STREAM IT National Inspiration Hub in Bulgaria: Streaming Girls and Women in STEAM

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STREAM IT – Национален хъб за вдъхновение в България за насочване в STEAM на момичета и жени

Abstract

NIH (National Inspiration Hub) is an inspiration network created formally as a deliverable from STREAM-IT (Streaming girls and women into STEM education, innovation and research) Project. The main aim of the National Inspiration Hubs is to create an online networking group for STEM teachers and capacity-building communities, as well as to host activities for sharing and exchanging expertise and experience, as well as transferring good and best practices, promoting the results of the project and organizing events. The Hubs (from 17 countries) will be able to interact within an online platform. The article represents NIH as an instrument for establishing and developing sustainable STEAM communities based on values and knowledge. NIH also brings together educators, researchers and community stakeholders willing to support gender equality in STEAM education and career.

Keywords: *STEM; STEAM; Ecosystem; NIH (National Hub for Inspiration).*

Introduction

The acronym 'STEM' refers to the fields of Science, Technology, Engineering, and Mathematics. Gender equality in STEM is used to describe the equal rights, responsibilities, and opportunities in STEM fields that individuals can access. It is based on education, opportunities, and qualifications that individuals acquire in STEM-related fields [1].

This publication aims to present the experience and vision of the authors in the field of building a National Hub for Inspiration (in Bulgaria) for STEAM, including supporting girls and women in research-based careers, representing established practices and according to existing up-to-date research. She Figures is a significant European Commission initiative that provides statistical insights into gender equality in research and innovation across Europe. It is released every three years and details the progress and representation of women in academics, leadership roles, and research careers. The report looks at metrics such as the proportion of female researchers, gender salary gaps, and accessibility to research funding. Gender equality in research and innovation is critical for economic growth, societal progress, and scientific brilliance. She Figures highlights disparities in leadership positions, funding distribution, and the participation of women in STEM (science, technology, engineering, and mathematics) fields. Additionally, diversity in research teams has been shown to increase creativity and improve problem-solving by bringing in a range of perspectives. By ensuring

that women have equal opportunities in research, She Figures contributes to the development of a more innovative and competitive research environment in Europe [2].

The most problematic area is connected with gender stereotypes, that is commonly accepted "collective representations" that associate responsibilities or characteristics (e.g., career/family, science/arts) with gender categories (e.g., male/female). Such collective prejudices, particularly implicit stereotypes, are typically seen to be so ingrained in society that they are difficult to alter. Additionally, these patterns were seen in almost every demographic category and in every region of the US and a number of other nations, suggesting that implicit and explicit gender stereotypes are changing globally [3]. In 2024 a review examines the role that gender stereotypes play in promoting gender bias and discrimination [4].

Such surveys and documents also help in STEA(rt)M awareness for methodology of learning and teaching, as well as STEAM careers, which allows for faster analysis, transfer and integration of good practices, as well as community development and new activities and policies, depending on the environment.

I. State-Of-the-Art STEAM Research

1. STREAM-IT Project

Despite growing attention, numerous studies, and various institutional and national programs aimed at addressing the underrepresentation of women in STEAM fields, many disciplines within STEAM still experience significant gender imbalances among students, researchers, and faculty. The "STREAM-IT" project, as a European initiative, was designed to raise awareness about this issue and to encourage girls and young women across various age groups to pursue education in these traditionally male-dominated fields. To make these actions effective and address the challenges accurately, an in-depth sociological study was conducted engaging two key stakeholder groups: female students and educational experts, including STEAM teachers in both formal and informal education, faculty members, and policymakers. Additionally, a comprehensive literature review was done to map the primary sociological perspectives and research efforts that have sought to understand the gender imbalance in STEAM fields.

Online and in-person methods were used to collect data in 14 European nations between March and May of 2024. All participants who signed an informed consent form were granted anonymity. A total of 346 sources were reviewed, 97 female students took part in semi-structured interviews, and 85 educators and professionals working in STEAM outreach and education contributed through expert interviews. In addition to policymakers and experts in non-formal education, the majority of interviewees are representatives of higher education institutions. Informatics, biotechnology, chemistry, mathematics, physics, engineering, education management, and the arts are among the areas of expertise.

2. Key Findings

2.1. Diversity of Opinions on Intervention

- There is a wide range of views among experts regarding the necessity and type of interventions to increase women's participation in STEM, particularly in fields where female representation is already high.
- Some advocate for structural changes, while others focus on individual empowerment, inclusion, and diversity in leadership for innovation.

2.2. Persistent Barriers

- Societal stereotypes and family expectations continue to discourage girls from pursuing STEM careers.
- Gender biases may be reinforced by educators at primary and secondary levels, sometimes unconsciously.
- Institutional support at universities is insufficient, and students often experience subtle exclusion from peers and faculty.
- Workplace policies and societal expectations about family life contribute to barriers in hiring, advancement, and re-entry after maternity, particularly for female researchers.

2.3. Institutional Strategies

- Few institutions demonstrate formal commitment to reforms promoting gender equality.
- Supportive efforts often rely on volunteer initiatives rather than systematic programs.
- Emphasis is placed on mentorship, role models, and creating inclusive school environments, but institutional support at senior levels is limited.

2.4. Expert Recommendations

- Early development of critical skills and confidence-building.
- Gender-sensitive training for educators.
- Real-world, experiential learning approaches that stimulate creativity.
- Enhancing visibility of role models.
- Application of gender-sensitive methodologies in early education.
- Addressing financial barriers, especially for girls from underprivileged backgrounds.
- Expanding community programs and parental support to break societal barriers.
- Challenges identified.

2.5. Education Level

- Stereotypes persist about subjects and careers suitable for boys versus girls.
- Girls are influenced by family and social pressure towards non-STEM fields.
- Lack of role models, extracurricular programs, and targeted teacher support.

2.6. Higher Education and Employment

- Work-life balance, maternity leave, and child-rearing responsibilities remain significant obstacles.
- Academic progression is hindered by insufficient institutional support and family expectations.
- Women experience gender-based discrimination, subtle exclusion, lack of peer support, and difficulty gaining visibility as researchers.
- Labor market expectations and biases affect hiring and salary.
- Negative workplace culture, unstable positions, and inadequate child care facilities deter many from STEM careers.

2.7. Institutional Attitudes

- Most obstacles are seen by universities as external (social, familial, or educational) rather than systemic or institution-driven.

- Limited institutional intent for reform, with most efforts focused elsewhere.
- Institutional representation & scope.

3. Overall Conclusions

There is consensus among experts about the value of supportive environments and innovative methodologies in bridging the gender gap in STEM. The main obstacles for girls and women remain rooted in cultural, social, and institutional biases. Effective change requires coordinated efforts at institutional, societal, and family levels, with stronger commitments to gender equity and systematic support mechanisms.

II. NATIONAL INSPIRATION HUB (NIH)

II.1. NIH in STREAM-IT Project

The gender gap in higher education STEM degree programs across Europe remain marked, with women significantly underrepresented in several fields, particularly engineering, technology, and the physical sciences. According to the European Commission's She Figures 2021 report, women comprise only 34% of STEM graduates in the European Union, with especially low representation in engineering (15.5%) and information and communication technology (ICT) (19.2%) [5]. This imbalance restricts diversity in STEM fields and perpetuates broader gender inequalities within the labor market and society.

Despite regional and disciplinary differences, this gap persists within research and academia. Women make up approximately 41% of the European research workforce, but their representation declines to only 24% at the full professorship level—a phenomenon widely known as the "leaky pipeline," reflecting the attrition of women as they ascend academic ranks [4], [6]. Gender disparities extend to research funding, publication rates, and recognition, impeding women's career advancement. Underrepresentation is also pronounced in STEM leadership roles, limiting women's influence on research agendas and policy decisions.

These persistent issues underscore the necessity of focused interventions and all-encompassing policies that promote gender equality while tackling systemic obstacles influencing women's career paths in STEM and STEAM fields.

A comprehensive needs assessment—through survey—identified gender disparity priorities in STEM education and revealed barriers affecting engagement, policy effectiveness, and resource gaps [7], [8].

We access potential learners at different ages, to achieve the most stable results, we must work from a young age. To become robust scientific thinkers, however, young children need opportunities to engage in high quality science activities throughout their day [9]. Moreover, to achieve better results we have to use all types of environment including virtual and hybrid, that's why the integration of STEM Centers in a Virtual Education Space is natural. In a research paper a distributed educational platform that supports sharable usage of teaching material at university and in STEM centers in secondary schools is presented. The use of the platform is demonstrated by two educational games. The platform is expanded with four educational robots to increase the attractiveness of the educational process [10].

Since these women are among the most significant STEAM influencers and role models for successful practices and careers, several studies and reviews pertaining to women as researchers and women in STEAM careers are crucial. According to a 2020 study on research and women researchers, regardless of authorship status, women researchers produce fewer publications than men in every nation. First writers show the least difference in the number of

publications by women compared to men, while all authors show the greatest gap. Among first authors, the average citation impact of men is higher than that of women, suggesting gender bias in citation practice. In all countries studied and the EU28, the ratio of women to men among all authors was closer to parity during a recent 5-year period compared with a decade ago. Men are more highly represented among authors with a long publication history while women are highly represented among authors with a short publication history [11].

The She Figures 2024 report showcases notable progress in gender equality across various research and innovation sectors since 2021. Key developments include:

- A gradual increase in the percentage of female researchers, particularly in life sciences and social sciences, with some progress in STEM fields.
- A reduction in the gender pay gap in research institutions, though disparities remain in certain disciplines, particularly in high-earning STEM careers.
- More women attaining senior academic positions, with policies supporting gender-balanced hiring practices, mentorship programs, and flexible work arrangements.
- Increased participation of women in EU-funded research programs, contributing to a more diverse and inclusive scientific landscape.
- Strengthened efforts to combat gender-based biases in research funding allocations, ensuring equal access to resources for women-led projects.
- Continued challenges in engineering and technology fields, where female representation remains significantly low compared to other disciplines, despite outreach programs encouraging young women to pursue careers in these areas.
- While these improvements indicate positive trends, persistent barriers such as unconscious bias, work-life balanced challenges, and limited representation in top leadership positions require further attention and action [2].

Scholarly research indicates that persistent gender stereotypes play a major role in sustaining these disparities. Societal expectations and cultural norms frequently cast STEM fields as male-dominated, discouraging girls and women from pursuing these disciplines from a young age. The absence of female role models further exacerbates this challenge, diminishing girls' identification with STEM careers and lowering their aspirations and engagement. The academic environment itself is critical: female students in STEM commonly report experiences of bias, microaggressions, and insufficient institutional support, contributing to higher rates of attrition. The interaction of these factors creates pronounced obstacles to women's persistence in STEM higher education [8].

Europe follows in the ranking in second place, with three-quarters of the regional gender gap closed (75.1%). In Health and Survival, Europe sees, like many regions, a decrease in healthy life expectancy affecting its subindex scores. Europe posts the highest regional score in Political Empowerment (35.4%). Out of all regions, Europe has the third- and second-highest scores for ministerial and parliamentary parity in 2025, at 55.3% and 53.3%, respectively [12].

We have to pay special attentions to educators – to motivate and to support them. They are the first group of people influencing the choice of young people for career or specialty at university. Educators are central to shaping students' attitudes, self-efficacy, and career aspirations, especially in environments affected by gender stereotypes. The crucial differences between the girls who intended to study physics and those who did not is that girls who intend to study physics had higher physics extrinsic motivation, more positive perceptions of physics teachers and lessons, greater competitiveness and a tendency to be less extrovert [13].

Teachers have the closest direct contact with students, not only during their education, but also afterwards, the support of teachers, especially the active ones, is of utmost importance. During various events organized by the Biomed-Varna Foundation and the

activities of the STREAM-IT project, we have repeatedly received evidence of the need for scientific support for teachers who are active in communities, which gives them the opportunity to diversify, expand, adapt and personalize more what they do.

A special organizational structures STEM Outreach Units (SOUs) in Canada is a representative example in this area. The purpose of this research is to explore the conceptual position and role of Canadian university-based STEM Outreach Units (SOUs) as knowledge brokers within K-12 STEM learning ecosystems. Overall, the findings affirm that university-based SOUs have a role to play in the K-12 STEM learning ecosystem, helping students develop STEM knowledge and skills [14]. Another example is STEM Learning Ecosystems(SLEs) in USA, a form of cross-sector collaboration and problem-solving innovation to strengthen the STEM workforce, and the role that industry partners bring to them [15].

Every professional community needs not only experts but also resources. As for the resources, huge influence we have in sharing practices, and also publishing practice in journals/conferences. Over the years, the journal has continued its growth trends in terms of multiple performance measures, reflecting on-going development of STEM (science, technology, engineering, and mathematics) education research and the journal's international leadership:

- Serving as a leading knowledge resource in multidisciplinary STEM education research worldwide;
- Pursuing high quality in scholarly output through a rigorous process of screening, reviewing, and publishing;
- Engaging researchers and educators with diverse disciplinary, educational, and cultural backgrounds to address diverse issues in STEM education worldwide;
- Elevating the journal's article visibility, accessibility, and impact with diverse approaches, including open-access publications;
- Keeping a professional commitment and dedication in promoting research excellence in STEM education worldwide as a distinct field [16].

The similar idea is embedded in ECR Data Resource Hub to facilitate rigorous and reproducible research practices such as data sharing and study registration. The Hub will foster innovation in open and reproducible research practices for the breadth of research activities in education including experimental, observational, longitudinal, and qualitative methods. Finally, the Hub will connect the STEM education research community with neighboring communities to leverage shared insights and knowledge building [17].

In one of our previous work on STEAM KPIs we pointed out the importance of identity of every STEAM center [18]. The same idea is explored in IMSA Innovation Hubs Around the State of Illinois are offering emerging technology and innovation (quantum computing, bioinformatics, cybersecurity, big data, synthetic biology, agriculture, healthcare); responsive to the community's needs; university partnerships: leverage resources from local colleagues/universities area hub managers: foster partnerships [19].

For the trends in STEM education among the 10 countries, some directions are similar: strengthening networks or partners from outside of schools to diversify students' STEM learning experiences in non-formal education, increasing the importance of STEM education through introducing STEM curricula in formal education, accelerating efforts to increase the number of women in the STEM field, enhancing the provision of inclusive and integrated STEM environments such as applying the phenomenon-based approach/ project-based learning/ authentic hands-on problem solving, emphasizing holistic or transversal [20], [21].

Infrastructure for STEAM practices in schools in Bulgaria is provided at the national level through the so-called National STEM Center at the Ministry of Education and Science, which coordinates and supports the creation and development of a STEM environment in

every Bulgarian school. According to this initiative, implemented through project funding, a STEM center has been built in every school, with emphasis on the following areas: "Sciences", "Mathematics and Informatics", "Robotics and Cyber-Physical Systems", "Green Technologies and Sustainable Development" and "Design and 3D Prototyping" (stem.mon.bg).

The main difference in the two structures is in the approach to building and funding. While the national STEM center is a structure supporting formal education and building the environment in each school, the NIH is aimed at supporting girls and women, but not in isolation from boys or male experts, but exactly the opposite. Therefore, the initiatives of the hub are also aimed at girls and boys. The approach to building STEM centers, through the coordination of the national STEM center, is top-down, while the NIH is built bottom-up by bringing together open practices and expertise, in partnership with existing local ecosystems, free initiative and a dynamic flexible environment not only for activities, but also for goals and values. So, through the establishment of National Inspiration Hubs—collaborative forums for exchanging best practices, resources, and creative approaches devoted to increasing gender equality in STEM education—initiatives like STREAM-IT aim to assist instructors.

Coordination outside of individual classes is necessary for systematic transformation. Promoting gender equality requires teacher empowerment and continuous professional support, which emphasizes the value of cooperation between educators, governmental organizations, non-governmental organizations, business stakeholders, and local communities. The STREAM-IT initiative intends to create a strong infrastructure for National Inspiration Hubs by forming alliances and encouraging networks, guaranteeing sufficient funding and institutional support for long-term effect. In order to include gender equality into STEM education, community engagement is essential.

The National Inspiration Hubs represent a multi-stakeholder approach aimed at enhancing the capacities of secondary school STEM teachers, university educators, and other professionals. These hubs focus on deconstructing gender stereotypes and biases by applying STEAM-based pedagogical approaches to real-world scenarios. Established as informal networks bridging societal sectors, the hubs allow participants to identify context-specific needs and barriers, collaborating to devise solutions tailored to their unique circumstances.

Within STREAM-IT, several coordinated activities will support the National Inspiration Hubs, such as hosting an online platform for information sharing both within and across hubs. These activities—addressed collaboratively by project partners—can serve as a model for others establishing similar hubs, using comparable platforms (e.g., Basecamp) to share resources and best practices. Stakeholder engagement is key to the success of National Inspiration Hubs, ensuring contextually relevant, widely supported, and sustainable initiatives. Involving various stakeholders—including educators, policymakers, industry leaders, community organizations, parents, and students—facilitates collaboration, resource sharing, and advocacy. Educators and administrators are fundamental to integrating the hub's agenda within existing curricula and structures, while policymakers and industry partners align the hub's activities with strategic priorities and employment pathways [22], [23]. Community organizations and parents reinforce objectives outside school settings.

One of the partners of STREAM-IT Project published that its commitment focuses on promoting change in persistent gender inequalities in STEAM education, research and innovation to contribute to the implementation of the 'European Manifesto for Gender Inclusive STEM(A)M Education and Careers'. In order to achieve this, four objectives are proposed: Empowering underrepresented groups in STEM, with a special focus on girls; promoting gender-inclusive career paths and increasing the talent pipeline in STEM fields, along with enhancing the attractiveness of STEM career; piloting and fostering the integration of STEAM approaches in STEM education by synthesizing previous knowledge and

networks, and supporting STEM education providers by sharing knowledge and building capacity to eliminate gender-based barriers, including gender stereotypes in STEM education. They interpret NIH as a collaborative platform where different stakeholders, specifically, secondary school teachers, have a significant influence on their students' future decisions, can exchange best practices, share resources, and develop approaches to STEM education that promote gender equality [24].

A step-by-step process includes forming the NIH steering committee, conducting the needs assessment defined by priority questions, surveying stakeholders, analyzing data for webinar topics, and organizing regular meetings. Drawing on peer learning and network expertise, webinar topics address priority issues and best practices identified through needs assessments. Suggested modules include gender sensitivity training, inclusive pedagogy, and STEM curriculum redesign, leveraging evidence-based resources and publications.

In Bulgaria the two webinars for 2024 that were held in April and May tackled the topics of good practices for STEAM educations incl. for girls and good practices in STEM centers in life sciences, mathematics and informatics. The third one to be held in Sept. 2025 will be dedicated to the storytelling in STEAM with public library partnership. One of very specific aim is to collaborate between active learning centers, ecosystems in order to exchange practices and receive more added value.

II. 2 NIH Perspectives and Sustainable Ecosystems

Supporting STEAM centers and communities can be done by institutions or individually, formally and informal. In some countries there are initiatives like community individuals known as "STEM Guides," who were employed to act as intermediaries between young people and STEM learning resources, participated in a five-year experimental program to enhance informal STEM education. Respected individuals with genuine relationships to young people, flexible schedules, the capacity to travel within the community, and a passion for finding local STEM resources were STEM guides [25].

In every topic the high level of maturity is awareness. In the state of Texas, 211 secondary art educators completed the STEM Awareness and Community Survey. The data collected from the secondary art teachers revealed perception differences in regards to teacher educational background and teacher certification training. Follow up interviews with participants revealed teacher's perceptions of the benefit of art within STEM in terms of creativity, communication, and visualization of concepts. The data concluded the necessity for educational leadership to implement more STEM related training for their arts faculty in order to ensure meaningful integration of STEAM based curriculum [26].

Several research studies are devoted to the development of a model for constructing STEAM education, based on project-based learning in so-called "creative spaces" (these are integration platforms for school children, students and postgraduates working in a collaborative way on projects initiated by various structures of society and business) [27]. The huge motivation factor in STEAM interest clubs is AI. In the publication is shared that the highest results are obtained in the interest groups at the school STEAM centers, where AI learning enables the building of the target digital competencies at basic, intermediate, and even advanced levels. Interdisciplinary and problem-based learning in STEAM clubs creates a suitable environment for understanding and awareness of various ethical problems and the possibilities for their overcoming and resolution [28].

Another motivation factor is the support. Mentoring is a key component in the process of supporting learners. This is actually the new role of teachers/lecturers changing role from being a main source of information to being a mentor leading the learning process. Gender, oppression/patriarchy, social institutions, and systemic change are all explored in the CFT

(Critical Feminist Theory) meta-synthesis review of the literature to find the answer to the question of how mentoring programs support women's occupational advancement and retention in traditionally male-dominated STEM fields [29]. So, naturally, the next task for the preparing educators is preparing in mentoring. The mentors could be from different background: teachers, university students, parents, researchers, people from industry, even AI agents.

The Collaboratory as a network of independent entities collaborating to investigate the potential of promising efforts in local STEM education. The scientific perspective inherent in a collaboratory also implies a data-driven, analytical approach to evaluating the impact of the organization itself and the impact of individual programs and projects. The Collaboratory is a good example of allowing an ecosystem to emerge organically [30]. Developing of networks and alliances is beneficial, creating networks of GEP-implementing HEIs and other research organizations is at the core of the funding that EU has provided [31].

According to our experience the variety of topics is also very important, so in NIH BG we are planning specific topics like: colors [32], light, sound/audio and their connection to bigger topics like quantum computing, blockchain, nanotechnology, etc [32].

Some very specific motivation factors for STEAM initiatives that we are using for years are those connected with emotional design, where we are doing something in order to generate, provoke positive emotions that could be joy (fun experiments), happy (successful experiment), proud (awards, public events) among teachers and students.

NIH sustainability is guarantee by establishing network the kernel of this network is the ecosystem of BioMed-Varna and entrepreneurial network of RAPIV [33] and establishing and promoting new generation collaborations, starting from experts and individuals in bottom-up approach through collaborative AI-based platforms [34].

CONCLUSION

In conclusion, it is seen that small, regional or national and global communities are already available to support STEAM careers, activities, learners, incl. people who have decided to seek a new career. A current emphasis is the search for sustainability of these networks of experts or supporting communities and the preservation of NIH after the completion of the project, which is why a dialogue is sought between active experts and communities, with the aim of cooperation. The presence of already established practices of interaction school-universities, schools-business, schools-experts, teachers-researchers, provides grounds for development. The next step is interaction between communities internetworking, including interaction between Hubs and other types of STEAM-based organizations.

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