

Computing Impacts and Ethics in the CSTA Standards: A Synthesis of Expert Perspectives

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Recommendation Map

Table 1 overviews the 17 key recommendations (listed in shorthand) in relation to standard topic areas. This table serves as a reference map that shows at-a-glance the standard topic areas that each key recommendation is most applicable to.

Table 1. Crosswalk of key recommendations by standard topic areas

	Cross-Cutting	ALG 	PRO 	SAS 	DAA 	CAS 	Specialty Standards
1 Political Courage	✓						
2 Forgo Techno-solutionism	✓					✓	
3 Ethical Frameworks		✓	✓	✓	✓	✓	
4 Harms, Power & Systems		✓	✓	✓	✓	✓	
5 Environmental Impacts		✓	✓	✓	✓	✓	✓
6 Expansive Historical View						✓	
7 Prosocial & Justice Examples						✓	
8 Reimagining Future						✓	
9 Critical Design Practices	✓	✓	✓		✓	✓	✓
10 Voice, Reimagining & Refusal	✓			✓	✓	✓	
11 Critical Data Practices		✓	✓	✓	✓		✓
12 Expansive Career Exploration						✓	
13 Terms & Examples	✓	✓	✓	✓	✓	✓	✓
14 Cross-band strategy		✓	✓	✓	✓		
15 Raise the Ceiling		✓	✓		✓	✓	✓
16 Relationality	✓			✓	✓	✓	
17 Amp Up Specialty Standards							✓

Recommendation Tables

1. Embrace political courage in taking a clear, uncompromising stance on computing impacts and ethics

Overview: A broad recommendation from the expert reviewers related to embracing political courage in the process of standards development. While acknowledging that pragmatism will be necessary to ensure the standards will be adopted in the context of a highly politicized educational landscape, they saw the risks of 'watering down' the standards to be much greater, on numerous fronts, than those associated with taking a clear stance on what students should learn vis-à-vis CS impacts and ethics.
Related topics/subtopics: Cross-cutting
High level suggestions 1.1 Aim for standards that act as a highest, not lowest, common denominator around impacts and ethics in computing. In that CSTA Standards have, as a primary aim, guiding educational institutions in ensuring that all students have access to the same high-quality computing education experiences, regardless of the politics of their state, the standards should act as a "highest common denominator", taking a clear and well articulated perspective on impacts and ethics in CS education. 1.2 'Thread the political needle' through deliberation and empowerment. It is not only politically viable, but potentially preferable from a pedagogical standpoint, to take a stance on CS impacts and ethics in the standards that (1) launches (rather than closes off) collective inquiry for learners, (2) shares the multiplicity of conceptions of ethics, harms, and benefits for consideration and discussion, while at the same time, (3) not giving equal merit to all perspectives.

2. Tone down implicit techno-optimism/techno-solutionism present in parts of the standards

Overview: While the standards draft effectively balanced computing's potential harms and positive potential in most places, experts noted that some parts of the standards, and in particular, the Computing and Society topic area, felt heavily skewed towards techno-utopian, techno-optimistic, and/or techno-solutionist perspectives, as opposed to what one expert called "techno-realist" approaches.	
Related topics/subtopics: CAS-HS, CAS-ET, CAS-CE, History of Computing front matter	
High level suggestions 2.1 Revise techno-solutionist/optimist language to be more critical of the historical purpose, impacts, and evolution of computing technology. 2.2 Consider adopting a guiding frame of "techno-realism": a type of critical hope, where computing maintains its imaginative potential and possibilities but with the understanding that for it to be used in justice-centered ways requires careful thought and deliberate action across technology design, deployment, use,	Targeted suggestions 2.5 Pay close attention to and edit techno-optimism/techno-solutionism language in the early grade band standards. 2.6 E4-CAS-HC-01, MS-CAS-HC-01, and History of Computing front matter on P12: Revisit and revise language that centrally

and disposal. 2.3 Balance presenting the potential harms associated with computing with the way that the positive contributions of computing are currently being highlighted in the standards document. 2.4 Consider where and how to introduce opportunities for students to actively consider both what problems computing is well positioned to address, vs those that it is not.	frames creation of computing technology as "evolving" in response to societal need. 2.7 Consider adding standards in the Emerging Technology and/or History of Computing subtopics that speak to both exploring the varied motivations behind technological development, and the tradeoffs associated with rapid technological change.
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3. Evaluating Social Impacts through Multiple Clearly Defined Ethical Frameworks

Overview: The standards sometimes have an implicit bias toward presenting ethics through a utilitarian framework, which might be downplayed to promote more pluralism in the ethical frameworks that the document presents. It is less important for the standards to <i>tell</i> teachers and students what ethical frameworks should be used for what social issues or topics than to present multiple frameworks that teachers and learners can use to evaluate such an issue or topic. Teachers and learners should have an understanding of what different frameworks get them for addressing social issues and problems (i.e., their limitations and affordances).	
Topics/subtopics: Cross-cutting; SAS-IM; DAA-IM; ALG-IM; PRO-DH; CAS-HC; CAS-ET; CAS-CE	
High level suggestions 3.1 The term ethics has multiple meanings and uses within the document and thus the meaning or meanings of the term should be clarified with more precise and intentional language. 3.2 No one ethical framework should dominate the standards document at an implicit or explicit level. Instead multiple ethical frameworks like consequentialism, deontological ethics, and virtue-ethics, but also justice-centered ethics, pragmatist ethics, ethics of care, and indigenous inspired ethics should be included. 3.3 Attend to the implicit presence of the ethical framework of "utilitarianism"—that what's "good" is what's good for the most people—in the standards as it came through in discussions of ethics without ever being mentioned explicitly. This should be avoided as it undermines the desire for pluralism in engaging with ethical issues and frameworks. 3.4 Make ethics and ethical issues concrete by connecting them to the personal and collective lives of teachers and learners, helping them make connections to micro- and macro-ethical issues by showing why ethics is important not only in their designs, uses, and disposal of technologies but in their everyday lives.	Targeted suggestions 3.5 E-1-SAS-IM-03, E3-SAS-IM-04, MS-SAS-IM-12, HS-SAS-IM-11, E4-ALG-IM-04, E4-DAA-IM-04, E5-DAA-IM-04, MS-DAA-IM-14, HS-DAA-IM-15, HS-DAA-IM-17, MS-ALG-IM-08, HS-ALG-IM-11, E5-CAS-HC-01, S-ALG-IM-11, HS-CAS-HC-02, E3-CAS-ET-02, MS-CAS-ET-04, HS-CAS-ET-07, HS-CAS-ET-09: Could ethical frameworks or the evaluation of specific issues through multiple ethical frameworks be incorporated, to varying degrees and in different ways, into one or more of the following standards. 3.6 "Impacts and Ethics": Expand the concept of "Impacts and Ethics" to "Impacts, Values, and Ethics", highlighting the central role that values play in mediating between ethics and impacts (e.g. centering a value of profit maximization over a value of minimizing harms)." 3.7 E5-SAS-IM-04, E5-ALG-IM-04, HS-ALG-IM-11, E1-CAS-HC-01: Could respect for ethical pluralism be supported

4. Broaden the ways students are invited to understand computational harms and how they come about

Overview: The experts appreciated how the standards capture, as one stated, "multiple nuanced dimensions of ethics and societal impacts that the current standards do not." At the same time, they noted how sometimes the standards tend to frame benefits and harms as results of individual decision-making in ways that obscure issues of power, marginality, institutional structures (e.g., state and corporate), and the uncertain outcomes of any individual or collective action for diverse stakeholders. They suggested that the language of the standards not only point to individual decision-making but also to how policies, laws, and regulations shape technological devices and interactions in ways that, when considering diverse stakeholders, cannot be reduced to just positive or negative outcomes.

Topics/subtopics: ALG-IM; SAS-IM; SAS-SC; DAA-IM; PRO-DH; PRO-PD; CAS-HC; CAS-ET; CAS-CE

High level suggestions

4.1 Consider representing harms at multiple scales so that responsibility for their mitigation does not fall on individuals alone.

4.2 Consider more content on harms and their mitigation at the level of institutions, policies, and laws. Given that there are harms being done with and by technologies that go beyond any individual, some reviewers made suggestions about putting more emphasis on political and legal solutions to harms.

4.3 Include families, communities, ecosystems, and professional sectors when reflecting on computing impacts specifically so that students gain perspective on collective and systemic forms of computing impacts. This could work well for younger students who are often thinking in terms of family and community in their daily lives.

4.4 Consider sharing other examples of controlling technology development, ethics, and impacts beyond "laws" mentioned in the current draft. This connects to the notion of moving beyond individuals.

4.5 Consider how the standards might attend to how the harms and benefits of technology are unevenly distributed within society, requiring not only attention to historical context but also political, economic, and sociological ones.

4.6 Consider how the standards might try to show socio-technical complexity in language, moving

Targeted suggestions

4.7 E5-SAS-SC-03: Maybe clarify what "other harms" means in this context.

4.8 HS-ALG-IM-11; HS-PRO-PD-07; HS-ALG-HD-06; HS-PRO-PM-16, pillars of Impacts & Ethics, and ALG-IM: Much like with E4-CAS-ET-02 and MS-CAS-HC-03, consider coupling language around unintentional harms with language around intentional harms in these areas.

4.9 E1-SAS-IM-03: Consider how to include benefits and harms arising from multiple scales, not just "an individual's use".

4.10 E1-SAS-IM-04: Consider how to include benefits and harms arising from multiple scales, not just an "individual's life." Could "human connection" could include "and disconnection" or "human connection and alienation."

4.11 MS-SAS-IM: Consider adding a standard along the lines of *"Explain how computing systems contribute to disparate benefits and harms to groups positioned differently in society."*

4.12 MS-PRO-PD-10: Consider rephrasing so that "harms" and "negative social impacts" do not read as redundant.

4.13 E1-CAS-ET-02: Consider including scales beyond individual and family (e.g., community, neighborhood, city, etc.)

4.14 ALG-HD: Consider adding a standard along the lines of *"Consider what is gained and what is lost when humans solve a problem using a technological solution. Examine*

beyond the reproduction of outcomes along a strict positive or negative binary.

the social, political, and economic roots of the problem. Does human-centered technology address those issues?"

5. Addressing computing's environmental impacts (beyond a focus on humans)

Overview: Reviewers believed that the language and focus on computing's environmental impacts and harms could be taken further. Relatedly, one reviewer noted it may be worth reflecting on the human-centric focus of the standards. They suggested expanding them to include how computing impacts more-than-humans on the planet.

Topics/subtopics: ALG; ALG-HD; ALG-IM; PRO; PRO-DH; CAS; CAS-ET; CAS-CE; DAA; DAA-DP; DAA-IM; SAS; SAS-IM; DSC; AIN

High level suggestions

- 5.1** Add explicit description of the tech sector's unique role in contributing to environmental harm (e.g., in Systems and Security, Impacts of Computing Systems or Computing and Society, History of Computing).
- 5.2** Add explicit language such as "environmental harm" and "environmental destruction" to emphasize the severity of the problem.
- 5.3** Add explicit language to emphasize the range and mechanisms of environmental harms, including terms like the "mining of materials," "disposal of materials," "carbon release," "water usage," "light pollution," "noise pollution," etc.
- 5.4** Add clarification that technology advancements alone cannot fix the environmental harms of computing technology.
- 5.5** Since human-centered design tends to ignore non-human-centered impacts, consider adding an explicit standard related to "non-human-centered design."

Targeted suggestions

- 5.6 Cross-cutting:** Highlight "environmental" alongside "social" when calling out "social impacts" throughout the standards document.
- 5.7 E4-SAS-IM-04:** High-level suggestions to the left could apply to current environment-focused standards such as Analyze the impacts of widely used computing systems and networks on ecosystems and the environment in terms of "harm" language or explicit environmental harms.
- 5.8 Data and Analysis & Impacts of Data Science:** Consider adding information about environmental impacts of data processing.

6. Portray a more nuanced and expansive historical perspective in the History of Computing subtopic

Overview: Noting that computing's history can be an important site of learning foundational ways that sociotechnical systems unfold in society, experts shared a number of suggestions to both nuance and expand how students might learn in this subtopic. This included highlighting the contingent, uncertain, and unpredictable nature of technological change, exploring competing narratives of socio-technical progress (or lack thereof), and acknowledging deeper, more expansive roots of computing historically.

Topics/subtopics: CAS-HC	
High level suggestions	Targeted suggestions
6.1 Highlight the contingent, uncertain, and unpredictable nature of technological change in the subtopic standards 6.2 Explore competing narratives of technological progress in the subtopic standards 6.3 Expand beyond Western histories of computing	6.4 History of Computing: Consider adding a standard focused on exploring competing narratives of progress, with the following as suggested language: <i>"Compare and contrast distinct social narratives related to computational technologies in terms of how they emerged and have been contested across various historical contexts and groups with attention to issues of power, marginalization, and access."</i> 6.5 History of Computing: Consider editing the History of Computing frontmatter to acknowledge non-Western roots of computing historically.

7. Elevate pro-social, generative, and justice-oriented uses of computing in society

Overview: While reviewers shared that there was sometimes a bent towards the kind of techno-optimism noted above, at least one reviewer saw it as important to elevate positive, justice-oriented, and non-traditional examples of pro-social computing that are not confined to workplaces and the dominant technology sector. In doing so, standards related to ethics and impacts would not simply be, as they put it, "the voice of no" (i.e., "don't do this", "reject that", "just critique things"), but also elevating a vision of computing oriented toward human (and non-human) flourishing.	
Topics/subtopics: CAS-HS; CAS-ET; CAS-CE	
High level suggestions	Targeted suggestions
7.1 Encourage exploration of exemplary, imaginative, and unique positive efforts related to computing that do not emerge from "big tech" discourses and spaces in the Computing and Society topic area (e.g., the Open Source movement, projects like Wikipedia, Lilypad Arduino, tech worker cooperatives, and others).	7.2 Emerging Technologies: Revise front matter related to "Emerging Technologies" in ways that both acknowledge ethical challenges and dilemmas, but also highlight justice-oriented uses of technology. One possible re-phrasing could be: <i>"In middle grades, students explore how computational thinking drives innovation across industries. They examine the ways that innovators have used computing to support issues such as environmental sustainability and human rights, and they examine the ethical challenges other industrial professionals may encounter."</i>

8. Center possibilities for reimagining the future of computing within Emerging Technologies

Overview: Acknowledging the forward-looking nature of the Emerging Technologies subtopic, more could be done to encourage practices of speculating and reimagining the directions of technology and computing in ways that center ethics and social impacts.
Topics/subtopics: CAS-ET

High level suggestions	Targeted suggestions
8.1 Explicitly add or revise standards within the Emerging Technology subtopic to encourage students to engage in speculation and reimagining around the place of computing in society in ways that promote social goods and prevent harms.	8.2 E5-CAS-ET-02: One possible standard that might be revised to include such practices of reimagining and speculation is: <i>"E5-CAS-ET-02: Analyze the limitations of existing technologies and how emerging technologies change the way people work, behave, and communicate."</i>

9. Tighter Coupling of Technical and Critical Inquiry with Design Practices

Overview: While the standards do a nice job of highlighting ways to think about ethics and social impacts of computing technologies <u>after</u> they have been created and are used in the world, more is needed to support student learning about how to directly incorporate ethical practices and consider social impacts <u>within computing design processes themselves</u>. The standards would benefit from creating a tighter coupling of technical and critical inquiry with design practices.	
Topics/subtopics: Cross-cutting, DAA, CAS, PRO, ALG, Specialty Standards; MS-DAA-IM, MS-CAS-ET, MS-PRO-PD, S2-AIN, S1-SWD / S2-SWD, S1-PHY / S2-PHY, S1-GMD / S2-GMD, S1-XCS / S2-XCS, HS-DAA-IM	
High level suggestions	Targeted suggestions
9.1 Integrate ethics and social impacts throughout the design process. 9.2 Focus on ethics and social impacts as design activities, not just as discussion topics. 9.3 Clarify for students how values shape design decisions. 9.4 Integrate ethics and social impacts throughout the non-impacts subtopics (which the impacts subtopics build on and offer opportunities to dig deeper into) 9.5 Incorporate student engagement in empirical critical inquiry related to algorithmic harms in the standards, which can be named in the standards as	9.7 Impacts of algorithms & Programming fundamentals: Couple ethics topics with technical topics more specifically by connecting "impacts of algorithms" to "programming fundamentals," for example, since their current separation suggests that they are unrelated topics. In another example, the "impacts of algorithms" and "human-centered design" areas have students focus on ethical/societal issues, but the "problem-solving" subtopic focuses on efficiency and accuracy only. 9.8 The Algorithms and Design - Human-Centered Design subtopic: This subtopic puts <i>"the emphasis on accommodating the needs and requirements of users. It would be great to also include a broader conception of stakeholders (going beyond users) whose needs/interests/desires should be part of the design process."</i> 9.9 Consider all of the following specific language/edits/additions in the named standards sections below: - 9.9.1 Data & Analysis - Impacts of Data Science - Grades 6-8: <i>"Create data sheets that document the motivation, composition, collection process, and recommended uses of datasets."</i> - 9.9.2 Computing and Society - Emerging Technologies - Grades 6-8: <i>"Evaluate when it is appropriate to use emerging technologies (e.g., AI) to solve a problem, taking into account technical, ethical and environmental considerations."</i> - 9.9.3 Programming - Program Development—Grades 6-8: <i>"Consider potential ethical issues prior to developing a program."</i> - 9.9.4 Artificial Intelligence - Specialty II: <i>"Create data sheets that document the motivation, composition, collection process, recommended uses of datasets."</i> - 9.9.5 Software development: <i>"Conduct user testing sessions to evaluate if the software serves the needs of users."</i>

specific computing and technical activities such as algorithmic audits, red-teaming, external evaluations, analysis of system documentation, etc. 9.6 Embed ethics topics into technical practices in the standards without isolating concepts across domains.	- 9.9.6 Software development: <i>"Critique the values behind software used in everyday life and its societal implications."</i> - 9.9.7 Physical computing: <i>"Consider ethical issues (e.g., surveillance, privacy, consent) of collecting data from users with sensors and microcontrollers."</i> - 9.9.8 Games and Interactive Media: <i>"Discuss the values embedded in the design of games and interactive media and their ethical implications."</i> - 9.9.9 CS+X: <i>"Consider the ethics and possible limitations of incorporating computer science in a non-CS discipline."</i> - 9.9.10 Data & Analysis - Impacts of Data Science - Grades 9-11: <i>"Empirically investigate potentially harmful behaviors of AI systems through audits or external evaluations."</i> - 9.9.11 Artificial Intelligence - Specialty II: <i>"Empirically investigate potentially harmful behaviors in AI systems through external evaluations or audits."</i>
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10. Encourage civic practices—voice, reimagining, and refusal—that respond to impacts of computing at individual and collective levels

Overview: Reviewers saw a need to better support students in learning how to respond, with agency, after gaining awareness related to impacts of computing. They pointed to various civic and community-oriented practices that could be incorporated into the standards related to voice and advocacy, refusal, and reimagining of computing futures that would better position students as agentic actors in computing.	
Topics/subtopics: Crosscutting, CAS-CE, CAS-ET, CAS-HS, SAS-IM, DAA-IM, DAA-DI	
High level suggestions 10.1 More directly incorporate practices of engaging in voice and advocacy, resistance, or collective action around computing, in relation to state actors and regulation, to industry to promote design changes, and to cultural practices to promote shifts in norms around computing. 10.2 Incorporate or revise standards to promote creative expression (e.g. digital storytelling, podcasts, visual art, video essays, or other narrative forms) as possibilities for student engagement in public dialogue around the impacts of computing. 10.3 More directly incorporate standards that support students	Targeted suggestions 10.5 Career Exploration Subtopic: Consider edits to the Career Exploration subtopic that encourage students to explore the ways that workers in and outside of the tech sector are engaged in collective action in relation to in response to issues of automation, surveillance, or development of technological systems that are counter to their values. 10.6 Career Exploration Subtopic: Consider revisions to Career Exploration subtopic to incorporate practices of reimagining and speculation. 10.7 Impacts of Computing Systems subtopic: Consider integrating or adding to the High School standards for the Impacts of Computer Systems subtopic opportunities for students to not only debate, evaluate, and investigate social impacts, but to also construct "artifacts including stories, art, podcasts, videos, games, etc. that share their representations and ideas" 10.8 MS-DAA-IM-14: Building off of MS-DAA-IM-14 - consider a high school standard that emphasizes agency along the lines of "what can they do now that they know that their decisions can lead to biased data, misleading conclusions & compromised AI models." 10.9 HS-DAA-IM-18: Consider revising Data Science standard

to consider or engage in practices of refusal—either as designer, user, or both—of computing technologies that they see as counter to their values. 10.4 Incorporate opportunities in the standards for students to engage in practices of speculation and reimagining of computing and associated social futures.	HS-DAA-IM-18, which currently emphasizes "writing plans" for data investigations, to include possibilities for students to create a story or media artifact for their community that illustrates the ethical dimensions of a data issue. 10.10 HS-DAA-DI-14: Consider revising already strong Data Science synthesis activity in HS-DAA-DI-14 to, as one reviewer put it, "<i>expand beyond formal reports to include oral presentations to diverse audiences including community members, school leaders, policy makers</i>", with the intention to "<i>have students take seriously the question of audience and usability of their data investigations.</i>"
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11. Include more Content on Practices that Support the Critical Evaluation of Data as Value-Laden

Overview: Many experts advocated for a greater emphasis on the value-ladenness of data through more language about data practices, data collection and ownership, the inherent politics of any data set, and data manipulation in and beyond storytelling. These suggestions would help to provide more nuanced understandings about how data are always partial representations of the world.	
Topics/subtopics: DAA-DF; DAA-DP; DAA-DI; DAA-IM; ALG-AF; PRO-DH; PRO-PF; PRO-DH; PRO-PD; SAS-CS; SAS-HW; SAS-NW; SAS-SC; SAS-IM; CYB-FC; CYB-NT; CYB-EC; SWD-PD; SWD-DH; AIN-CD; PHY-SD; DSC-DM; DSC-DS; DSC-AV; DSC-EL; DSC-PM; DSC-T; XCS-XC; GMD-TR; XCS-XC	
High level suggestions 11.1 Consider explaining how data are always partial, situated, and an approximation to the social and physical world that they are supposed to represent, and avoid the idea that data should be treated as neutral or value-free. 11.2 Consider including content on practices for how data are manipulated. This can include verifying if data sets are relevant, complete, and consistent, while also discussing how to present data to different audiences in ways that are transparent and meaningful.	Targeted suggestions 11.6 EK-SAS-SC-02, E4-DAA-DF-01, MS-DAA-DF-04, E4-DAA-IM-04: Could content about data ownership, privacy and sovereignty be part of one or more of these standards? 11.7 MS-SAS-CS-08 & HS-SAS-SC-7-10: Consider including content on the role of industry and the state in limiting and regulating physical harms and intentional harms. 11.8 MS-SAS-IM: consider adding content in terms of use and agreement such as "<i>Examine how users consent to their data being collected by computing systems.</i>" 11.9 EK-DAA-DF-01, MS-DAA-IM-13-15, HS-DAA-IM-15-18, & S2-DSC-AP-16: Given that data don't speak for themselves, can content around representation or presentation be included in one or more of these standards ? 11.10 E3-DAA-DF-02, 11.13 MS-DAA-DF-02, S1-DSC-PM-10, S2-DSC-EL-20: Could language about the inherent partiality of data sets and models be added to one or more of these standards? 11.11 MS-DAA-DF-01: consider adding content about surveillance and privacy.

11.3 Consider how storytelling (either creating narratives or critically evaluating narratives) is one way (or one practice) for teachers and learners to think about how data are partial and situated, presented differently to different audiences. 11.4 Consider placing a larger emphasis on data ownership and privacy at individual and collective levels to help teachers and learners understand how data are analyzed and presented. This would help them understand how to advocate for themselves and the communities they are part of when data is collected on them and how to secure ownership over their data. 11.5 Consider emphasizing the importance of industry regulations on data use in design, research, and development so that teachers and learners have a sense about what laws, policies, and regulations currently exist around data and how they might be involved in shaping them. The move here is for the standards to point to the responsibility of industry, universities, and the state to ensure ethical data collection, store and use.	11.12 MS-DAA-DF-03: consider putting qualitative and quantitative data into conversation or convergence? Could storytelling be one way? With an acknowledgement of its limitations? How might students consider questions of the audience here? 11.13 HS-DAA-DF-01: How might questions about the limitations of nominal, ordinal, discrete, and continuous data be included. 11.14 MS-DAA-DP-0 and HS-DAA-DP-05-09: Could some of these standards include something about the relationship between data manipulation and partial representations of the world? 11.15 HS-DAA-DI-14: consider revising to add <i>"justify which data you included and excluded and why that was ethical (or potentially unethical)"</i> 11.16 DAA-DI: consider adding a grades 6-8 standard "Explain how data approximates natural and social phenomena in the world, often in ways that introduce bias" and a grades 9-12 standard "Analyze data definitions for how accuracy and bias [result]." 11.17 EK-DAA-DI-03 & E1-DAA-DI-03: Could stories be paired with patterns in these standards (e.g., "Patterns and stories" or "patterns and narratives")? 11.18 E3-DAA-DI-04 & E4-DAA-DI-03: Is evolve the right word here? How might an emphasis on industry design choices and state policies make human agency more central here? 11.19 E5-DAA-DI-02, MS-DAA-DI-08, & HS-DAA-DI-13: Could "partiality" be paired with variability here (e.g., "variability & partiality")? 11.20 MS-DAA-DI-10, MS-DAA-DI-12, & S1-DSC-DM-02: Could content about storytelling, audience and representation help to support the purpose and goals of these standards? 11.21 E2-DAA-IM-04 & E3-DAA-IM-04: Could "analysis" and "presentation" or "representation" be paired with "collection here (e.g., Data collection, analysis, and representation approaches)"? For 04, might storytelling be included? 11.22 E5-DAA-IM-04: "Real-world scenarios" is too vague, should it be "...using data to make decisions about how technology affects immediate social issues"?
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12. Portray a more nuanced, expansive conception of Careers and 'Real World' Application of CS

Overview: While acknowledging that the Career Exploration subtopic goes beyond a traditional "explore tech careers" orientation, experts saw possibilities for both expanding the scope of this subtopic as well as to acknowledge and address important dynamics related to computing in professional life.

Topics/subtopics: CAS-CE

High level suggestions	Targeted suggestions
12.1 Support student examination of how computing careers in for-profit, not-for-profit, and government vary. 12.2 Explore “real world” applications of CS that go beyond professional life, including civic and community engagement and personal expression and creativity. 12.3 Acknowledge and support exploration of issues of diversity and identity-safety within tech-related careers. 12.4 Consider incorporating complex shifts in labor conditions related to automation and surveillance within the Career Exploration subtopic. 12.5 In the “Emerging Technologies” section, consider mentioning how new tools are shaping work, values, and expertise across all fields (particularly for high school standards and the “Career Explorations” section).	12.6 Career Exploration subtopic: Add a standard in the high school grade band exploring careers in varied sectors. This might be phrased as: <i>“Examine how computing careers in for-profit, not-for-profit, and government vary.”</i> 12.7 HS-CAS-CE-10 and HS-CAS-CE-11: Consider revising these standards to support “real world” applications of CS that go beyond professional life. 12.8 MS-CAS-CE-09: Consider revising this standard (“Examine how changes in technology can create new jobs or change how people work.”) to incorporate concerns related to automation and surveillance.

13. Clarification and Consistency of Vocabulary and Key Terms

Overview: Expert reviewers commented on the important role that the CSTA Standards will ultimately play in K12 education systems as a North Star for what computing teaching and learning should involve at its best. This also means that the document may serve a pedagogical purpose, introducing many new ideas to its readers. Therefore, experts offered specific suggestions for maximizing readers’ understanding and use of the standards document, particularly in relation to consistency and clarity of vocabulary and terms.	
Topics/subtopics: Cross-cutting; Pillars; SAS - HS; DAA-IM; ALG-HD; ALG-IM; PRO-PD; PRO-TR; PRO-PM; CAS-HC; CAS-ET; CAS-CE; AIN; PHY; GMD; CYB	
High level suggestions	Targeted suggestions
13.1 - Address inconsistent use of language and lack of clarity around terminology throughout the standards. 13.2 - Incorporate the “5 equity frames” outlined in the NASEM report on “Equity in K12 STEM Education” to help readers understand the multifaceted nature of “equity” and its meaning for the purposes of interpreting the CSTA Standards (see explanation below). 13.3 - Clarify (in definition and use) that there are different forms of bias that relate to computing ethics and social impacts. For example, make the distinction between “data bias” (as a scientific term) and implicit or explicit bias (as factors that cause it). 13.4 - Consider adding examples throughout the document, using The New York State CS and Digital Fluency Standards as a model.	13.5 Cross-cutting: Add a glossary/menu of key terms and definitions with brief parenthetical examples. 13.6 Cross-cutting: This glossary/menu could include different conceptualizations of ethics and harms, as well as explanations of “intended consequences” that are ethical/unethical alongside “unintended consequences” language in the standards. This latter point is particularly relevant to the “Algorithms and Design” section. 13.7 Cross-cutting: Check for consistent use of terminology and combinations of terms (e.g., “fairness, transparency, and accountability” versus “equity, access, and the ethical” versus “ethical, legal, and social implications” etc.). Consider checking for this consistency from the Pillars to other areas of the standards document. 13.8 Cross-cutting: Some terms are emphasized in “Computing and Society” but others in the “Impacts” sections without a clear explanation of the difference or connections between these two areas.

14. Ensure Cross-Band Vertical Progressions of Ethics and Impacts-Related Content

Overview: Whereas the Standards provide ample opportunities for students to work with technical concepts at a fundamental level in the early grades and then refine and build upon these in the later grades, the opportunities for similar learning progressions of ethics and impacts related content were not as consistent or frequent.	
Topics/subtopics: PRO; ALG-IM; DAA-IM; DAA-DI; SAS-IM	
High level suggestion 14.1 - Develop and apply a cross-band integration strategy for learning progressions of ethics and impacts-related content that scale up vertically.	Targeted suggestions 14.2 MS-ALG-IM-09: Add a more complex version of this standard into the high school standards. 14.3 EK-DAA-DI-02: Build on this standard in grades 6-8 and 9-12 at a more sophisticated level of analysis to ensure students understand the limitations of data-driven modes of inquiry and the affordances of non-empirical modes of inquiry. 14.4 DAA-IM: Consider building more complexity for upper grades around the ideas about privacy and data protection that are introduced in earlier grades, including a description of tradeoffs with other goods and values. 14.5 DAA-IM: The 5th grade standard here could perhaps go deeper with the 1st-4th grade standards, rather than introducing the new task of being able to analyze the risks and benefits of AI. 14.6 SAS-IM and PRO: Revisit these (sub)topics to check for unclear or arbitrary learning progressions.

15. Raise the Ceiling for PreK-5 Engagement with Impacts and Ethics-Related Content

Overview: Although there were several standards that invited PreK-5 students to grapple with the complexities of the social impacts of computing, many reviewers advocated for more consistent opportunities for complex inquiry across PreK-5 standards, especially in places that framed technology as unequivocally beneficial, that reserved compelling topics such as data bias for later grades, or that precluded PreK-5 altogether (e.g. Program Development). Relatedly, experts identified various standards where the inquiry was overly complex, either because it was overmatched to students' developmental capabilities or it was too dense to fit into a single standard.	
Topics/subtopics: DAA-IM; ALG-HD; ALG-IM; PRO-PD; PRO-TR; PRO-PD; CAS-HC; CYB; AIN	
High level suggestions	Targeted suggestions 15.4 DAA-IM: Consider introducing the concept of "data bias" at the late elementary level.

15.1 Support PreK-5 students to grapple with the complexity of the social impacts of computing in an age-appropriate way by: (1) situating the social impacts of computing in students' lived contexts, and (2) providing tools and building blocks to extend students' reasoning to social impacts they are less familiar with. 15.2 Integrate appropriate topics in upper grade standards that do not appear in PreK-5 such as group decision-making and data bias. 15.3 Consider engaging tools and activities from the Philosophy for Children Movement to support PreK-5 conversations about ethics and social impacts (see below).	15.5 ALG-HD: Consider introducing concepts such as fairness, accessibility, and inclusiveness, in the context of human-centered design, in the younger grade bands rather than wait for this to be introduced only in later grades. 15.6 EK-ALG-HD-02: Consider editing this standard to include harms or problems of technology. 15.7 PRO-TR: Add more to the story of computing that reflects the nuance of that history, context, and historical accuracy. 15.8 PRO-PD: PreK-5 standards could be added for prototyping and planning projects using unplugged methods or plugged platforms such as Scratch and Scratch Jr. Further, the social impacts of using platforms to share computational projects could be highlighted to introduce concepts such as "open source" in the context of how sharing projects for others to use, remix, and learn from benefits the community overall. 15.9 MS-CAS-HC-03: Consider building this standard into earlier grades rather than waiting until older grade bands. 15.10 EK-CAS-HC-01: Consider making this standard more tractable for students - instead of thinking about changes in technology over the last 50 years, students could draw on their experiences with their guardians' older technologies for example. 15.11 E5-DAA-IM-04; MS-CAS-HC-02, S2-CYB-NT-19: Revisit and check for issues of overmatching. Provide examples, if possible, to MS-CAS-HC-02 to show what this kind of analysis could look like at the 6-8 grade level. 15.12 HS-DAA-IM-16, HS-DAA-IM-15, S1-AIN-HE-07, HS-ALG-HD-06, MS-ALG-IM-08, HS-ALG-IM-11: consider breaking out these standards into multiple standards. For example MS-ALG-IM-08 could be <i>"broken out into something like:</i> <i>-Describe common societal impacts, ethical issues, and biases of algorithms.</i> <i>-Analyze the properties of an algorithm that might lead to negative social impacts and ethical issues including bias.</i>
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16. Integrate Real-World Examples and Personal Connections More Cohesively Across the Grade-Bands

Overview: Experts advocated to build on the exploration of real-world examples in the current draft (there are some initial examples of this in PreK-5) to support personal connections in later grades as well, alongside the given opportunities for analyzing social impacts of computing at larger scales.	
Topics/subtopics: Cross-Cutting; SAS-IM; SAS-NW; DAA-IM; CAS-HC	
High level suggestions	Targeted suggestions

16.1 Standards at later grade bands that focus on larger scales of impact should be coupled with standards that offer personal connections. 16.2 Multiple strategies can be used to offer personal connections in the standards by positioning students as: (1) producers of computing technologies; (2) as aspirants to a flourishing life whose aims can be helped or hindered by technology; (3) as participants in increasingly digitized personal routines and cultural practices; (4) as decision-makers who use data to stay informed; and (5) as observers of the way technology has changed within their own lifetimes. 16.3 Consider topics that lend themselves to analysis of social impacts at personal and larger scales such as the attention economy of social media, self-quantification/tracking of physical and mental health, the remixing of media.	16.4 SAS-IM: For this standard, consider adding more about students' own impacts, values, and priorities as producers of computing technology, not just consumers. 16.5 E3-SAS-IM-04: Consider adding standards in the middle and upper grades about how technology use both helps and hinders our ability to live a flourishing life while building meaningful relationships. 16.6 DAA-IM: Consider making more explicit how students' own personal data are captured, stored, processed, sold, etc. and other ways to connect to the personal and cultural experiences of students with these specific topics and competencies. 16.7 DAA-IM frontmatter: Consider building this idea of data-informed decision-making for early grades into standards for older grades, specifically around engaging in algorithmic audits and questioning algorithmic outputs. 16.8 ALG frontmatter: Consider editing the text so that it reads: "In early grades, students learn about age-appropriate algorithms from the real world. As they progress, students continue exploring real world examples to learn the development, combination, and decomposition of algorithms, the evaluation of competing algorithms, and the difference between traditional algorithms and artificial intelligence/machine learning algorithms." 16.9 CAS-HC: Consider having students discuss how computing technologies have changed in their own lifetimes.
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17. Represent Ethics and Impacts in Specialty Standards More Comprehensively

Overview: Reviewers appreciated the opportunities provided in the Specialty Standards for students to engage in ethics-related content, especially in the sub-areas of <i>Data Science</i> and <i>Cybersecurity</i>. Reviewers advocated for such opportunities to be consistently provided throughout the Specialty Standards. Additionally, reviewers offered multiple ways to broaden the analysis of ethics in the <i>Cybersecurity</i> section.	
Topics/subtopics: SWD, CYB, AIN, PHY, DSC, GMD, XCS	
High level suggestions 17.1 Build on and dig deeper into the ethical issues of the Cybersecurity and Data Science Specialty Standards.	Targeted suggestions 17.3 CYB: Consider adding examples of how cybersecurity can protect individuals and communities (not just industry and government) since a focus on good business practices has proven insufficient in the field. 17.4 CYB: Consider including "<i>more politically sensitive topics such as national security, definitions of citizenship and adversaries, immigration, and the weaponization of data</i>"

17.2 Integrate Ethics and Social Impacts into other Specialty Standards (see **Recommendation 9** for additional examples that tightly couple technical design practices with critical inquiry)

17.5 CYB: Consider including how AI and computing systems are related to warfare and the military.

17.6 DSC: Place explicit attention on the politics of classification (as visible in racial categories, for example).

17.7 SWD: Expand the focus beyond analyses of efficiency to be inclusive of analyses of ethical and responsible use.

17.8 S1-SWD-PD-02: Consider *"highlight[ing] accessibility standards/best practices here."*

17.9 S2-AIN-HE-15: Consider adding more issues *"such as environmental harms, labor exploitation, and others issues that illuminate the political economy of AI/GenAI"*

17.10 S2-AIN-CD-10: Consider including *"language relating to the limitations of machine perception systems (systematic biases in recognizing people) and the dangers of misuse of those systems (surveillance)."*