**Study Group on Algorithmic and Computational Thinking for MIT Undergraduates**

**Charge**

For many years, at least since the 2004-2006 Taskforce on the Undergraduate Educational Commons chaired by Prof. Robert Silbey, various MIT faculty members have asked whether, and if so how, MIT should ensure that all its undergraduates learn algorithmic reasoning and computational thinking. To answer this question, we are charging a small group of faculty to conduct an in-depth study of what the phrases “algorithmic reasoning” and “computational thinking” mean in the context of the education of MIT’s undergraduates across all five schools.

In conversation, many colleagues who have thought about this issue are clear in saying that these phrases should mean more than an introduction to programming languages. As a place to begin this study, we believe that computational thinking should encompass an intellectual framework, not just a skill. Phrases that were used in the Silbey report include “computational modes of analysis”, “algorithmic reasoning”, “data abstraction”, “designing computational solutions to theoretical and practical problems”, and “providing a computational paradigm for reasoning and problem solving.” We are asking you to do a careful, deliberative assessment of what these and other phrases (“abstraction and complexity”, “modularity and interfaces”, “complexity of algorithmic solutions”, “algorithmic paradigms”) mean across MIT.

Questions that we would ask you to examine include:

1) How do faculty, students and alumni in different fields of endeavor, across the full breadth represented by MIT’s five schools, use computational thinking? Is it an important mode of thinking in (for example) economics, policy formation, management, architecture, biology and biological engineering, chemistry and chemical engineering, and other disciplines?

2) What, if any, is the common intellectual framework that people across MIT employ when they speak of computational thinking and algorithmic reasoning? In what ways is diversity among the meanings of such phrases in different disciplinary contexts important?

3) To what extent are algorithmic reasoning and computational thinking already being taught? What fraction of our graduates, across all five schools, learn them in the course of meeting the explicit requirements of their majors? What fraction take a course that covers computational thinking even if not an explicit requirement of their majors? To what extent and in what ways do we already implicitly expect that a broad spectrum of MIT undergraduates across many majors understand algorithmic and computational thinking by the time they graduate from MIT? When in their career at MIT do we expect students to learn computational thinking?

4) Should we acknowledge algorithmic and computational thinking as an explicit expectation of all our graduates? If yes, what is the rationale/case for this?

5) If yes, what are the key elements of algorithmic and computational thinking and what are the associated learning objectives and measurable outcomes for knowledge, skills and attitudes? How are they common across the broad spectrum of MIT undergraduates, and how do they differ? Across MIT, how are they relevant to solving problems and mastering endeavors?

6) If yes, does it matter when during their careers at MIT our students are exposed to computational thinking and algorithmic reasoning? What benefits would accrue from a uniform approach to teaching them and what might the downsides be? What benefits would accrue from discipline-specific approaches and what might the downsides be?

7) What are our peer institutions doing? Are there possible models outside MIT that merit our consideration?

As you start to formulate your answers to the questions above, we would ask that you develop a list of possible options for accomplishing the goals for the computational education of MIT undergraduates that you articulate, if these goals are not already being met. Please describe each such option as concretely as you can, including pros and cons, including which goals among those you articulate each option addresses, and including actionable next steps. Examples of options that you might consider include:

i) Modules, with or without online components, that could be incorporated within MIT's existing GIR subjects.
ii) New subjects or modules with no prerequisites, ranging in duration from one month to one semester, whose development and teaching may involve collaboration among departments and other academic units.
iii) A model for teaching computational thinking along the lines of how CI-M subjects teach communication, where each major can make discipline-specific choices for how to achieve overarching MIT-wide goals that you have articulated, via more advanced subjects or modules designed for students in the specific major.

The first two are examples of options where next steps would include curriculum development. For such options, we hope that you will provide preliminary examples of partial syllabi, with explanations of your rationales for the elements in these syllabi, and a sense of the (groups of) colleagues who might be asked to develop the curricula. That is, these are examples of options that we would hope you develop to the point that the next step could be Dean Freeman pulling together people and resources for implementation. The third is an example of an option where your study might prompt some departments to initiate next steps, perhaps with support from Dean Freeman. All are examples of options where the next steps would include consideration by a broader group of faculty, including relevant faculty committees.

We are convinced that a deep study as described above is a key step toward evaluating whether or not changes to MIT's undergraduate curriculum and pedagogy are merited. Depending on your findings, your study may provide the foundation for subsequent advances in how we educate our students. We are asking you to focus on questions as above and on options with near-term actionable next steps. We hope that the answers that your study provides, together with any subsequent curriculum development that it prompts, will serve as valuable input to any future discussion of our GIRs.

We would ask that you set as your goal that by June 30, 2016 you have completed the majority of your work and reported your progress and your emerging conclusions to us, so that by that date we have a full understanding of what remains for you to do, and a firm late-summer or early September deadline for your report.

Sincerely,

Prof. Dennis Freeman
Dean for Undergraduate Education

Prof. Krishna Rajagopal
Chair of the MIT Faculty

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Membership:

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