ARTIFICIAL INTELLIGENCE IN PHYSICS

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There is a huge wave of interest in artificial intelligence (AI). So ubiquitous has the term become that the acronym is usually no longer defined. The 2024 Nobel Prize in Physics was awarded to two scientists who are credited with laying the foundations of the field of AI, John Hopfield, a physicist at John Hopkins University, and Geoffrey Hinton, a computer scientist at the University of Toronto [1]. The citation reads "for foundational discoveries and inventions that enable machine learning with artificial neural networks".

The subject of AI is vast, and the hype is tremendous. It has built up over the last decade to a feverish pitch [2-5]. The acronym is being used broadly, even in areas that simply reflect the increasing power of more or less traditional computational tools. In this time of rapid change, I would like to address a few points that are relevant to our physics community, in particular the impact of AI on education, research, and employment. In these few pages, I can only touch on them to promote further inquiry and emphasize the urgency of staying informed and preparing for the (near) future.

Universities and high schools are scrambling to adjust to the easy access of powerful AI tools [6-8]. They are invading student study space like a tsunami. Rejecting the tools is no longer an option. In high schools, students who have laptops and tablets enjoy an unfair advantage over those who do not as they can quickly collect information with AI tools. In universities, programs across the board are facing increased workloads to maintain integrity and fairness in their evaluation processes. Institutions are working on guidelines to make AI an effective educational tool, but guidelines are not yet in place in most institutions [8]. Guidelines that apply to all courses, all disciplines and all types of institutions will be difficult to provide. The field is moving very fast, courses are very different, and professors want to preserve their academic freedom. At the moment it is up to each professor to set their own rules, but for the sake of the students, the rules have to be transparent, and each academic unit should strive to set clear rules. Social science disciplines must rethink the whole purpose of essays and term papers [9]. Theses are included in this challenge. The impact of AI is notably significant in Computer Science where the breakthroughs in AI are seen in real time with exponential progress. They raise questions about the future of the field and how future computer scientists should be trained [10]. Controlling student online access has for years been a struggle in Computer Science. The exponential growth in the AI tools will force some professors to forego computer-based evaluations and to return to pencil and paper exams, as has done Jure Leskovec, a Stanford University professor [10].

However, whatever the threats and challenges (and they are many), AI is bringing excitement back into learning and ultimately teaching [8]. Students can be taught to harness AI tools and go deeper into a

subject. Information is collected in minutes but the hard work begins then. The material needs to be organized and analyzed, relevant content selected and structured, and references checked. This can only be done if the foundations of the field are understood. Critical thinking cannot be taught in a vacuum. It is worth noting that AI provides valuable help to students with difficulty writing or formulating sentences or working in a language which is not their native tongue. AI can easily generate content from a few keywords, and this raw material becomes the basis to build a coherent work. By providing a wealth of material with just a few keystrokes, AI makes critical thinking sexy again. But we must be mindful that large language models collecting information for AI tools are not yet able to distinguish between high quality science and poor quality or fraudulent science, and this task will only become more difficult as fake science and fraudulent scientific publications fill up the internet [11].

We hear almost every day of new applications of AI in research, engineering and industry, ranging from the simple to the very complex, some are simply applications of our computer tools with on-time data regulating processes, instead of historical data which takes time to collect and input [2-4]. That is not really AI, even if the press calls it so. For instance, a few judiciously placed cameras along a busy road can feed data into a computer to optimize the timing of traffic lights based on the actual flow of cars instead of average data collected over weeks by teenagers sitting at intersections. AI algorithms use AI's unique ability to learn from data and identify complex patterns. AI can automate tasks and eliminate tedious work. It can write computer code and analyze data [5]. It increases productivity and makes modeling fun again. Applications are not without challenges such as algorithm bias, and privacy issues, but it is a powerful tool that will not cease to amaze us, and we should embrace it.

AI's strengths in automating routine tasks and providing powerful tools will revolutionize the work force. It will eliminate entry level jobs [5,12-16]. This is a societal problem, as those were the jobs where young graduates learned core skills in their profession and grew into the organization [5,14]. Employers need new tools to build a committed and integrated work force. A fundamental change in the structure of the workforce may occur. AI will revolutionize the nature of work at a pace not experienced probably since the industrial revolution. It is hard to predict how long this new age will last. Some wonder whether it is a just transitional situation. As with the move to increased online work and education, a significant permanent change is taking place, which should be faced with purpose [5].

Unemployment among new graduates across the world is increasing [12,13]. Over the years, a university degree has become less of a guarantee of employment. There is still the conviction that higher education is the right choice for good employment prospects on the long run as it provides intellectual growth and skills difficult to learn on one's own or on the job. But ultimately what matters is skills and not degrees. The employment challenges will likely accelerate with AI taking a more important role in all sectors of the economy. One comes across intriguing headlines that illustrate the rapidly changing employment landscape: "META is hiring entry-level roles that pay up to $290,000 a year and require little prior experience" [5,17]. META is still looking for the very best talent, but they select their new hires after extensive interviews. In many technological fields job candidates are subjected to grilling interviews, often multiple interviews. In AI-relevant sectors, degrees can still get you an interview but not the job. Universities are aware that the skills acquired to complete degree

requirements are not enough to prepare graduates for a successful career and they try to offer opportunities to broaden them.

The AI revolution is making it urgent to look critically at our curriculum [18,19]. It is still essential to teach the fundamentals, but the age of AI requires graduates "who are adaptable, forward thinking, ready to learn, and ready to embrace these (AI) tools in particular"[15]. We as physicists want to think that training in physics which combines problem solving skills, critical thinking, analytical tools, both experimental and computational, and an ability to quantify natural phenomena or systems of all types (including economic or financial) provides a training like none other to face the challenges of the new world. We need now to look critically at the delivery of our teaching and see how we can put the emphasis on developing skills that are important for a changing economy. And AI tools should be an integral part of this. We are better placed than most diciplines to produce graduates who can adapt to new circumstances. Our graduates, especially those with advanced degrees (MSc and PhD), do well. Many of our BSc graduates bring their skills to other disciplines, and we cannot emphasize enough the invaluable service our graduate provide if they become high school, college or CÉGEP teachers. Urgent work needs to be done in our teaching. We should not take a relaxed or complacent attitude to the situation. To finish on a revealing note which shows that there is a consensus on the issue, ChatGPT exhorts us to take on the challenge: "Universities should adapt, not resist. They should embrace AI, teach AI, govern AI, and prepare students for a world shaped by AI—while preserving the human-centered essence of higher education."

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