Computational Science in Developing Countries

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This special *CiSE* issue offers comments and thoughts about computational science in developing countries. Several successful national and international initiatives concerning high-performance computing education and training are described. In addition to countries officially classified as developing, programs for underprivileged minorities in mostly developed countries are also mentioned.

There has been much discussion of "What is computational science?" in this magazine; this is indeed an important topic, and its distinction from core computer science can be confusing. For this current issue of *CiSE*, the quandary is "What is a developing country?" Since 2016, the World Bank has dropped the developed/developing distinction, so we chose as a first approximation the International Statistical Institute (ISI) list, which is based on World Bank data (www.isi-web.org/index.php/resources/developing-countries).

Decisions concerning which countries are "developed" lead to some absurdities. Countries with representatives in the June 2017 Top500 computer list (www.top500.org) include several that also feature in the developing country list and host projects described in this issue. One extreme is China, which had the top two computers in the November 2017 Top500 list but is classified as developing. The other extreme is Israel, which currently has no computers in this ranking (and has historically had very few, and never any in high positions) but is considered developed and has a highly developed hardware and software industry. Some countries officially classified as developing have average low incomes but an outstanding record of scientific research and education, for example, the Russian Federation.

An aspect related to our topic is computational science development for underprivileged minorities within otherwise developed countries. These range from township black children in South Africa to native Americans in the US and minority populations in countries such as Israel and India. Although not intentionally excluding projects concerning encouragement of women in science and engineering in both developed and developing countries, our emphasis has been on gender-neutral projects.

A seminal organization for physics in developing countries is the International Center for Theoretical Physics (ICTP; www.ictp.it) in Trieste, Italy. Funded by Nobel Prize Laureate Abdus Salam in 1964, it's played a role in the African School on Electronic Structure Methods and Applications (ASESMA) project, which is reviewed in this issue. The center is not limited to theoretical physics; its early adoption of Linux and parallel computing has supported computational advances in the developing world.

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Another ASESMA sponsor is a subcommission of the International Commission for Pure and Applied Physics (IUPAP): C13 Physics for Development, which was established in 1981 (iupap.org/commissions/c13-physics-for-development).

There has also been general engineering and high-performance computing (HPC) activity in developing countries, although most is relatively recent compared to ICTP. In the more general computational science area, the EU has sponsored projects—most notably LinkSCEEM (described in detail in this issue), which includes EU-associated countries clearly classed as developing, and RISC, which served as the initial link between several countries in South America and Europe. A current HPC continent-wide initiative has been selected for detailed discussion. (Figure 1 highlights just one of the many current activities supporting this effort.)

A complicating factor is that the criterion of per capita income used to distinguish developed/developing varies greatly within countries. The EU, US National Science Foundation, and other funding bodies have special programs for minorities. One example is the Israeli Science Ministry projects for Arab, Druse, and Circassian students, and new immigrants from Ethiopia (www.gov.il/he). Some of these require special attention due to different languages of instruction. At the Technion, we have many Arab (Christian and Muslim) as well as Druse students, many of whom wear traditional dress to class. (Figure 2 features two Technion students who are members of a minority community.)

Computational science has played an enormous role in many of the Asian "tiger" economies; countries such as Singapore and China have become leaders in this area in recent years, with both HPC centers and research activity. Some of these countries are now classified as developed and have not been emphasized in detail in this issue.

Figure 1. HPC camp organized by CSC-CONICET and the Universidad de Buenos Aires in September 2018. Students from across Latin America attended courses on HPC operations, parallel programming and advanced applications. Esteban Mocskos (standing, fourth from right) was one of the organizers.

Figure 2. Joan Adler (left) with two students from her computational physics class whose project connected Wolfgang Christian's physlet applets to the Israeli high school syllabus, with instructions for their use by high school teachers.

Two of the projects highlighted in this special *CiSE* issue encourage use of HPC, visualization, and advanced algorithms by students and researchers who have not been previously exposed to serious research or computing. It would be impossible to mention all of the computational science initiatives in only one collection of articles, and so our selection was arbitrary—with apologies to those who were not invited or exposed to our calls. Descriptions of good educational projects in computational science are welcome to be submitted to *CiSE* as regular feature articles, and we hope that this issue will encourage such submissions.

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