PROGRESS IN FUSION WORKFORCE DEVELOPMENT AND EDUCATION IN EUROPE, USA, JAPAN AND ITER

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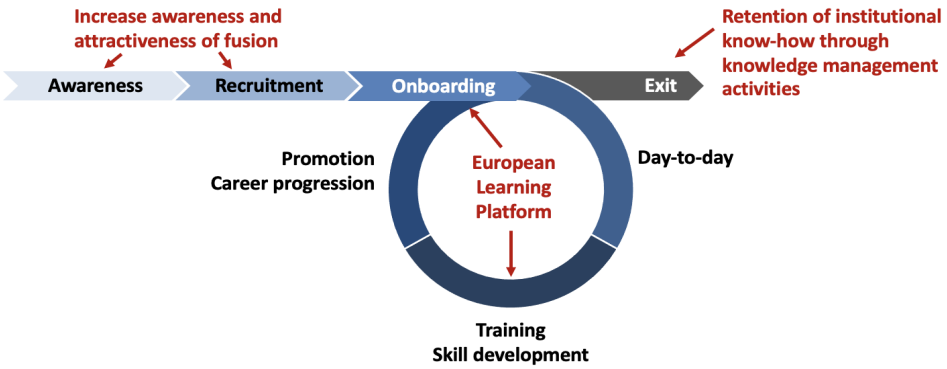
The fusion energy sector is undergoing significant growth, with substantial private investment, widespread industry involvement, and scientific breakthroughs that will require the support of a highly skilled workforce. Addressing this challenge requires a multi-faceted approach that includes expanding academic programs, developing vocational training, and strengthening knowledge retention mechanisms. In 2024, both the USA and Europe developed their respective fusion workforce development strategies [1-3]. Initiatives launched recently in the USA [1], Europe [2, 3], Japan, and ITER show the impact of coordinated strategies to attract, train, and retain fusion professionals along with a new set of dedicated activities to enhance fusion education locally and worldwide. This paper highlights the educational and training needs, recent global efforts to address them, and the impact of such efforts on strengthening the fusion workforce by ensuring that expertise, knowledge retention, and engineering capacity keep pace with the evolving demands of fusion research and technology deployment.



The expansion of **public engagement,** particularly in early STEM education, plays a critical role in inspiring and attracting the next generation of fusion scientists and engineers. UKAEA strengthened its engagement of students from primary school, secondary school, and universities using classroom visits, shows and workshops, work experiences, and structured internships. In the USA, new university partnerships and national STEM programs introduce students to fusion early. FuseNet translated educational material for classrooms into 8 European languages. Both FuseNet and ITER engaged teachers directly through dedicated events and visits, while offering an increasing repository of educational materials, books, seminars. By embedding fusion into broader STEM programs, these efforts spark early interest, expand career pathways, and ensure a steady pipeline of talent to meet the demands of a growing global fusion industry.

Strengthening **fusion education** requires attracting STEM students at undergraduate and graduate levels while addressing the faculty shortage and key gaps in access and curriculum. In many countries and regions in Europe, fusion education is limited or absent at the university level. To address this, in 2025, EUROfusion is launching the Fusion Education and Learning Hub [2] that will help bridge the gap by providing open access to recorded and live university courses, along with training materials. The UK Fusion Skills programme [3] works to mitigate faculty shortages by placing researchers as university lecturers, expanding the curriculum and their expertise. Multinational collaborations, like the ITER International School and the JT-60SA International Fusion School, offer specialised education in key engineering and operational topics. Summer programs in the USA, such as those at PPPL, MIT, and William & Mary, have generated some open-source instructional materials in fusion energy and plasma topics. However, the lack of sufficient in-depth academic fusion courses remains a significant challenge. In both the USA and Europe, efforts are underway to map fusion-related university courses and identify gaps and emerging needs [2, 5]. A well-coordinated global effort is required to expand access to existing courses and to create educational material in scarce but vital and emerging areas.

Post-graduate training programmes, internships and vocational training is critical to train young professionals in these areas. Internship programmes are widely available in the USA, UK, and in Europe where FuseNet and ITER play a vital role attracting and training students and early career professionals. Longer, excellence-based scholarships, such as the EUROfusion Engineering and Researcher Grants, offer post-graduate training in areas identified annually as high-priority to the field. Graduate and apprenticeship schemes are increasing, like those in the UK, offering hands-on technical training, and preparing engineers and technicians across diverse fusion-related disciplines. Apprenticeship programs for fusion technicians are available at national labs in the USA, such as PPPL. Vocational training however, while growing, is less widespread and will require further resources to establish.

To **preserve and transfer knowledge**, EUROfusion's Fusion Knowledge Management Framework, inspired by NASA's approach, identified four pillars: capturing knowledge in writing, expert-to-expert transfer through communities, education and training, and digital tools for accessibility [9]. The ITER Engineering Design Handbook, launched in 2024 by ITER with the support of EUROfusion, documents design decisions, lessons learned, and insights directly from engineers who designed ITER. Operational communities of practice, such as the EUROfusion-F4E ECRH network, facilitate knowledge sharing and organize joint training for new operators. Additionally, EUROfusion has organized knowledge transfer workshops in collaboration with EIROforum, F4E, ITER, IAEA, and NASA to establish best practices.

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