

Principles and Processes

The Task Force

The CS2023 task force consisted of a Steering Committee of 17 members and a committee for each of the 17 knowledge areas. In all, the task force consisted of 94 members from 17 countries.

The Steering Committee

The ACM and IEEE-Computer Society each appointed a co-chair. The rest of the Steering Committee consisted of three members nominated by IEEE-CS co-chair, two members nominated by AAAI, one member nominated by the ACM Committee for Computing Education in Community Colleges (CCECC) and the remaining nine members selected through interviews in April 2021 from among the educators who nominated themselves in response to a Call for Participation posted to multiple ACM Special Interest Group (SIG) mailing lists. The requirements for the Steering Committee members were that they were subject experts willing to work on a volunteer basis, willing to commit to at least ten hours a month to CS2023 activities, willing to commit to attending at least two in-person meetings a year; and were aligned with the CS2023 vision of both revising the CS2013 knowledge model and producing an appropriate competency model.

Knowledge Area Committees

In June 2021, each Steering Committee member took charge of a knowledge area and assembled a committee of 5 to 10 subject experts drawn from: 1) individuals who had nominated themselves in response to the Call for Participation posted to ACM SIG mailing lists; 2) industry experts; and 3) other Steering Committee members who shared interest in the knowledge area. Knowledge Area committee members met monthly to discuss curricular revisions. While the revision effort was in progress, additional subject experts who expressed interest in volunteering were added to the committees.

Guiding Principles for the Process

The guiding principles for the CS2023 curricular revision process were the following.

- **Collaboration:** Each knowledge area was revised by a committee of experts.
- **Diversity:** At every level of activity (Steering Committee, knowledge area committees, knowledge area reviewers, survey participants), participation was solicited and obtained from academia and industry, from different types of academic institutions, and from all over the world.
- **Data-driven:** Data was collected through surveys of academics and industry practitioners to inform the work of the task force.
- **Community outreach:** The work of the task force was presented at multiple conferences including the annual SGCSE Technical Symposium every year. Its work was publicized through regular postings to over a dozen ACM Special Interest Group (SIG) mailing lists.

- **Community input:** Multiple channels were provided for the community to contribute, including feedback forms and email addresses for knowledge areas and for earlier versions of the curricular guidelines.
- **Continuous review and revision:** Each version of the curricular draft was anonymously reviewed by multiple outside experts. Revision reports were produced to document how the reviews were addressed in subsequent versions of the drafts.
- **Transparency:** The work of CS2023 was documented for review and comments by the community on the cshed.acm.org website. Available information included composition of knowledge area committees, results of surveys, and the process used to form the task force.

The Process

The objectives of documenting the process are several.

- Knowledge of the process informs interpretation of the product.
- Future curricular revisions can benefit from knowledge of the process, particularly how the process can be improved to produce better curricular guidelines.
- Curricular guidelines are a community effort. Documenting the process helps the community understand how it has contributed to the effort and how it can have a greater voice in curricular design going forward.

The overall curricular revision process was as follows.

- In 2021, surveys were conducted of the current use of CS2013 curricular guidelines and the importance of various components of curricula. The surveys were filled out by 212 educators in the United States, 215 educators from abroad and 865 industry respondents. The summaries of the surveys were incorporated.
- In May 2022, Version Alpha of the curricular guidelines was released. It contained a revised version of the CS2013 knowledge model. It was publicized internationally, and feedback was solicited. The draft of each knowledge area was sent out to reviewers suggested by the knowledge area committee. Their reviews were incorporated into the subsequent version of the curricular draft. In September-November 2022, a survey of the mathematical requirements of computer science was filled out by 597 educators.
- In March 2023, Version Beta of the curricular guidelines was released. It contained a preliminary competency model. This draft was again sent out to reviewers suggested by the knowledge area committee as well as educators who had nominated themselves through online forms. Their reviews were incorporated into the subsequent version of the curricular draft. In all, 99 reviewers from 18 countries were involved in the two review cycles.
- Over July and August of 2023, 182 educators from 30 countries filled out 70 surveys on the list of core topics. One hundred and ten educators filled out a survey of the characteristics of graduates and 65 educators filled out a survey of the challenges for computer science programs.
- In August 2023, Version Gamma of the curricular guidelines was posted online for a final round of comments and suggestions. It contained course and curricular packaging information, core topics and hours, a framework for identifying tasks to build a competency model and summaries of articles on curricular practices.

- The report was finalized in January 2024 and copy-edited in March 2024.

This process is illustrated in Figure 1.

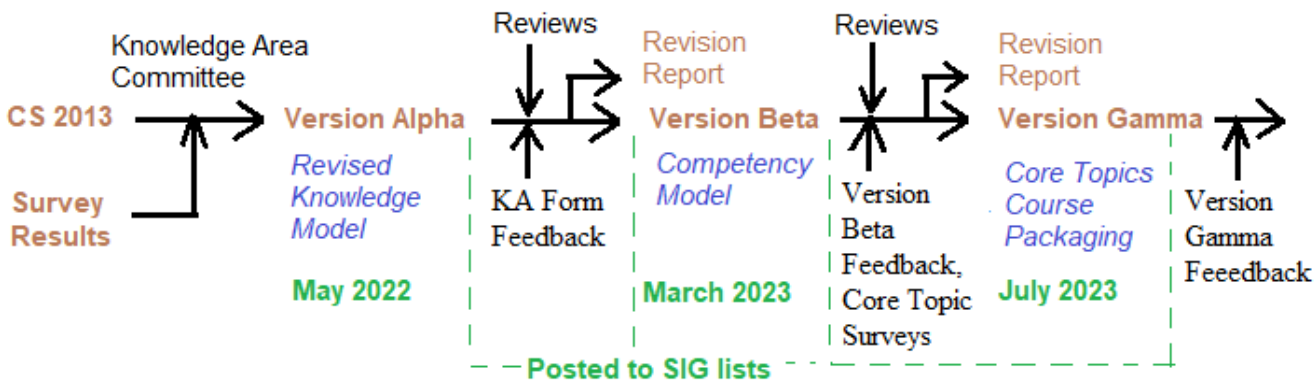


Figure 1. CS2023 Curricular revision process

Guiding Concerns for the Curricular Recommendations

The concerns guiding the CS2023 curricular recommendations are the following.

- Computer Science is a rapidly changing discipline. The curriculum should be designed to prepare graduates to not only keep up, but also thrive in the discipline.
In CS2023, emerging areas have been introduced (e.g., quantum computing) or expanded (e.g., machine learning). Self-directed learning has been listed as a characteristic of graduates.
- One size does not fit all with computer science curricula. A curriculum must be responsive to the needs of its students and the industries that hire them.
In CS2023, programs are offered the flexibility to select the knowledge areas on which they want to focus. When the knowledge areas are coherently chosen, they define the **competency area(s)** of the program. This design caters to a variety of institutions, department sizes, and student populations.
- Computer Science is rapidly growing as a discipline. A curriculum that covers everything that could be considered computer science would be too onerous with limited broad-based utility.
In CS2023, the size of CS Core, i.e., the topics that all graduates must know, has been reduced so that programs will have more room to specialize in the competency area(s) of their choice. Programs are encouraged to go beyond CS Core topics to include as many KA Core topics and Non-core topics as possible. But the lack of coverage of any non-CS Core topic should be interpreted as a choice of focus, not lack of value.
- Computer science is more than the sum of the 17 knowledge areas specified by CS2023. The connections between these knowledge areas are important. A curriculum should help students mature as computer science practitioners by helping them make lateral connections among the knowledge areas.

In CS2023, “See also” annotations have been inserted throughout the Body of Knowledge to help educators make connections for their students between knowledge areas.

- Given the pervasiveness of computing applications in every walk of life, a curriculum must address issues of society, ethics, and the profession as integrally and widely as possible. Dealing with these issues is integral to the **whole solution** to a problem that every graduate must be prepared to deliver.

In CS2023, these issues have been specified in the Society, Ethics, and the Profession (SEP) knowledge area. In addition, SEP topics specific to other knowledge areas have been specified in separate knowledge units within those knowledge areas.

- A curriculum should strive to educate the **whole person**. In computer science, this includes creating opportunities for students to develop professional dispositions (often called soft skills) valued in the workplace.

In CS2023, the professional dispositions most relevant for each knowledge area have been identified.

- The application of mathematics has increased in computer science. At the same time, mathematics should not be the reason why otherwise well-qualified students are kept away from computer science.

In CS2023, mathematical needs have been individually identified for each knowledge area. This gives students the flexibility to negotiate a curriculum based on their level of mathematical maturity. It also provides educators the option to cover the necessary mathematics as part of a computer science course, thereby foregoing mathematics prerequisites that may pose barriers for wider participation of students.

- Computer science is at an inflection point with the advent of generative AI. Given that generative AI is only about a year old in its current form and its capabilities are expected to increase rapidly in the near future, it is too early to predict the effects of generative AI on computer science education.

In CS2023, a speculative exercise was conducted on the implications of generative AI for the various knowledge areas. The results are to be treated as thought exercises, not predictions. A curricular practice article on the implications of generative AI for introductory programming has also been included.

The Knowledge Model Revision Process

Each knowledge area was reviewed and revised by a committee of experts who met regularly and invited contributors who provided input as needed. The committee used CS2013 as the starting point. For each knowledge area, a form was posted on the csed.acm.org website that could be used by the computer science education community to provide targeted feedback. A presentation at the SIGCSE Technical Symposium in Providence, RI, USA in March 2022 was used to publicize the CS2023 effort and invite the community to contribute.

Version Alpha draft was released in May 2022. The draft was posted on the csed.acm.org website.

- The computer science education community was invited to provide feedback through postings on the mailing lists of over a dozen ACM Special Interest Groups (SIGs) including SIGPLAN, SIGOPS, SIGMOBILE, SIGCHI, SIGCAS, SIGCSE, SIGARCH, SIGAI, PODC, SIGACCESS, SIGCSEIRE, UK-SIGCSE, and SIGGRAPH in May 2022 and again in September 2022.

- The draft was sent out for anonymous review to outside experts suggested by the committee as shown in Table 1.

The committee incorporated the feedback from the community and the reviewers to produce Version Beta. It also produced a revision report documenting how it had addressed the comments and suggestions of the community and the reviewers. Both Version Beta draft and knowledge area revision reports were posted on the website.

Version Beta draft was released in March 2023. Educators were invited to nominate themselves to review it.

- The computer science education community was again invited to provide feedback through postings on the SIG mailing lists mentioned earlier in March 2023. The draft was also publicized at the SIGCSE Technical Symposium in Toronto, Canada in March 2023.
- The draft was sent out for anonymous review to additional outside experts suggested by the committee as well as qualified self-nominated educators as shown in Table 1.

Again, the committee incorporated the feedback from the community and the reviewers to produce **Version Gamma** in August 2023. It also produced a Version Beta revision report. Both Version Gamma draft and Version Beta revision report were posted on the website. Their availability was publicized through postings on the SIG mailing lists mentioned earlier in September 2023. Subsequent feedback received from the community was incorporated to produce the final version of the report.

Table 1 lists the number of formal reviews solicited and received for each knowledge area on its Version Alpha and Beta drafts. The formal reviewers, both invited and self-nominated, have been listed in the Acknowledgments section at the end of this report. Note that Table 1 does not include statistics about informal feedback provided by the community to various drafts.

Knowledge Area	Version Alpha		Version Beta		
	Invited	Reviewed	Invited	Self-Nominated	Reviewed
Artificial Intelligence (AI)	1		10		2
Algorithmic Foundations (AL)	6	3	9	5	5
Architecture and Organization (AR)	15	1		3	2
Data Management (DM)	10	2		2	2
Foundations of Programming Languages (FPL)	10	3	16	4	4
Graphics and Interactive Techniques (GIT)	3	3	3		3
Human-Computer Interaction (HCI)	9	3	15	2	2
Mathematics & Statistical Foundations (MSF)			15		4
Networking and Communication (NC)	9	1	10	3	4
Operating Systems (OS)	7	3	6	1	2

Parallel and Distributed Computing (PDC)	4	4		1	1
Software Development Fundamentals (SDF)	4	2	10	2	8
Software Engineering (SE)	4	3	10	1	4
Security (SEC)			6	2	3
Society, Ethics, and the Profession (SEP)	8		7	1	3
Systems Fundamentals (SF)	5	1	5	2	2
Specialized Platform Development (SPD)	9	3	8		

Table 1. The number of formal reviews solicited and received for each knowledge area.

CS Core and KA Core topics were identified by knowledge area committees and instructional hours needed to cover the topics were estimated as follows.

1. Tier 1 and Tier 2 topics from CS2013 were reallocated into CS Core and KA core topics. Some CS2013 core topics were dropped, and others were newly added, in CS2023.
2. The skill level recommended for each core topic was identified, as listed in *Core Topics Table* in Section 3. Based on the skill level, the instructional hours needed to cover each topic were estimated.
3. Seventy surveys were conducted covering all the CS Core topics. In the surveys, for each CS Core topic, respondents were asked whether every computer science graduate must know the topic and if so, the skill level at which they must know the topic. The surveys were filled out by 182 computer science educators. The results of the surveys were used to revise the list of CS Core topics in each knowledge area.
4. Finally, core topics and hours shared between knowledge areas were identified and documented.