Integrating a Computational Perspective in Physics Education

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Demands on computing in research continue to grow. How can we integrate computing in core Physics courses in a coordinated and coherent way? Computing competence represents a central element in scientific problem solving, from basic education and research to essentially almost all advanced problems in modern societies.

I. INTRODUCTION

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A 2012 AIP survey [**?**] of 5,000 recent physics Bachelor's degree recipients indicated that 50% chose to enter the workforce immediately after receiving their degree. Of these, roughly 75% go into STEM-related fields including engineering, software development, or information technology.

Depending on sub-field, 60-80% of physics degree-holders in industry regularly need to engage in computer programming, simulation and modeling tasks. Many respondents to the survey stressed the importance of computer skills, including programming, in increasing their marketability to potential employers.

The use of computational modeling in the classroom setting provides students with insights that are complementary to those resulting from pencil-and-paper manipulation of equations.

Computing in core physics courses allows us to bring important elements of scientific methods at a much earlier stage in our students' education.

The ability to closely examine the behavior of systems that are too complex to be easily analytically tractable, or that have no analytic solutions (i.e., many systems of practical interest), helps to develop intuition that is unavailable to many students from analytic calculation.

The growth in computer power over the past decades has radically changed science and its applications. Computational modeling, using computers and programming to solve, visualize, and explain phenomena, is now an integrated and central part of research, development, and innovation. Yet, this change is sparsely reflected in most educations, even in science and engineering. Thus, there is a need to renew curricula and integrate computational modeling to ensure students are prepared for the 21st century workplace, a development that opens pedagogical challenges and opportunities. However, because the use of computational modeling is sparse, there is a near absence of research on students' use of computational modeling in education. In addition, there is a growing need for students at all lveles and across disciplines for digital skills and computational literacy. This requires the infusion of aspects of computational and computer science into educational programs at all levels. Such a transformation of the contents of our education calls for new content in teacher education, new curricula both in computing and in disciplinary subjects with integrated computing, and research-based methods for instruction at all levels. The lack of such curricula, adequately trained teachers, and the supporting education research is a significant national and international challenge. In the US, this was recently addressed in a report on Computer Science education research [**?**]. Similarly, in the European Union there is a significant focus on development of digital skills [**?**]. Both reports signal an urgent need for curricular development, professional development programs, and education research on computational methods and their integration in various disciplines.