private companies are establishing partnerships with governments to act with regard to STEM/STEAM. Some private companies provide equipment, materials, STEM/STEAM content, training sessions, mentoring, etc. to schools. Some of these resources are crucial because they relate to the most recent industrial processes. The creation of educational resources for teaching STEM/STEAM no longer relies solely on the activity of traditional publishers or publicly-funded publishers operated by ministries.

In Spain, for example, the Ministry usually collaborates with private organisations, such as **Samsung**, to develop innovative educational projects (**Samsung Smart School programme**). In addition, other agreements have been signed for the development of a **Future Classroom Lab** on the premises of INTEF with the support of private partners.

At the European level, some programmes are based on cooperation between ministries and companies or NGOs. The **STEM/STEAM Alliance Initiative** benefits from the support of more than a dozen private companies. This type of cooperation is key, especially for some technologically advanced STEM/STEAM areas: private companies are providing up-to-date devices and industrial materials to train teachers and students in high schools and higher education. The **T³ Europe Network** of mathematics and science teachers has also developed the **TI STEM Lab Network**, a group of general and vocational secondary schools across Europe with a strong profile in STEM/STEAM education. It is a platform for collaboration where teaching and learning content is developed, evaluated and shared for adoption in everyday classrooms.

4. Conclusions

There are neither policies nor literature on the gifted dimension of STEAM. Regarding gifted education, there is an urgent need to improve educational practices and activities aimed at gifted students, something which is impacted by the scarcity of teachers trained about the special learning needs of these highly able learners.

STEAM education policies and initiatives, however, are receiving continued political and financial support in the face of underachievement, the lack of student interest in STEM/STEAM studies and careers, and the unmet labour market needs in STEM/STEAM-related sectors that are likely to expand in the future. Nevertheless, recent research has detected an urgent need to continue improving the quality and relevance of STEAM skills development, to promote STEM/STEAM studies and careers and to support teachers' professional development.

Considering the general context of the gifted and STEAM education in Europe, there are some **improvement areas detected** by recent studies funded by the European Commission:

Gifted education policies (European Economic and Social Committee, 2013)	**STEAM education policies** (Scientix Observatory Report, 2018)
Initial and ongoing training of teaching staff to improve teachers' **perception of students** with high abilities and **facilitate their understanding**, along with the methods to be used for their **detection** and **targeted educational care**	Attracting more students and teachers to STEM/STEAM education through a **global approach from primary to adult education** that will better **anticipate the skills needed** for the society of the future
Incorporating into teacher training the values of **humanism**, the reality of **multiculturalism**, the educational **use of ICT** and the encouragement of **creativity, innovation and initiative**	Developing a **common European framework of reference** for STEM/STEAM education and coordinating **national STEM/STEAM initiatives** related to publishing pedagogical content to ensure teachers' needs are being met
Pooling of **psychoeducational assessment** procedures, along with those to assess **social and family-related** factors	**Evaluating and integrating curriculum** and pedagogical innovations
	Fostering deeper **collaboration with universities and industry** to develop STEM/STEAM teachers' skills.
	Breaking down the barriers between subjects with pragmatic initiatives to **improve the quality of** STEM/STEAM **education** by building on **each country's strengths**

The STEAM Stars project contributes to addressing most of the areas of improvement identified, by developing an integrated strategy involving both domains on a European scale by building on each country's strengths. Specifically, STEAM Stars contributes by:

- Identifying the competences that teachers need to provide rigorous and challenging material to the most capable learners.
- Training teachers to recognise giftedness and address the unique needs of gifted and talented students.
- Incorporating into teacher training the educational use of ICT and the encouragement of creativity innovation and initiative.
- Creating specialised and innovative training and assessment methods, content and tools in STEAM education for gifted students to support the professional practices of teachers.
- Expanding the number of individual schools that apply STEAM education for gifted students in Europe.

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