The First Edition of the World Nanotechnology Marathon

Shifting paradigms in teaching and learning embraced by the nanotechnology council young professionals

by Matteo B. Lodi, Santhosh Sivasubramani, José Berkenbrock, Daniela Vieira, Tory Welsch, Yi Li, and Rafal Sliz

TO SHAPE THE NEXT GENERATION of nanotechnologists and nanoscientists, especially during and post the Covid-19 pandemic, the teaching and learning paradigms for nanotechnology must change. To this aim, innovative solutions driven by digital tools and new inclusive initiatives have to be proposed. This work reports the experience of the first edition of the World Nanotechnology Marathon organized by the IEEE Nanotechnology Council Young Professionals. Throughout 24 hours, 24 nanotechnology experts inspired the new generation of nanotechnologists as well as experienced professionals in this area, paving the route to a sustainable and active network of nanotechnology young professionals around the world.

INTRODUCTION

On the 24th of November 2021, at 10.00AM in Australia, the first edition of the World Nanotechnology Marathon (WNM - https://ieeenano.org/2021/marathon) kicked off, marking the start of a 24-hour tour de force exploring research at the cutting edge of nanotechnology. Under the patronage of the former IEEE Nanotechnology Council (NTC) President, Professor James Morris, the Young Professionals (YPs) team organized and hosted this unique virtual event.

The first WNM presented an opportunity for scientists worldwide to share the most recent advances in their field and exchange innovative ideas on nanoscience and nanotechnology. Throughout a 24-hour period, 24 distinguished lecturers, nanotechnology experts, and influential scientists presented their work, giving the audience a unique insight into the process of developing new technologies, the background of their innovative research, and their hopes for the future. Over 600 participants (Figure 1a) from across the globe joined virtually the 24 speakers not just to watch presentations, but also to engage in lively discussions.

The discussion covered a wide range of nanotechnology-related topics: from physical and life science, through medicine and engineering, ending at fabrication technologies such as printing [Figure 1(b)]. The diverse geographic distribution of the speakers [Figure 1(c)] allowed an agenda with versatile topics to be divided into sessions offered around-the-clock, ensuring participants have the opportunity to join exciting sessions that would fit their schedule, regardless of time zone.

The Covid-19 pandemic imposed significant changes worldwide, and the higher education system was no exception to this, leading to the accelerated transition to remote teaching and learning. Most likely, some aspects of the transition will remain permanent and a "new normal" will be established [1]. As we proceed through these difficult times, we realize that the hybrid model of teaching will be the most suitable because it offers flexibility in terms of fulfilling the needs of students and educators. As nanotechnology relies strongly on experimental and applied sciences, the need for practical laboratory activities and interactions will remain the same. Nonetheless, at this stage virtual reality is not capable of replacing physical presence in the laboratory and practical exercises. At the same time, lecturing and knowledge dissemination can be conducted by using currently available online tools. In a hybrid model, these two teaching models can be blended and provide the best experience to both learners and teachers. Thanks to online meeting tools, students are gaining access to the top scientists and engineers, and the ability to learn from the best. This setup also reduces the financial and time commitment burdens, making it possible to effortlessly disseminate high-quality knowledge around the world, enabling access to and participation of students and individuals from underserved communities.

The aim of the WNM was to provide an effective and immediate technological knowledge transfer worldwide through all generations of scientists with a focus on YPs. In this framework, the adoption of a virtual platform as an engagement tool to reach this goal can be regarded as a valuable attempt to bring innovation and developing nanoscience education, while spreading it across the globe. Given the potential for nanotechnology to lead the next industrial revolution and change the world, there is a shared belief, that the implementation of effective and competitive educational programs for nanotechnology is lacking, and the situation calls for significant paradigm changes. Therefore, there is an urgent need for solutions. From the columns of this magazine, concerns about the awareness and need for nanotechnology safety education were raised [2]. The challenge of training the next-generation workforce in the complex, highly interdisciplinary

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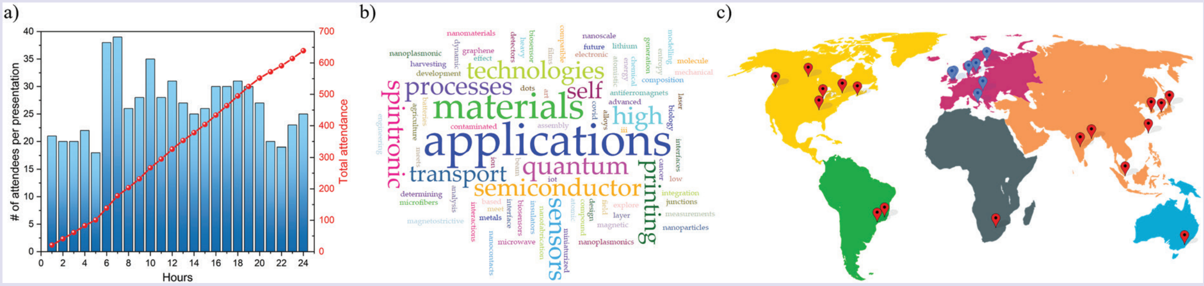

FIGURE 1 (a) Number of attendees and total attendance trend during the First Edition of the World Nanotechnology Marathon. (b) Word cloud representation of the keywords from WNM titles and abstracts (https://voyant-tools.huma-num.fr/) [9]. (c) Geographical distribution of the speakers, based on their country of affiliation.

field of nanotechnology has been faced by Purdue University, which reported implementing technical solutions, most notably the introduction of virtual learning environments (VLE) [3]. In this framework, the use of VLE solutions, such as virtual reality, is recognized as a stimulating solution for empowering both students and instructors [4], [5]. Indeed, the majority of the incoming nanotechnology workforce will belong to a generation comfortable with VLEs. In this regard, in order to enhance public engagement and outreach to a larger audience, the National Nanotechnology Initiative (NNI) invested in podcasts, Twitter, LinkedIn, and YouTube to host workshops, webinars, and share news about the nanoscale sciences [6].

To increase the awareness and need for nanotechnology education, and to reach undergraduate students and provide tools for higher education, the IEEE NTC developed and supports the TryNano portal (https://trynano.org/, Figure 2) [7]. The TryNano portal is the educational outreach site for the IEEE on all aspects regarding nanotechnology. It provides information for students, educators, and the general public to help them understand what nanotechnology is, how it impacts their lives and how they can learn more about this field. It also provides career-related information for students considering what their future career directions could be, in addition to profiles of engineers and scientists who are currently contributing to the ever-evolving landscape of nanotechnology in our world.

Given the strong need for innovative methods in nanotechnology teaching and learning, especially in the pandemic era [7], [8], and motivated by the necessity to educate the next generation of high impact nanoscientists, the NTC YPs team has focused on the organization of events with local speakers for global audiences. Since late 2020, NTC YPs team has been organizing technical webinars, virtual summer schools, and nano days, among others. These were events at the local level with distinguished speakers, aiming to give attendees the chance to gain high-quality information and discuss state-of-the-art research findings. In all webinars, YPs acted as moderators, introducing the theme and bridging the conversation with the audience. With dozens of hosted events, we learned that timely subjects attract great interest from the nanotechnology community and enthusiasts (*e.g.*, Perovskites, MXenes, photonics). Most importantly, the continuously growing number of attendees and post-event feedback surveys reaffirm the need for channels that connect researchers, educators, and learners. These activities culminated with the proposal for the first edition of the World Nanotechnology Marathon as an effective solution for engaging scientists, young researchers, and students worldwide.

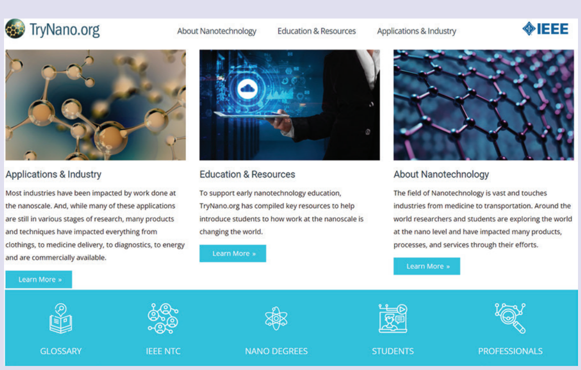

FIGURE 2 TryNano.org is the portal launched by the IEEE NTC on the emerging field of nanotechnology. It helps visitors in exploring articles, applications, graphical animations, video clips, and demonstrations about many aspects of nanotechnology.

INSPIRING NEW NANOTECHNOLOGIST GENERATIONS FOR ADVANCING HUMANITY

The first WNM embodied the interdisciplinary nature and the intrinsic ubiquitous character of nanotechnology, presenting the faceted aspects of nanoscience to a wide virtual audience. The 24 talks during the event showed the level of connection between physics, chemistry, biology, materials and engineering fields that is innate to nanotechnology, encompassing and addressing specific crucial social, economic and ethical challenges. In this framework, the first WNM has inspired YPs and students to think of using nanotechnology as a means for the benefit of humanity, also addressing several of the sustainable development goals [11], shown in Figure 3 [12].

During the first WNM, the talks dealt with emerging nanomaterials, nanomagnetics, nanomanufacturing, but also with nanobiomedicine, energy and environmental applications. For instance, the use of III-V compound semiconductor nanowires for optoelectronics [13], and the role of dynamic semiconductor junctions in mechanical energy harvesting [14] were discussed.

In regards to nanomagnetics, atomistic switch based on magnetostrictive nanocontacts for nanoelectromechanical systems (NEMS) were presented [15]. In addition, there was a discussion of the role of composition and order in determining the magnetic properties of high-entropy alloys [16]. The possibility of enabling spintronics with heavy metals, topological insulators and antiferromagnets was addressed [17], along with a perspective on the modeling and design of spintronics oscillator-based applications [18], and the state of the art and future of spintronic for microwave and THz detectors [19]. The value and potential for nanobiomedicine was demonstrated with talks about a miniaturized, high throughput platform for cancer biology research [20], and the status of MEMS and DNA nanotechnology and its challenges [21], and graphene-based technologies for biosensors, from field-effect transistors to microfiber-based devices [22]. Atomic layer neutral beam processes for nanofabrication and interface engineering [23], tetrapods-based 3-D nanomaterials for advanced technologies [24], and reactive printing, compatible with R2R processes, for the self-assembly of nanoparticles and quantum dots for photonics and COVID-19 applications [25] were introduced as innovative nanofabrication approaches. The use of nanotechnology for energy harvesting was discussed through the development of self-powered physical and chemical sensors for the next-generation Internet-of-Things (IoT) [26], as well as the integration strategies to meet low-power requirements of biosensor interfaces [27]. The WNM was populated with talks devoted to sustainability issues and environmental remediation challenges. For instance, the development of sustainable lithium-ion batteries and solid electrolytes were debated [28], [29]. The various perspectives of nanotechnology applications in agriculture were provided [30], as well as the potential of nanomaterials as a tool in the analysis and removal of pollutants from contaminated water systems [31]. In the last part of the event the speakers focused on the issues and challenges related to laser-plasma interactions in the relativistic regime [32], the development of nanoplasmonic nucleotide sensors [33], the single molecule investigation with nanoplasmonic [34], the nanoscale transport phenomena in electronic thin films [35], the value of material science for nitride optoelectronics [36], and the printing of optical materials [37]. The diversity of the topics emphasizes how monumental is the field of nanotechnology and the need for comprehensive approaches towards education of nanotechnology.

The aim of educating and training a new generation of scientists and workers in nanoscience and nanotechnology is not a trivial task.

TOWARDS A SUSTAINABLE AND ACTIVE NETWORK OF NTC YPS AROUND THE WORLD

The aim of educating and training, at all levels, a new generation of scientists and workers in nanoscience and nanotechnology is not a trivial task. Nanotechnology is currently intersecting with artificial intelligence, quantum science, 5G/6G wireless communication, biotechnology and advanced manufacturing, probably being one of the main factors leading the next industrial revolution. Due to the multidisciplinary nature of nanotechnology, and its intimate relationship with concerning socio-economic issues and implications, education and learning in this area are further complicated. To this aim, there is a need for proactive research for creating virtual information centers for the public, teachers, and industry. In this framework, several key factors must be considered, focusing on the development of undergraduate curricula, career advancement and fostering the research potential of graduate, postdoctoral, and faculty researchers. Accordingly, during the COVID-19 pandemic, the first edition of the World Nanotechnology Marathon was a virtual solution, based on a creative concept and a new educational approach that generated a noticeable interest by providing access to a large and relevant variety of topics across nanotechnology to anyone regardless of the time zone. The 24 talks, during a 24-hour period, reached hundreds of participants, ranging from undergraduates to mid-career researchers, providing unique access to the nanotechnology world.

FIGURE 3 A Set of the Sustainable Development Goals Introduced by the United Nations [12].

Given the powerful impact introduced by the first WNM, future editions will follow. While the outcome of this digital initiative undertaken by the IEEE NTC YPs was overwhelmingly positive, the WNM format can be improved by prescreening the audience to identify the most urgent and hot topics, or by structuring more interactive sessions, possibly by using more versatile online platforms and tools. We forecast that the WNM initiative could be a powerful educational resource for developing an active network and being the motivation for the young generation of nanotechnologists.

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