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

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An Amplifying Social Impacts of Computing Standards (ASICS) initiative report

UCLA Telos Learning Michigan State University CSTA

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Executive Summary

Introduction

The relationship between computing and society has deepened and evolved in dramatic ways since the CSTA K12 computer science standards were released in 2016. There is greater widespread acknowledgement of how the social and the technical are always already intertwined, and a more robust set of practices, both professional and civic in their nature, associated with responsible and critical computing. In line with these shifts, CS educators have made powerful strides in conceptualizing what it can look like to use this knowledge to educate all students to pursue a wide array of future pathways in, with, and, importantly, in response to computing.

The perspectives in this report have been gathered from 16 experts that have been at the forefront of this work exploring the place of impacts and ethics in CS education. Collected and synthesized by the Amplifying Social Impacts of Computing Standards (ASICS) project in response to the standards writers' desire for concrete feedback, the recommendations that follow are offered as a guide to how the standards might be revised and improved in ways that these experts believed would not only meet our collective moment, but maintain relevance and applicability into the next decade.

Overview of Expert Recommendations

First and foremost, the experts shared a great deal of praise in terms of how deeply this draft engaged with issues of CS impacts and ethics (see "Praise" section). As one reviewer put it,

> *"There is lots to admire here, but I have been asked to provide a critique, so my comments here are all negative. But in reality, the authors need to also be congratulated on their outstanding achievement as well!!".*

They noted how much of an improvement the draft was on the existing standards, with far greater representation of impacts and ethics issues across topic areas both in terms of integration with technical standards as well as through elevation in dedicated subtopics. In many ways, the recommendations they shared can be seen as encouragement to "stick the landing", so to speak—to keep going, effectively deepening and sharpening the directions present in the current draft as the writers move towards a final one.

A high level overview of these recommendations, shared below, aims to provide a map through which to understand the more detailed suggestions offered throughout the report. We group our recommendations into four areas:

- Root in a Coherent Vision of Computing Impacts and Ethics (7 recommendations)
- Aim for Consistent Application of this Vision Across the Standards (5 recommendations)
- Elevate student agency through applied ethical and critical practices (4 recommendations)
- Embrace political courage in taking a clear, uncompromising stance on computing impacts and ethics (1 recommendation)

Root in a Coherent Vision of Computing Impacts and Ethics

The experts noted how deeply issues related to impacts and ethics were incorporated into the draft standards, but shared some limitations when it came to how cohesive the underlying perspective was as it related to these issues. In some cases experts highlighted ways this lack of central cohesion could send mixed and possibly contradictory signals. In others, they commented on how to extend and deepen certain ways of thinking about impacts and ethics in computing that were present in some, but not all places in the standards. As one expert put it, the standards should have "a clear north star" in terms of how to think about computing impacts and ethics that can guide choices about what should be prioritized when it comes to what students should know and be able to do.

In relation to these issues of cohesive vision, they more specifically encouraged that the next version of the standards should:

- **Forgo common sociotechnical myths.** The experts argued that techno-solutionism and techno-determinism were overrepresented in some areas of the draft standards (see **Recommendation 2**). Experts voiced that these viewpoints are at odds with current understandings of how the social is always technical and the technical is always social, which encourages a more nuanced view. They also noted places where such a nuanced view, for example the contingent and unpredictable nature of technological development, might be elevated (see **Recommendation 6**).
- **Center an expansive view of computational harms and how they come about**. If there was one thing that the experts felt should be unequivocal in the standards, it was supporting students to develop a dynamic understanding of the nature of computational harms and what leads to them. This included moving beyond a focus on individuals as both sources and recipients of harms, more directly addressing the role of power and marginalization in the context of computing in society (**Recommendation 4**), and consistently and clearly highlighting environmental impacts (**Recommendation 5**)
- **Foreground ethical pluralism**. There was an acknowledgement that there are many ways to understand what is right and good, and that different standpoints can lead to different actions and outcomes in relation to computing (see **Recommendation 3**). Related to this is the suggestion to remove language that implicitly favors a utilitarian ethical standpoint—that what's good is what's good for the most people—which has been heavily critiqued for its various limitations, and represents an elevation of a particular ethical standpoint over others.

- **Portray possibilities for computing that support human flourishing**. In avoiding either extreme of an unbridled (and uncritical) techno-optimism and a techno-pessimism that simply takes a stance of persistent rejection or negativity, experts saw possibilities for promoting student exploration of both historical examples of exemplary, imaginative, and justice-promoting positive efforts related to computing (**Recommendation 7**) as well as engagement in positive reimagining of computing futures (**Recommendations 8** and **10**).

Taken together, these recommendations aim towards a coherent vision of computing impacts and ethics that: (1) does not reproduce common, inaccurate, and often harmful ideologies often tied to the tech sector (by forgoing sociotechnical myths); (2) centers an understanding of computing as it actually plays out in society (by deep exploration of harms and their sources); (3) does not push one perspective on what's "ethical", but rather supports exploration of what "ethical" can mean in relationship to human values (by encouraging ethical pluralism); and (4) still, in the context of the above, aims to inspire a grounded positivity in relation to computing (by centering imaginative possibilities for flourishing).

This vision might be summed up as someone saying:

> *"I don't buy what uncritical techno-optimists say—I know that computing has real, and sometimes harmful, impacts, and I understand where those come from. And I know that there's not one 'right answer' to what it means to do computing responsibly, but I've thought through what different perspectives might be on that front, and what kinds of choices they lead to. And, while I think about computing with all of that in mind, I can see, and work to imagine, ways that computing might promote a better world."*

Aim for Consistent Application of this Vision Across the Standards

Whether the standards writers choose to adopt, adapt, or remix the vision of computing impacts and ethics offered above, or articulate something distinct from it altogether, the expert reviewers encouraged that a clear vision be applied *consistently* throughout the standards. They highlighted three ways to think about consistency, sharing that the next iteration of the standards should:

- **Be consistent and clear in use of language and terminology related to impacts and ethics.** Noting that many important terms, or combinations of terms, seemed to vary in their application (e.g., "fairness, transparency, and accountability" versus "equity, access, and the ethical" versus "ethical, legal, and social implications" etc.), experts encouraged a thorough review to ensure that key terms were being used intentionally throughout, and suggested that a glossary of such terms could encourage clarity on this front (**Recommendation 13**). They noted, in particular, the ways that the term "ethics" and "ethical" seemed to be used in varying ways that could lead to confusion (**Recommendation 3**).
- **Be consistent and developmentally appropriate in how impacts and ethics are represented across grade bands.** While noting that in many places there was strong gradeband progression vis-à-vis impacts and ethics in the draft, there were a number of places where such vertical progression could be improved (**Recommendation 14**). Relatedly, they pointed to issues of developmental appropriateness, highlighting

instances of both 'undermatching' (not aiming high enough) and 'overmatching' (aiming perhaps too high) when it came to what students at different ages are able to do (**Recommendation 15**). Finally, they pointed to ways to make connections to student interests, goals, and identities more consistent throughout the gradebands (**Recommendation 16**).

- **Be consistent in how impacts and ethics are represented across topic areas and specialty standards.** Finally, while praising the overall integration of impacts and ethics issues across the different topic areas, experts did note that there was less consistency in some areas, especially pointing out the specialty standards in this regard and noting integration opportunities (**Recommendation 17**).

Importantly, addressing these issues of consistency should be tied to aligning to a larger, coherent vision related to computing impacts and ethics—the aforementioned "clear north star". Essentially, these revisions should only be made *after* a coherent vision is agreed on, making clear what, exactly, is acting as an anchor for this consistency.

Elevate student agency through applied ethical and critical practices

A third area of recommendations related to the content of the standards focused on what reviewers saw as a tendency to have ethical and critical practices sitting in a vacuum, so to speak. Impacts and ethics related standards often aim to engage students in "analyzing", "describing", "arguing", practices that are certainly important in terms of coming to understanding. However, they highlighted a notable gap in terms of supporting an *applied approach* to impacts and ethics, one that could elevate students' agency both in the context of practicing ethical or responsible design, as well as in the context of being agentic citizens and community members in relation to computing. In short, they wanted to see the standards not just encourage 'critical thinking' but also 'critical doing' in relation to computing ethics and impacts. Experts highlighted four ways to address this, sharing that the next iteration of the standards should:

- **More tightly couple technical and critical inquiry into design practices**. Experts pointed to the reality that responsible or ethical computing should be applied directly throughout the design process—"before a system or application is designed, while a system is being designed, and after a system is deployed", as one expert put it. They recommended specific practices, such as algorithmic audits, external evaluations, threat modeling, red-teaming, and others that would support more robust approaches to responsible computing design (**Recommendation 9**).
- **Support critical evaluation of data as value-laden.** While there were a number of issues raised by experts in terms of better supporting student understanding of the relationship between data and impacts of computing (not all of them focusing directly on applied practices), experts encouraged more concrete engagements with critical data practices that could help elucidate issues like data bias and the politics of classification, data ownership and sovereignty, and bad-faith data manipulation (**Recommendation 11**).
- **Encourage civic practices—voice, reimagining, and refusal—that respond to impacts of computing at individual and collective levels.** Students may come to understand various risks, harms, or complex social implications associated with computing, but what do they do after they come into this knowledge? Experts pointed to various "after the

fact" 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 (**Recommendations 10** and **8**). A focus on these practices positions students not just as future technology designers who act responsibly, but also as community members and engaged citizens who can respond to the ways computing is playing out in the society they're a part of.

- **Portray a more nuanced and expansive conception of Career Exploration and "Real World" Application of CS**. While there were a number of suggestions related to the revision of the Career Exploration subtopic (see **Recommendation 12**), central among them was a desire to highlight more varied futures in terms of what students might do with computing. This included exploring and contrasting what computing work might look like across different sectors (especially those with actively pro-social orientations), as well as non-work applications of computing in areas such as creative expression, civic engagement, and community participation.

Taken together, these recommendations that focus on elevating student agency through applied practices imply a vision of education around CS impacts and ethics that positions students as both responsible designers as well as engaged citizens and community members. Incorporating these suggestions would, we believe, address the aspiration and question: How can we support K12 students to understand, analyze, critique, design, and reimagine the technologies that shape everyday lives?

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

A final, overarching recommendation (**Recommendation 1**) 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.

In particular, they pointed out the following when it came to the importance of taking a clear stance:

- Standards creators should assume "watering down" by downstream actors in the education system and as such the standards should act as "highest common denominator" and a strong signal to the field.
- There is a moral cost of self-censorship in that it would represent compromising on core values held by the writers, CSTA as an organization, and the field of CS education writ large.
- In that the standards effectively serve as a distillation of the purposes of K12 CS education, if they do not effectively address issues of impacts and ethics in computing, it invites the question of what are, in fact, the purposes of the standards, and of the field in general.

- Limiting, or, at worse, erasing, issues of CS impacts and ethics has real world consequences, and can lead to harms being perpetuated in the long term.
- There is no such thing as a neutral position, and watering down or attempting to sidestep naming issues that might be construed as politically sensitive is itself a political stance.
- A lack of clarity around CS impacts and ethics will make it difficult for what is likely a majority of educators that actively *do* want to address these issues in their computer science classrooms to do so effectively.

With all of that said, many experts saw it as 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. Essentially, some questioned the premise that there is a necessary tradeoff between political expediency and effectively addressing impacts and ethics topics in CS education. We believe that the vision offered at the start of this overview could offer direction for what such an approach might look like.

Structure of the report

In what follows, details about the process by which expert feedback was collected as well as the content of that feedback are shared. More specifically the report sections include: 1) a "Methods" chapter describing the background and context of the larger ASICS initiative and how feedback on the ethics and social impacts aspects of the CSTA standards draft was solicited from an expert panel; 2) the overall positive reactions experts had for this standards draft, detailing specific features to maintain and continue building upon in the next draft of the standards; 3) a "Map" providing a quick overview of the 17 key recommendations as well as the specific standard topic areas they most apply to; and 4) a detailed description of all recommendations, their implications for both high-level and targeted edits, and statements from experts motivating those recommendations.

Methods

Context and participants

The Amplifying Social Impacts of Computing Standards (ASICS) initiative, funded by the Kapor Foundation, has partnered with CSTA with a goal of improving the ways that ethics and social impacts of computing are represented in the CSTA standards that are currently being revised. Perspectives from experts that have considered and studied these issues are essential to ensuring that they are addressed effectively in the standards. Thus, during the spring of 2025, while the standards were being written, 16 experts on the ethics and social impacts of computing were contacted and gathered to provide feedback on the 2.0 draft of the CSTA standards. While all the experts had contributed to CS education research, curricula, and professional development for K12 teachers, they represented a range of disciplines including but not limited to: computer science, engineering, Science and Technology Studies, information sciences, political science, ethnic studies, philosophy, educational technology, and the learning sciences.

Expert review process

The 16 expert reviewers were provided with Draft 2.0 of the CSTA "Revised PreK-12 Computer Science Standards" and a set of directions for how to review them and provide feedback in a way that would be useful for the standards writers. The ASICS team asked the reviewers to consider three questions while working on their reviews, though the reviewers were encouraged to not constrain themselves or their feedback to just answering these questions. These questions included:

1. What ethics and social impacts content doesn't receive enough emphasis in the current draft? What can be changed to address these gaps?

2. What do you see as strengths of the standards draft in terms of how it incorporates issues of ethics and social impacts of computing?

3. What are the weaknesses or things missing that you have suggestions for changing, editing, addressing?

In answering these questions and providing feedback more generally, we asked the reviewers to help create four deliverables. As we will detail below, these deliverables were treated as data for analysis and synthesis by the ASICS team. The purpose of the analysis was to make the feedback useful for the standards writers during their July 2025 summer meeting.

Data collection: reviewer feedback

The 16 experts provided feedback in four ways: 1) written reviews; 2) in-line comments on the draft 2.0 of the standards themselves; 3) a short likert-type and open-ended survey; and 4) focus group discussions about the reviews.

Each expert reviewer read the 2.0 draft and wrote a narrative review that sought to answer the questions above and comment on them based on their own disciplinary background and expertise. Each full review was no more than 2000 words long to aid the ASICS team in synthesizing and analyzing the feedback. In addition to the full review, each expert reviewer was asked to write a short 350 word abstract that summarized their main points. The abstracts would later be shared with the other expert reviewers and used as a means for prompting discussions during the focus groups.

In addition to the full reviews and abstracts, each expert reviewer was asked to use a comment function to make in-line comments on the 2.0 standards draft itself. The purpose of these in-line comments were to offer standards writers with granular feedback on specific parts of the document and even specific standards themselves. While many of these comments were conceptual, linking up to the written reviews, some focused on word choices and formatting.

After completing the written reviews and in-line comments, the expert reviewers were asked to complete a survey comprised of four likert-type items that were each followed by an open-ended prompt (i.e., In brief, please explain your answer.) where individuals could clarify their likert score. The likert-type items were scored on a four-point scale, where 1=strongly disagree and 4=strongly agree. The four items were designed to elicit opinions from the expert reviewers on topics that came up during the March 2025 standards writers meeting, from the ASICS literature review, and the standards themselves:

1. The CSTA K-12 Standards should put “a thumb on the scale”, taking an explicit standpoint on what counts as "ethical", or as “harms” or “benefits” vis-à-vis computing in society.
2. The CSTA K-12 Standards should explicitly have students learn about different ethical standpoints or frameworks (e.g. consequentialism, pragmatism, indigenous ethics, justice-based ethics).
3. The CSTA K-12 Standards should have a balance between students understanding the social harms related to computing, on the one hand, and the social benefits of computing on the other.
4. The articulation of CSTA K-12 standards focused on ethics and social impacts of computing should prioritize likelihood of adoption by the widest range of actors, even if it means somewhat “watering down” the way they address politically sensitive or controversial issues.

Finally, after the written reviews, commenting, and majority of surveys were complete, the ASICS team organized three different focus group discussions for the reviewers. These discussions

lasted 60 minutes each and were structured around reading the 350 word abstracts that each of the reviewers submitted, using them to prompt discussion. We aimed for each attendee in each discussion to have their abstract commented on by the other attendees. These discussions were held over zoom and recorded.

Data analysis and synthesis

Each of the sources of feedback and data sets were used in a synthesis process where the ASICS team sought to make sense of the feedback and present it in a way that would be useful to the standards writers. The primary data set for this process was the written reviews, with the survey, in-line comments, and focus group discussions serving as sources of triangulation.

The written reviews were synthesized through a thematic analysis where summaries of the reviews were written up before excerpts of the reviews were themed into multiple categories. First, comments were organized between "strengths" and "recommendations." The strengths category was for those parts of the write up where expert reviewers commented on what the standards did well, while the recommendations category was for those parts of the write up where the expert reviewers thought they could be improved or provided critiques for the standards writers to consider. Within each of these two categories excerpts from the reviewers were labeled with a theme that sought to summarize the strength or recommendation.

The strengths category had 22 initial themes, while the recommendations category had 108 initial themes. The strengths were reduced into four overarching themes (see pages 12-15). The recommendations themes were reduced into 17 overarching themes (see pages [rec pages]), which were organized into four categories: political courage (1 theme), coherent vision (7 themes), elevating student agency (4 themes), and consistency (5 themes). The analyses of the in-line comments, discussions, and survey were corroborated with these themes to support and shore up interpretations and presentations.

The in-line comments (582 total) were imported into a spreadsheet and organized by: 1) topic area, 2) sub-topic area, 3) specific standard, 4) grade band, 5) type of feedback, 6) recommendation theme. In addition, notes were taken about the comments to support their synthesis into the larger recommendations. After the 17 overarching themes were identified, the in-line comments pertaining to more substantive feedback on specific standards (e.g. experts provided constructive critique or proposed new standard additions) were reviewed and tagged as foregrounding one of the 17 overarching themes (or tagged as other). For the sake of transparency both these in-line comments via an Airtable and the anonymized reviews have been made available to the standards writers as supplemental materials to this report. The spreadsheet was then imported into an "Airtable" filterable database, where users can sort by the organized categories (1-6) listed above. While the recommendations were being synthesized, focus group discussion recordings were listened to and noted for any relevant information that aided or clarified the themes and recommendations. Finally, the survey was analyzed in two steps. First, the likert-type scores were calculated for the four items listed above, second, they were made sense of by summarizing and theming the open-ended items. These were then used to help prompt discussions during the focus groups.

Praise for the CSTA Standards Draft's focus on impacts and ethics

Expert reviewers were tasked with the goal of pinpointing noticeable gaps and potential additions to the CSTA Standards Draft in relation to ethics and social impacts. However, *none* focused only on what to change because *all* had positive feedback to share about where the current draft has landed. Indeed, many of the recommendations present in the Executive Summary and Recommendations sections of this report reflect that reviewers liked the direction of the standards draft and, as a result, recommended ways to take the standards even further in that direction.

Here we highlight expert reviewers' exuberant praise for the overall draft's focus on issues of impacts and ethics that:

> *"**radiates from the screen** with its comprehensive approach to integrating ethics and social impacts…The output of this endeavor is **nothing short of remarkable** and a **huge leap forward for CS education at a critical moment**. It was **a joy to review**!...While I did leave many comments (with suggestions as requested!) I am ultimately **heartened, excited**."*

This sentiment was shared by others who felt, for example, that the draft standards "**represent a significant and promising step** toward integrating ethics and social impacts into computing education across grade bands." This expert shared, "As someone committed to ethical and socially engaged approaches to computing education…I **applaud the draft's commitment to embedding ethics into computing education, while advocating for deeper and bolder approaches** that support **critical, creative, and justice-oriented engagement** with the technologies shaping our world." As noted by two other experts, the standards draft "include[s] a **thoughtful and well-specified** range of topics on the ethics and social impacts of technology" and "do[es] a **good job** recognizing a full spectrum of ethical and social impacts".

Noticeable improvement from earlier CSTA Standards

In particular, people noted that the current draft greatly improves upon past CSTA standards. For example, one expert noticed, "**compared to the current standards, the draft standards comprehensively examines multiple dimensions of social and ethical impacts of computing**" while another agreed, stating, "The standards [draft] **clearly work to address (and redress the absence in past standards)** the complex ethical and social impacts of computing." As shared by another expert:

> *"I've worked with the existing CSTA standards as a curriculum developer since 2018 and frequently needed to supplement them with other frameworks for deeper, cross-cutting guidance on ethics and social impacts. **This iteration addresses these gaps**…Specifically, the message that humans create technology and that there is a reciprocal relationship between culture and technology comes across clearly and is a core strength of these new standards."*

Experts were particularly struck by the ways ethics and social impacts were explicitly centered in focal areas that were not as visible in previous standards iterations:

> *"Another **strength is the presence of ethical considerations in sections that have not always foregrounded them in past standards work**, such as cybersecurity. The inclusion of ethics here signals an important shift in how computing education is conceived. Similarly, the attention to career exploration and the encouragement of students to see how technology is shaping their future fields of work is both timely and necessary."*

Overall reviewers felt that the standards writers were truly moving CSTA standards up in quality, purpose, and value and were appreciative of how much more the current draft has to offer for CS education. Choosing to make impacts and ethics its own pillar was particularly valued as an explicit move on the part of the standards writers to center these important topics in CS education as described below:

> *"The **pillars are a stellar addition to the standards overall**. The Human-Centered Design and Impacts and Ethics pillars clearly define and express the main ideas synthesized across the standards in a concrete way. I deeply appreciate the way they ground standards while serving as a tool for educator interpretation. I found myself returning to them often as I reviewed specific standards. I found the language to be clear, specific, and impactful enough to use directly with students. Overall an **excellent compass** that I would encourage writers to highlight even more for educators who will use this framework."*

Appreciation for efforts to integrate impacts and ethics throughout the standards

Experts were particularly appreciative of standards writers' attempts to integrate impacts and ethics throughout the standards. While the reviewers also identified additional ways to do so, they recognized the current draft's initial efforts to "**interweav[e] these themes** alongside technical skills/concepts and…includ[e] ethics standards in technical subtopics and assign them their own for a more fleshed out progression." Another expert shared that "It is really **encouraging to see components of social impact, human-centered practices, and ethical concerns spread throughout**" while another noted that:

> *"It is **exciting to see this much content related to the ethics, impacts, history, and social aspects of computing in these standards**. Including this content across K-12 CS Ed acknowledges that while all learners should have a chance to explore the technical aspects of CS, doing so through the lens of critical thinking about broader contexts is necessary in a world where technology has complex impacts for people and environments."*

As pointed out by another expert, the "**consistent focus on situating technologies in broader social systems** in order to analyze the interactions between a technology and the systems into which it is introduced" was a "strength" as well as how the draft explicitly pointed out how "**technology's impacts will differ according to a person's/group's identities**, and understanding how identity is entwined with impact appears to be a core focus of the standards."

Appreciation for attention to elementary standards and grade band progressions

Overall experts also liked initial efforts to center ethics and social impacts in early grade bands, as well as the draft's intent to support deepening of learning across the grades. While experts pinpointed additional ideas for doing so, "[The standard's] strengths consist in the **breadth of topics** included and the **early introduction** of socio-technical content starting in pre-K/K" as well as "attention to developmental appropriateness, scaffolding complexity over time, and maintaining thematic continuity…In early grades, the focus is on recognition and awareness, which evolves into investigation, analysis, and even design and critique in later years." One expert was "**most excited and impressed by the elementary standards**" because there tends to be an assumption that "younger students didn't have the developmental skills or experience required to pursue these types of questions, which I find to be wrong with potentially deleterious effects in setting up younger students for the skills, behaviors, and mindsets expected in later grades."

In particular, reviewers really liked…

In addition to the above, experts also liked the inclusion of history and emerging technologies because, "**Highlighting computing and society broadens the standards** from simply 'impacts' towards some other key issues—**history of computing** and how that shapes our lives today, computing in the world of work, and to some degree even understanding the political economy of how technologies get produced, by who, for who." As another expert shared, "In my own teaching, I've found it helpful–and based on their feedback, so do students–to contextualize contemporary technology and discourse about that technology in history…Helping students take a long view of computing can assist them in making sense of contemporary narratives and technologies." As another expert shared, focusing on history, emerging tech, and impacts of algorithms in the current draft "make[s] a strong foundation for including considerations of the impacts of computing."

Getting more specific, one expert appreciated the "**focus on Data and Analysis and Algorithms and Design**. Taken together, these standards compile a comprehensive and nuanced understanding of how under or overrepresented data can lead to deep societal impacts and harms to communities and individuals." Another liked how "impact-oriented considerations as part of their core competencies" for data science, algorithms, AI, etc. While another felt that "More **deeply incorporating Data Science** feels like an important prioritization as well. While connections to other content areas are not explicitly made in this draft…the inclusion of Data Science standards means easier connections could be made to content areas like social studies and the sciences." Finally, another expert shared that "The **expansion of AI concepts and skills** related to ethics and social impacts is one of the biggest improvements to these standards."

A number experts also liked how the current draft brings forward issues of policy and computing in relation to ethics and social impacts. One expert shared, "I like how discussions of policy might encourage students to use their individual and collective agency to engage civic leaders at

different scales (e.g., school officials or state/federal government officials) to shape how computing affects young people's lives in and out of school." And another believed that calling out things like policy and legislation "signal to many audiences that there is more than just 'ethics' to consider, but actually a whole range of complex areas of social and political inquiry."

Finally, one expert was "impressed by how these standards **meet the moment and feel their design is flexible enough for a swiftly shifting future**."

While the experts shared many recommendations for edits (described in the next section), these were rooted in excitement for this initial CSTA standards draft and its potential for positive impact on CS education.

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.

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 *tell* 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	Targeted 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.	**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

	in these standards.

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 **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	**Targeted suggestions** **6.4 History of Computing:** Consider adding a standard focused on exploring competing narratives of progress, with the following as suggested language:*"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."* **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 **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).	**Targeted suggestions** **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: *"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."*

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: "*E5-CAS-ET-02: Analyze the limitations of existing technologies and how emerging technologies change the way people work, behave, and communicate.*"

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 after 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 within computing design processes themselves. 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 *"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."* **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:** *"Create data sheets that document the motivation, composition, collection process, and recommended uses of datasets."* - **9.9.2 Computing and Society - Emerging Technologies - Grades 6-8**: *"Evaluate when it is appropriate to use emerging technologies (e.g., AI) to solve a problem, taking into account technical, ethical and environmental considerations."* - **9.9.3 Programming - Program Development—Grades 6-8**: *"Consider potential ethical issues prior to developing a program."* - **9.9.4 Artificial Intelligence - Specialty II**: *"Create data sheets that document the motivation, composition, collection process, recommended uses of datasets."* - **9.9.5 Software development**: *"Conduct user testing sessions to evaluate if the software serves the needs of users."*

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**: *"Critique the values behind software used in everyday life and its societal implications."* - **9.9.7 Physical computing**: *"Consider ethical issues (e.g., surveillance, privacy, consent) of collecting data from users with sensors and microcontrollers."* - **9.9.8 Games and Interactive Media**: *"Discuss the values embedded in the design of games and interactive media and their ethical implications."* - **9.9.9 CS+X: "***Consider the ethics and possible limitations of incorporating computer science in a non-CS discipline."* - **9.9.10 Data & Analysis - Impacts of Data Science - Grades 9-11**: *"Empirically investigate potentially harmful behaviors of AI systems through audits or external evaluations."* - **9.9.11 Artificial Intelligence - Specialty II**: *"Empirically investigate potentially harmful behaviors in AI systems through external evaluations or audits."*

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	Targeted 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	**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, "*expand beyond formal reports to include oral presentations to diverse audiences including community members, school leaders, policy makers*", with the intention to "*have students take seriously the question of audience and usability of their data investigations.*"

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	Targeted 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.	**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 *"Examine how users consent to their data being collected by computing systems."* **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-0211.13 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 *"justify which data you included and excluded and why that was ethical (or potentially unethical)"* **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"?

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:*"Examine how computing careers in for-profit, not-for-profit, and government vary."* **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 *"broken out into something like:* *-Describe common societal impacts, ethical issues, and biases of algorithms.* *-Analyze the properties of an algorithm that might lead to negative social impacts and ethical issues including bias.*

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.

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 *Data Science* and *Cybersecurity*. 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 *Cybersecurity* 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 "*more politically sensitive topics such as national security, definitions of citizenship and adversaries, immigration, and the weaponization of data*"

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)."*

Full Recommendations

1. Prelude: 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.

Expert reviewers believe that the 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. Reviewers recognized, just as standards writers do, that this can be challenging to achieve depending on the context of a school and its leadership. However, if the goal is to create a standards document that exemplifies the best of computing education and what we truly hope all students will learn across their K12 schooling pathways, then this means that the CSTA Standards document must cater to our highest expectations of what teachers can do with their students.

Aiming to speak to concerns about both the issue of having the standards take a particular perspective on ethics and impacts as well as the intersection of impacts and ethics-related standards with political realities around standards adoption by policymakers, the ASICS team directly polled expert reviewers on their perspectives on these issues. We shared the following statements, which reviewers rated on a scale from "strongly disagree" (1) to "strongly agree" (4):

> *"The CSTA K-12 Standards should put "a thumb on the scale", taking an explicit standpoint on what counts as "ethical", or as "harms" or "benefits" vis-à-vis computing in society."*

"The articulation of CSTA K-12 standards focused on ethics and social impacts of computing should prioritize likelihood of adoption by the widest range of actors, even if it means somewhat "watering down" the way they address politically sensitive or controversial issues."

The results (see **Figures 1** and **2**), highlight that while there is not a clear consensus among the reviewers on these issues, there are some clear trends.

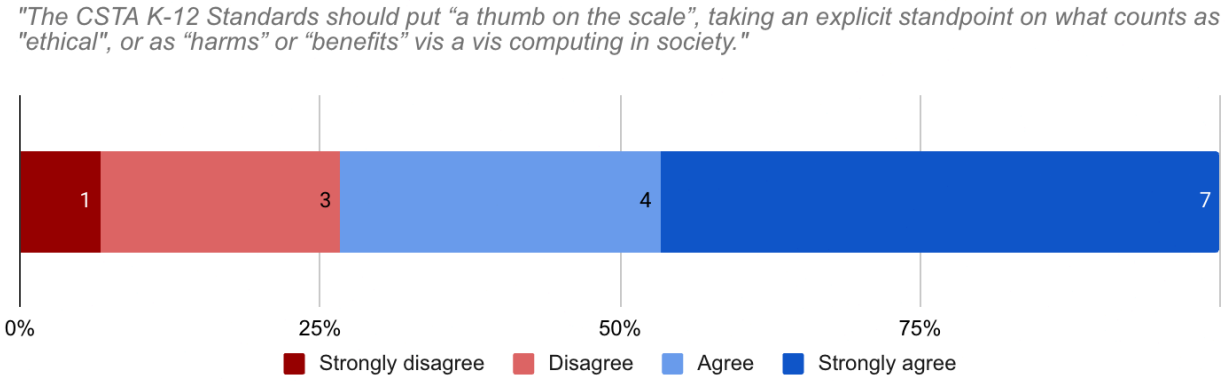

Figure 1. *Expert reviewer responses to the likert scale question "The CSTA K-12 Standards should put "a thumb on the scale", taking an explicit standpoint on what counts as "ethical", or as "harms" or "benefits" vis-à-vis computing in society."*

For the first statement, relating to "putting a thumb on the scale" vis-à-vis ethics, harms, and benefits, nearly three quarters of the reviewers agreed with the statement.

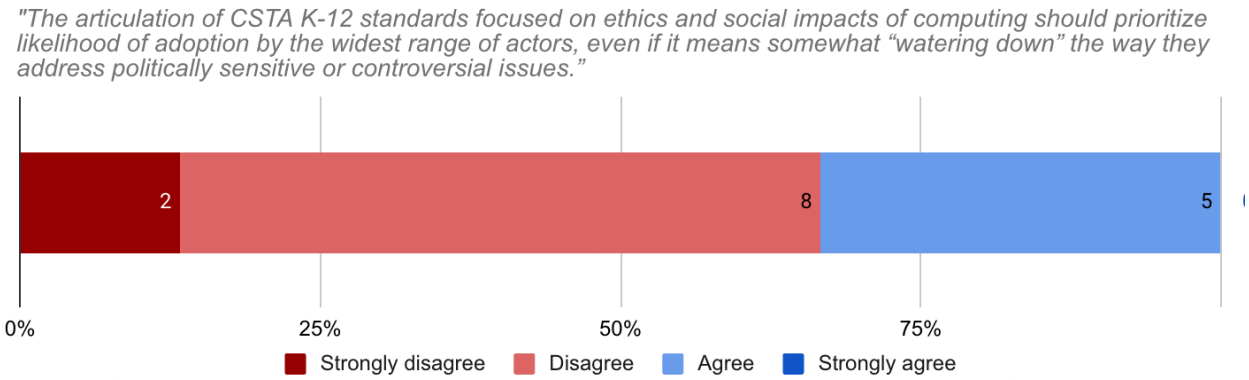

Figure 2. *Expert reviewer responses to the to the likert scale question "The articulation of CSTA K-12 standards focused on ethics and social impacts of computing should prioritize likelihood of adoption by the widest range of actors, even if it means somewhat "watering down" the way they address politically sensitive or controversial issues."*

For the second statement, two thirds of the group (n=10) disagreed or disagreed strongly with the statement—evidencing a view that they did not believe standards should be "watered down" for political expediency—and, among those that did agree, none agreed strongly.

In qualitative responses where reviewers explained why they took the position on these questions, we observed a number of themes.

Rationales against "watering down", and for taking a clear stance

Among those that argued against "watering down" standards to prioritize widest adoption and who argued for taking a clear stance on ethics, harms, and benefits, six central rationales were articulated:

- Standards creators should assume "watering down" by downstream actors in the education system and as such the standards should act as "highest common denominator" and a strong signal to the field.
- There is a moral cost of self-censorship in that it would represent compromising on core values held by the writers, CSTA as an organization, and the field of CS education writ large.
- In that the standards effectively serve as a distillation of the purposes of K12 CS education, if they do not effectively address issues of impacts and ethics in computing, it invites the question of what are, in fact, the purposes of the standards, and of the field in general.
- Limiting, or, at worse, erasing, issues of CS impacts and ethics has real world consequences, and can lead to harms being perpetuated in the long term.
- There is no such thing as a neutral position, and watering down or attempting to sidestep naming issues that might be construed as politically sensitive is itself a political stance.
- A lack of clarity around CS impacts and ethics will make it difficult for what is likely a majority of educators that actively do want to address these issues in their computer science classrooms to do so effectively.

Standards creators should assume "watering down" by downstream actors in the education system and as such the standards should act as "highest common denominator" and a strong signal to the field. Numerous reviewers noted that the standards set what should be the highest standard vis-à-vis teaching about ethics and impacts of computing given the reality that other actors in different parts of the education system will inevitably engage in either "cherry picking" or "watering down" of their own. In line with this view, one reviewer shared:

> *"From a collective impact standpoint, I don't think [watering down] would be effective. The processes by which the standards will be analyzed, prioritized, and adopted are already political, localized processes that do filtering. There's no reason why CSTA has to pre-filter these topics when it will be 63 states and territories engaged in their own editorializing of these. If there were alternative standards to consider, maybe, but for now, CSTA has everyone's attention. This is the moment to use it, and take a stand."*

Along similar lines, another reviewer noted that the states and localities, essentially, cannot grapple with what isn't there, and that the standards should thus aim to be the "highest common denominator", rather than the lowest:

> *"I view these as a guidance document. If states and localities don't like what's there, they can "water it down" themselves! It would be important for the CSTA to take a stance on what is important from the perspective of the field, the diversity of students, the ways technology is impacting society, and so on, so localities can grapple with it."*

A final reviewer summed up this perspective succinctly: *"If we can't say it here…"*.

Moral cost of self-censorship. Another rationale offered by those that disagreed with watering down ethics and impacts standards was simply that it would represent compromising on core values, both their own, of CSTA as an organization, as well as that of the field. One reviewer shared:

> *"This is "the" question, one that I have gone back and forth on often. Ultimately, I disagree because of my own personal ethics and belief that you cannot teach CS ed without addressing the power imbalances and dynamics that technology has spurred and been born from."*

Another reviewer put it this way:

> *"Ethics should make room for discussion and nuance. At the same time, I believe we have a professional obligation as educators and scholars to name harms and work to right them. If something is hurting a group of people, we should have the courage of our convictions to speak to that. What is the point of any of this (education, scholarship) if not to ultimately be working toward a freer and more just world?"*

The standards will reflect what the field of K12 CS education sees as its purpose. Related to the issue of moral costs, one reviewer noted that the standards effectively serve as a distillation of the purposes of K12 CS education, and if they do not effectively address issues of impacts and ethics in computing, it invites the question of what, in fact, are the purposes of the standards, and the field at large. Acknowledging the complexity of the task and that there may be ways to avoid some obvious political lightning rods, the reviewer shared:

> *"I think it is ok to avoid some words which are banned in certain states. On the other hand, commitments to social good require naming that inequity exists. If we can't do that, why are we, as educators, doing this? What do we believe? What REALLY matters to CSTA? I mean it practically as well as morally. What is the end goal of the organization? If it is a genuine assessment of CS on society, they can't achieve their end goal with watered down language. Can some of it be tweaked? Sure. But you still need to be able to say things that are demonstrably true, like "computing has disparate effects on people depending upon their identity."*

More succinctly, another reviewer summed up this perspective by saying: *"The Standards should not signal that watering down is the core of computing education."*

Consequences and harms of self-censorship. One reviewer pointed to the reality that either erasing or limiting issues of ethics and impacts has real world consequences, and can lead to harms being perpetuated in the long term. One questioned what would happen, for instance, if the same was done in the field of health care:

> *"If the ethics and social impacts of MEDICAL science were watered down for the sake of adoption, the end result would be a long list of Stanford Prison Experiments and Tuskegee Experiments and we'd all be horrified. Why should we think any differently about the ethics and social impacts of COMPUTER science?"*

"Watering down" is a political stance, there's no such thing as a neutral position. Across their comments, experts expressed that there is functionally no way to avoid the issue of having the standards embody a particular stance. Echoing the title of Howard Zinn's famous book, *You Can't Be Neutral on a Moving Train*, one reviewer shared:

> *"There is no such thing as a neutral position. Even one portrayed as neutral is a stance that a document intended to put a "thumb on the scale" for every other area of CS [outside of computing impacts and ethics] conveys a stance that all of those other areas are somehow devoid of politics, values, or conflict. They aren't, and portraying them that way is a strong stance on neutrality, whether intended or not."*

Lack of a clear stance will present challenges to educators. A final theme related to the ways that a lack of clarity and presence of impacts and ethics issues could make education in this area more difficult for the many educators that actively want to explore these issues with their students. On the one hand, a lack of clarity could end up causing confusion and incoherent implementation on the ground. On the other, a lack of presence of these issues leaves them without direction at all, and without official guidance supporting them to argue for the inclusion of these issues in their classrooms. This theme was reiterated in the expert review panel discussions. As one reviewer cautioned:

> *"If it's not in the standards and there are state organizers wanting to have more engagement with power systems, etc, they're going to be undermined by these national standards because they're going to get the feedback 'Well it wasn't important enough to put in the national standards, right?' Or 'This isn't what the national standards say'. And so it's undermining organizing that might happen at the state level as well as organizing and decision making that might happen at district or school levels."*

"Threading the political needle" through empowerment and deliberation

A central theme among those that agreed with these statements was questioning the premise that there is a necessary tradeoff between political expediency and effectively addressing ethics and impacts topics in CS education.

A number of reviewers noted that it is possible to construct the standards in a way that is not ideological in the sense that they prescribe, and push, a particular standpoint, but rather invite deliberation and empowerment of students. One reviewer shared:

> *"This is a difficult balancing-act. However, I do believe that many controversial or sensitive topics can be included if it's clear that the curriculum does not subscribe to promoting a specific perspective but intends to equip students with the intellectual tools to reason critically about them."*

Another took a similar view, seeing it not as "watering down" but instead as a way to "create opportunities for a wide range of actors to enter the conversation."

One reviewer noted, "we should be engaging students in dialogue and supporting students in developing their own conceptions of 'ethical', 'harms', and 'benefits'." Another reviewer noted that there needs to be conversations to support the understanding that "What may be a harm to a student may be a benefit to another." Or as another reviewer explained,

> *"I would instead emphasize that the goal of computer science education should be to make students familiar with the big ideas and debates related to ethics and technology, and create opportunities for students to think through those questions on their own terms. This doesn't equate to "both sides" thinking, rather an emphasis on student agency and critical thinking."*

Ultimately reviewers' sentiments reflected the belief that:

> *"Ethics should make room for discussion and nuance. At the same time, I believe we have a professional obligation as educators and scholars to name harms and work to right them. If something is hurting a group of people, we should have the courage of our convictions to speak that. What is the point of any of this (education, scholarship) if not to ultimately be working toward a freer and more just world?"*

Across all the responses to these questions, reviewers acknowledged how complex and challenging the current environment is with regards to what is considered acceptable to teach. As one reviewer put it, "This is a tough one that will require strong doses of pragmatism, as well as acting on principle."

With all of that said, many experts saw it as 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. Essentially, some questioned the premise that there is a necessary tradeoff between political expediency and effectively addressing impacts and ethics topics in CS education. We believe that the vision we speak to in the next sections could offer direction for what such an approach might look like.

Root in a Coherent Vision of Computing Impacts and Ethics

The experts noted how deeply issues related to impacts and ethics were incorporated into the draft standards, but shared some limitations when it came to how cohesive the underlying perspective was as it related to these issues. In some cases experts highlighted ways this lack of central cohesion could send mixed and possibly contradictory signals. In others, they commented on how to extend and deepen certain ways of thinking about impacts and ethics in computing that were present in some, but not all places in the standards. As one expert put it, the standards should have "a clear north star" in terms of how to think about computing impacts and ethics that can guide choices about what should be prioritized when it comes to what students should know and be able to do.

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, 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.	**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 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.

To this issue of balance, one reviewer stated:

> *"The positive contributions of CS are sometimes balanced with issues of "harm" or "risk" in the standards but inconsistently so and infrequently. I see a little more caution around AI but I think that's largely because it still falls into the role of a nascent, "emerging" technology, a topic that gets a particular kind of attention in this document. I think in general, I am okay with highlighting the positive contributions of computing but want to urge for a little more consistency about where and when the balance occurs."*

In this regard, reviewers noted that it would be problematic to suggest that all (or even most) technologies are centrally created based on pro-social motivations, because many are developed with a central orientation towards profitability. As one reviewer wrote when specifically focusing on the Emerging Technologies subtopic:

> *"[One] weakness was in the draft's engagement with emergent technology. It was mostly engaged unproblematically, but there are many aspects of emerging technology that come with tradeoffs in relation to society. Planned obsolescence of software and products can lead to e-waste and reduced sustainability; constant progress can increase digital divides, reserving emerging technology for those with enough wealth*

> *to purchase it. Adding standards to address these downsides of rapid progress would help youth think critically about the tradeoffs of rapid technological change."*

Speaking to what they saw as an implicit portrayal of technology as centrally developing in response to societal needs (e.g. in E4-CAS-HC-01, MS-CAS-HC-01, History of Computing front matter on P12), one reviewer stated:

> *"Computing hasn't always "evolved" (a metaphor with interesting connotations) in response to social, scientific, and economic needs. It often drives those needs or is a solution in search of a problem. My push on this phrasing is that it echoes techno utopian rather than techno-realist approaches."*

Here we might think of technorealism as 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 its lifecycle (i.e., design, deployment, use, and disposal).

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 *tell* 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	Targeted 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.	**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 in these standards.

A number of the reviewers found that the meaning of ethics in the document was unclear and imprecise. As one expert noted in a list of critiques:

> *"The first of these pertains to the document's use of the word "ethics". It is used to refer to different things within the document. It can refer to normative evaluation, it can refer to responsible computing use, and it can refer to social good or socially-responsible usage of computing. I feel that this will be a source of confusion for teachers."*

Indeed, the tricky part about using ethics in multiple and different ways is that it becomes difficult to develop a shared understanding to talk about social issues and impacts:
"So … the takeaway is "ethics" and "social good" in this field are empty signifiers, that is, phrases that can stretch to cover a wide range of incompatible goals and approaches. I wonder if more precise language would help K-12 curriculum designers more in this area. To be fair, the report's foundation standard specifications often do have precise language. In particular, I appreciated and applauded how the document often uses the word "harms" instead of "ethics"."

Thus, it will be important to "Clarify what the "various ethical frameworks" are in the standards document. Speaking specifically to HS-CAS-ET-07 ("Evaluate an emerging technology through multiple ethical perspectives."), multiple reviewers either felt it could be improved, or that it could point to a section of the standards that spells out these various ethical frameworks. Indeed, the way the standards are written suggests that there should be somewhere to turn to find these.

The reviewers were adamant that no one ethical framework should dominate the standards at an implicit or explicit level. This should include common ethical frameworks like consequentialism, deontological ethics, and virtue-ethics, but also justice-centered ethics, pragmatist ethics, ethics of care, and indigenous inspired ethics. The reviewers found it important for teachers and learners to understand the affordances and limitations of multiple ethical frameworks. This would support practices where teachers and learners are able to apply them to an issue at hand, critically reflecting and evaluating the values they support and lead to when applied to some ethical situation or issue. As one reviewer noted:

> *"…regarding ethical frameworks/theories: The important learning outcome is not knowing about a set of old white male philosophers—it is understanding that you can look at a situation using a different ethical framework and come to a completely different answer. That is an important lesson that students could get a lot out of—even in elementary school, without ever naming consequentialism (though once they get to high school, sure). I do think that this would be worth adding in some way."*

As this quote suggests, there is a desire for the standards to not only support applying ethical frameworks to a single case but also the skills to reflect on the values that the ethical frameworks entail. Thus, it is about: 1) knowing how to apply multiple ethical frameworks to a single topic and 2) critically reflecting on the values of the framework and the values they support when applied to the context, issue, or situation in question.

Utilitarianism is a specific type of ethical framework that fits within the larger category of consequentialism. Utilitarianism is about judging outcomes in ways that place value on the greatest good for the greatest number of people or beings. But, as pragmatists have noted, the calculation of outcomes is highly speculative and contingent, ignoring uncertainty and individuality. Thus, it is not an ideal framework, nor should it be normatively applied to the standards. Indeed, a number of the reviewers commented on an implicit ethical framework of "utilitarianism" in the standards, noting that 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. As one reviewer noted: "Move away from "utilitarianism" (maximizing the happiness and well-being of the most number of people) as the

implicit ethical framework present in the standards." They found that this reinforced some unfortunate assumptions about how people and institutions are valued. As one reviewer noted:

> *"While balance of coverage seems a worthy metric, in reality it engenders a type of moral utilitarianism that favors the status quo: "Yes there are harms, but look at these amazing benefits (that we might have eventually)!"...there is already a surfeit of "benefits" marketing pushed out non-stop by digital companies and their shills in the media, so there is no need for public education to provide more free marketing."*

Thus, as the writers revisit the standards it is important to question what values and even frameworks are implicit in the standards, and then seek to make multiple frameworks more explicit, not as assumed values but opportunities for critical thinking and reflection on the frameworks and values themselves.

One way to make ethics concrete is to connect ethics in the standards to the personal and collective lives of teachers and learners. Some reviewers thought that the standards should emphasize personal connections to micro- and macro-ethical issues, showing why ethics is important not only in their designs, uses, and disposal of technology but in their everyday lives. This is especially important considering the ubiquity of computing in many of their lives. As one reviewer pointed out:

> *"In my experience, many tech ethics curricula (at least at college-level which I am most familiar with) focus on ethics as moral and political philosophy. Those are important dimensions, but, classically, ethics also includes the study of how we can lead full and thriving lives, both individually and collectively. That's an aspect I only saw reflected to a somewhat limited extent in the current version of the content standards…Connecting those experiences to more formal ideas and theories about human flourishing (as, for example – though not exclusively – found in virtue ethics) is both enlightening and immediately empowering for students."*

This can be done by bringing in concrete issues that teachers and learners may encounter in their lives like the attention economy of social media, surveillance via the convenience of using biometrics on phones and in travel, and copyright law and the remixing of media in music (e.g., hip-hop) and video (e.g., anime music videos).

Multiple reviewers noted that the way that the standards address ethical and societal issues could be improved through expanding the concept of "Impacts and Ethics" to "Impacts, Values, and Ethics", highlighting the central role that values play in mediating ethics and impacts (e.g. centering a value of profit maximization over a value of minimizing harms). One reviewer noted:

> *"[Impacts and ethics] standards center ethics and social implications with little to no attention to axiological issues related to the design of computing technologies. Human values are embedded in the design of computing systems, and what we often call ethical and societal issues emerge from misalignment between the values of different key parties. Here the standards have the opportunity to involve older learners in thinking about the values that motivate technologies they use in their everyday life and the values that they bring into the design of their applications."*

This could include expanding the overall framing and naming of the Impacts and Ethics pillar, while also attending to particular places in the standards where students might have an opportunity to reflect on the value systems at play. For example, reviewers noted the need to

have students engage in “reflect[ion]/consideration of their own values and priorities and how that's manifesting in the design process” within the High School band of both the “Impacts of Computing Systems” and “Human Centered Design” subtopics. Additionally, one reviewer suggested the following as an expression of how this priority could be phrased in a standard for the “Artificial Intelligence - Specialty II” focus area:”Consider the values and priorities of different parties involved in the design and use of AI systems (e.g., create ethical matrices) prior to designing an application.”

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

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

Some reviewers noted that the standards tend to place ethical responsibilities for dealing with harms from computing devices or systems on individuals and their personal choices as designers or users. This, they argue, obscures how individuals fit into and are implicated within private and public systems that operate beyond any one person's intent and choice, but where some people have more power than others. As one reviewer noted:

> *"My main criticism with the document is that it is excessively focused on individual action as mitigating agents for those harms. Indeed, it boldly pronounces that it is the students' (eventual) job to ensure a lack of harm. For instance, on page 13, it announces that students "should study these implications to support them in becoming responsible creators of technology who use computing to benefit all members of society" and on page 14 that students should "Avoid, mitigate, and remediate harms caused by computing technologies… the document gives the impression that mitigating the social harms of digital technologies is the job of individuals or even the students themselves. But these harms almost always are perpetrated by companies and governments."*

This viewpoint might be considered heavily oriented against focusing on responsible design. Indeed, the reviews overall suggested a balance between the responsible design practices (**Recommendation 9**) and civic-oriented practices responding to computing in society (**Recommendation 10**). But, it does highlight the reality that students must be well prepared to understand the limits of design as a leverage point in terms of the impacts of technology. As explained by another reviewer, it would be helpful if standards included "...broader conceptions of 'impact' that go beyond individual users to include families, communities, ecosystems, and professional sectors" and that while focus on individual users "is a useful starting point, I encourage the standards to also attend to collective and systemic forms of impact."

While the ASICS team does not believe that it is necessary to go as far as to erase all mention of the need for individual children and future adults to learn how to act ethically with computing, what we gathered from the reviewers more broadly is that by expanding beyond a focus on individuals towards considerations of groups of people, communities, families, non-humans, etc., students/teachers would gain important perspectives on the larger institutional structures influencing how we individually and collectively engage and create with computing. This would also help students/teachers see both the importance of individual and collective thought and action. Indeed, there were a number of ways that the reviewers recommended that the standards could include a more collective or systems level understanding of harms.

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. While one reviewer noted how the standards "consistently raises accessibility, policy, legislation, and notions of disparate harm and benefit", another reviewer noted that it would be more honest to teach about the intersection of technological and political knowledge and less about responsibilities at an individual level:

> *"The benefit of the "harm" frame should make us and our students recognize that these issues require political and legal solutions not moral philosophizing or pedagogical pronouncements about personal responsibility. That is, the harms of 21st century computing will not be solved by teaching students about ethics (there is ample evidence from engineering, business, and computing education that it is not at all effective), but will require a critical consciousness pertaining to the technology and the political knowledge and willingness (voting) to affect changes in regulatory laws. The guidelines in the document does try in*

places to do the former (e.g., HS-ALG-IM-08 and -011) and only touches on the latter in HS-SAS-IM-12, but I wonder if this critical and political/legal perspective needs to be spelled out more explicitly within the document instead of relying on terms such as "ethics" and "impacts"."

It might be helpful here to recall the difference between micro-ethics and macro-ethics that the ASICS team introduced during the literature review presentation back in Chicago in March 2025. Micro-ethics are what individuals can do at the level of personal and immediate choices, whereas macro-ethics is about considering the moral implications of harms and benefits that result from large scale systems and organizations. To make change on macro-level issues (e.g., climate change) requires understanding social responsibility and how groups of people can pressure corporations, nation-states, etc. to change their operations and policies. In the quote above the reviewer puts a lot of emphasis on the importance of students knowing how laws and policies that shape technology R&D and use are created. But how these system-level harms of algorithms, computing systems, etc. impact people is differentiated, making issues of power and marginalization important to understand too.

Power describes how institutions' legacies and positionalities are structured to give some people more influence over how people behave and live than others. Thus, power is unequally distributed, say between an employer who buys labor and an employee who sells their labor. Power isn't inherently bad, as when a captain commands a crew on a ship or when a teacher manages students' behavior. But in societies that are stratified by class, have histories of racial supremacy, ignore or minimize disability, and create sexed and gendered hierarchies in private and public spheres, the unequal distribution of power can result in the marginalization of historically, economically, and politically disadvantaged groups (i.e., groups that are structurally placed lower in the social hierarchy - in the U.S. this includes but is not limited to immigrants, African Americans, Indigenous populations, Muslims, queer people, etc.). Thus, a number of reviewers made comments about how the standards should attend to how the harms and benefits of technology are unevenly distributed within such a society, requiring not only attention to historical context but also political, economic, and sociological contexts. As one reviewer noted:

"One important aspect that I did not see consistently addressed were ideas of marginalization and power. These topics are the underlying forces that drive many of the harms and benefits that the standards refer to, but they are rarely mentioned, and when they are, it is only as an aside."

Given that the harms and benefits of technology are unequally distributed, some reviewers found language about the outcomes of technology design and use as positive or negative too simplistic.

Many reviews had a desire for the standards writers to consider the uneven distribution of technological and computational harms in ways that leaned into the complexity of individual and collective actions, and laws and policies. Indeed, once diverse stakeholders with different levels of influence and power come into view, it can be seen that any development, use, and disposal of a technology may have both negative and positive outcomes (e.g., shipping e-waste away from my house is good for me but bad for those who live next to the e-waste dump), and in some cases it may be that the binary doesn't even work (e.g., data centers can provide a

community with well paying jobs while depleting their local water sources). Thus, a number of reviewers suggested that the standards try to show this complexity in language, moving beyond the reproduction of outcomes along a strict positive or negative binary, and potentially towards dilemmas that involve both. Here are two quotes on the topics:

> *"Though of course it is clear from the totality of the document that this is not the case, the way that there are two initial bullet points for "Computing has both positive and negative impacts on society and the environment" seems to imply that those are the only two components. And of course "impacting people differently" would be an incredibly narrow view of negative impacts. It might just be worth revising the purpose of those bullet points.*

> *One big picture concept that I think is missing here - and I think that probably where this fits is literally the very beginning, so probably PreK-5 under "Impacts of Computing Systems" - is how we actually think about the fact that technology can be good and bad at the same time. I think it is appropriate to be analyzing both benefits and harms, but then what?"*

Here we can see calls for having teachers and students think about the harms and benefits of computing in complex and dynamic ways that move beyond the positive/negative binary.
Finally, the reviewers generally recognized and praised the places in the Standards that highlighted unintended harms. This is important because the consequences of development, use, deployment, and disposal may not be known until after the fact. But the reviewers also found it important to suggest that there were a few comments about how the standards should acknowledge and teach about bad and malicious actors who design and/or use computational devices and systems to intentionally cause harm. As one reviewer noted:

> *"I think that use of the word "unintentional" to describe algorithmic harms is a bit naive. There are, of course, intentional harms of algorithms and computational systems."*

Thus, the reviewers suggested coupling the language around unintentional harms with language around intentional harms.

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

<table>
<tr><td colspan="2">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.</td></tr>
<tr><td colspan="2">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</td></tr>
<tr><td>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."</td><td>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.</td></tr>
</table>

While expert reviewers appreciated the current standards draft's mention of environmental impacts (e.g., E4-SAS-IM-04), four experts explicitly called out how more could be done to center and emphasize the environmental harms of computing in ways that support students' critical engagements with CS. More specifically, reviewers felt that the language around environmental impacts was *"not strong enough"* and that *"we need to use words like 'harm' and 'destruction.'"* Or as another reviewer noted, *"ethical considerations around AI and the climate crisis… are largely absent from the current draft."* Yet another reviewer noticed this in regards to discussions of AI and ethics: *"questions about the environmental costs of contemporary computing (esp. cloud computing and AI approaches to data analysis) [are needed]."* As explained by a fourth reviewer:

> *"Environmental issues and impacts were often situated with other vectors for analysis (e.g. HS-SAS-IM-13) where students were asked to consider impacts to society and the environment. I do wonder where there might be more opportunities to embed a focus specifically on environmental impacts, both due to tech's*

outsized contributions to the climate crisis and because it is an issue younger generations deeply connect with."

Based on these arguments, reviewers made the suggestions outlined in the "Recommendations" box above, regarding specific language use around environmental impacts (e.g., being specific about the "harms" and "destructive" nature of computing on the environment) as well as additional standards areas where environmental impacts could be considered/embedded. In particular, experts believe including specificity about the kinds of harms to the environment being made through computing would be important (by including terms such as the "mining of materials," "disposal of materials," "carbon release," "water usage," "light pollution," "noise pollution"). One expert believed that explicit mention should also be made that "*environmental impacts are not something we can "tech fix" our way out of, but this is not clear from the standards."*

At the same time, reviewers noticed that a focus on humans might be obscuring the critical connections students could be making between computing and its ethical, social, and environmental impacts. While human-centered design is a valued pillar by the expert reviewers - with meaningful connections to the broader focus on ethics and social impacts for the standards, one reviewer noted:

"[H]uman-centered is an ontological value (in design and in decision making) that is placed about other forms of life and orientation on earth. Not an area of expertise for me, but this emphasis on anthropocentrism is a significant one and a kind of value that is probably worth sitting with for a bit. I think about it the most from Katherine Hayle's recent book Bacteria to AI, though I think there are other texts that expand on this. Obviously, the human centered design is a corner-stone for CS, but there are non-human-centered design that are probably worth considering. Anthropocentrism often gets pointed to in terms of climate and the environment and there are breadcrumbs around this topic in the standards as well, but lifting this theme up as one that should be acknowledged here."

While the reviewer was not saying that human-centered design should be eliminated as a pillar or focus of the standards, this comment connected to the larger need to recognize that it is not just humans that computing impacts and potentially harms (i.e., computing also harms non-human animals, plants, fungus, and the relationships between them and earth's ecosystems), and it may be worth acknowledging and addressing this in the standards themselves. Basically this recommendation aims to make known that we live in what some geologists have termed the "Anthropocene" - an epoch where human activity has touched all parts of Earth's and even some of the surroundings of extraterrestrial environments - and have some acknowledgment that computing has played a role in getting us (i.e., Earthlings) to this point.

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: *"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."* **6.5 History of Computing:** Consider editing the History of Computing frontmatter to acknowledge non-Western roots of computing historically.

Referencing broader understandings from Science and Technology Studies that counter ideas of techno-determinism, one reviewer noted that the History of Computing subtopic is a perfect place to elevate the contingent, uncertain, and unpredictable nature of technological change. They articulated the opportunity for the standards in this subtopic to provide a view of the relationships between innovations that's more in line with the empirical research on how innovations unfold:

> *"History of Computing feels like it's missing the way in which innovations tend to spawn other innovations - often years later, and in unforeseeable and unanticipated ways. The creation of high-density storage allowed for hard drives to become bigger, vector processing units allowed videogames to have better graphics, and iteration constructs like map/reduce led to less buggy code. But without any one of these three, the Big Data Revolution (and the LLM revolution that followed) would never have been conceived of, let alone accomplished. This is an important theme to drive home, as it essentially justifies the social value of true, long-term research over short-term, profit-driven research."*

Along similar lines in terms of increasing a nuanced view of computing's history, one reviewer noted that many dominant narratives of computing, and its history, center those who have held the most power historically, and these stories drive larger cultural narratives about who should, or should not, be involved in shaping computing's role in society. They suggested that the standards should both aim to counter these cultural narratives, and encourage students "to dig deeper into the history to surface important stories of underrepresented communities or organizations not typically referenced." This might also be seen as an opportunity to have students explore how different groups understood or understand ideas of what counts as

"progress", or even question progress narratives completely (who benefits from this narrative?). For instance, some groups historically have argued for wholesale adoption of certain technologies, others have argued for careful consideration, moderation, regulation, and still others for outright bans and refusal to develop or deploy them (e.g. debates around nuclear weapons, explorations of the Luddite movement, Amish technology deliberation, municipal cases of banning facial recognition technologies, etc.).

A possible phrasing for a standard addressing this could read:

> *"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."*

A nuanced reading of history could also be enriched by speculative provocations: "What would CS be like if a different group had been guiding its development?" (this would be in line with **Recommendations 8** and **10** to add more speculative practices to the standards).

A final related suggestion in this area related to an implicit Western-centric view of computing history. It came from a reviewer responding to the way that the History of Computing subtopic is introduced in the frontmatter (p12), specifically the opening line which states that "Modern computing has roots in the 1800s". They shared:

> *"The binary code was developed in Africa, and brought to Europe via the divination system of "geomancy". Ramon Llull and Gottfried Leibniz were the first to "translate" this to algorithms; and Leibniz replaced the one stroke vs two strokes in geomancy to ones and zeros of the binary code. George Boole created an algebra for binary code, and Claude Shannon (a fan of Leibniz) the first computing utilization. [...] So to say that it has its roots solely in the 1800s is to subscribe to both the "great man" narrative of history, which most professional historians discourage, and to subscribe to a colonial view of what it means to "compute". [...] Other examples include the "discovery" of self-organization as a basis for computational thinking in terms of neural networks and similar technologies: a key origin point is at MIT, in Negroponte's examination of self-organized architectures in Indigenous traditions. See for example the brief description of this history in Generative Technologies from Africa."*
>
> *"That is to say, it is not enough to merely note that other cultures considered something that is "like CS." These contributions were every bit as influential as a figure like Ada Lovelace, if not more so. [...] There is nothing wrong with including her in these histories, as long as the more significant advances in CS concepts from non-western sources are also included. To do otherwise is to use whiteness as the criteria for inclusion."*

While singling out one line in the front matter might be seen as overly pedantic, it highlights how easily the framing of computing history can implicitly erase many contributions from those that are not typically seen as being at the center of computing culture and its formation, speaking to the need to counter dominant narratives, as noted earlier in this section.

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: *"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."*

One reviewer highlighted one example of how to thread the needle, so to speak, between criticality and a kind of "positive ethics" without falling into techno-utopianism or techno-solutionism. In their response to the way the overview of "Emerging Technologies" used the following phrase (p12): "In middle grades, students explore how computational thinking drives innovation across industries and examine the ethical challenges professionals may encounter.". In response, they stated the following:

> *"I think phrasing it this way -- "it drives industry, but occasionally there are ethical challenges" -- forces students to think about ethics only as the voice of "no". It says nothing about professionals who use computing as a tool for environmental sustainability, labor rights, human rights, democracy, etc. There is exciting work using ethics in positive ways, to reimagine what computing can do for us. That view could be easily integrated here."*

As a way to frame the dynamic differently, they offered the following:

> *"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."*

More broadly, the reviewer saw opportunities to elevate positive impacts of computing but in a way that does not play into dominant narratives of techno-optimism or techno-solutionism. For instance, they saw the possibility for the History of Computing and/or Career Exploration standards to encourage exploration of exemplary, imaginative, and unique positive efforts related to computing that do not emerge from "big tech" discourses and spaces, which might

include the Open Source movement, projects like Wikipedia, Lilypad Arduino, tech worker cooperatives, and others.

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: "*E5-CAS-ET-02: Analyze the limitations of existing technologies and how emerging technologies change the way people work, behave, and communicate.*"

The Emerging Technologies subtopic presents a powerful opportunity vis-à-vis exploring CS impacts and ethics by not only supporting students to consider potential impacts and ethical implications of *current* emerging technologies, but also support *speculation* and *reimagining* of the past, present, future of technology from a prosocial perspective. As one reviewer put it:

> *"I think it would be interesting and useful to, as part of Emerging Technologies, explicitly have students think about the future. Can we help them think through where technology will be going next, and how we can make sure now that it is on a path towards social good and not harm?"*

Another reviewer pointed to larger traditions of Afrofuturism and authors on race and technology like Ruha Benjamin as sources for inspiration. Indeed, Afrofuturism offers a way to think about emerging technologies (and science) as informed by more than markets and state-projects, but informed technical expertise and innovation grounded in a combination of aesthetic, philosophy, and history that speaks to the individual and collective creative experiences of peoples of African descent; (re)imagining what has been, is, and will be. Similar opportunities arise from Indigenous speculative fiction, feminist science fiction, and other creative outlets that bring together identity, imagination, and desires for liberation.

Addressing this concern would also increase the ways that the standards position students as agentic actors in relation to computing, as noted in **Recommendation 10**.

Elevate student agency through applied ethical and critical practices

The next area of recommendations relates to the content of the standards focused on what reviewers saw as a tendency to have ethical and critical practices sitting in a vacuum, so to speak. Impacts and ethics related standards often engage students in "analyzing", "describing", "arguing", practices that are certainly important in terms of coming to understanding. However, they highlighted a notable gap in terms of supporting an *applied approach* to impacts and ethics, one that could elevate student agency both in the context of practicing ethical or responsible design, as well as in the context of being agentic citizens and community members in relation to computing. In short, they wanted to see the standards not just encourage 'critical thinking' but also 'critical doing' in relation to computing ethics and impacts.

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 after 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 within computing design processes themselves. 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 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	**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 *"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."* **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:** *"Create data sheets that document the motivation, composition, collection process, and recommended uses of datasets."* - **9.9.2 Computing and Society - Emerging Technologies - Grades 6-8**: *"Evaluate when it is appropriate to use emerging technologies (e.g., AI) to solve a problem, taking into account technical, ethical and environmental considerations."* - **9.9.3 Programming - Program Development—Grades 6-8**: *"Consider potential ethical issues prior to developing a program."* - **9.9.4 Artificial Intelligence - Specialty II**: *"Create data sheets that document the motivation, composition, collection process, recommended uses of datasets."* - **9.9.5 Software development**: *"Conduct user testing sessions to evaluate if the software serves the needs of users."* - **9.9.6 Software development**: *"Critique the values behind software used in everyday life and its societal implications."* - **9.9.7 Physical computing**: *"Consider ethical issues (e.g., surveillance, privacy, consent) of collecting data from users with sensors and microcontrollers."* - **9.9.8 Games and Interactive Media**: *"Discuss the values embedded in the design of games and interactive media and their ethical implications."* - **9.9.9 CS+X: "***Consider the ethics and possible limitations of incorporating computer science in a non-CS discipline."* - **9.9.10 Data & Analysis - Impacts of Data Science - Grades 9-11**: *"Empirically investigate potentially harmful behaviors of AI systems through audits or external evaluations."*

the standards without isolating concepts across domains.	- **9.9.11 Artificial Intelligence - Specialty II**: *"Empirically investigate potentially harmful behaviors in AI systems through external evaluations or audits."*

Five experts noticed that the emphasis on ethics and social impacts in the standards draft tended to focus mostly on the results of engagements with computing, rather than during the design and problem-solving processes themselves. For example, one expert noted:

> *"[E]thics and social impacts are mostly addressed as issues to be considered after the design of computing systems once these are deployed. I argue that the standards could and should do a better job at incorporating ethical issues and social impacts throughout the design process of computing applications. That is before a system or application is designed, while a system is being designed, and after a system is deployed. A second and similar concern is that the standards frame ethical and societal considerations as aspects to be discussed and not practiced in the design of applications. Here there is great potential to incorporate standards that foster bringing in ethical, axiological and societal issues to the design and development process and that promote the empirical investigation of such issues. Such integration could support students to understand that technical and ethical aspects are intertwined. A third opportunity for improvement involves creating standards that highlight axiological issues related to computing to involve learners in considering the role that values (of designers, corporations, governments, and users) play in the design of technology. Finally, I argue that all specialties should include standards related to ethical/axiological/societal issues."*

Here the expert lists three different points all related to the same idea, namely the importance of: 1) including ethics and social impacts issues throughout the design process, 2) focusing on ethics and social impacts as design activities, not just as discussion topics, and 3) clarifying for students how values shape design decisions, and therefore why, in particular, the specialty standards should highlight the ethics and impacts of computing.

Each of these three points was echoed by another expert who noted:

> *"While the standards draft do an excellent job of raising awareness of the ethical and social impacts of computing technologies post-creation or release, the values, priorities, and contexts surrounding a technology's creation is sparsely covered. Given that students are learning to move past being consumers of technology and into becoming creators and designers themselves, it's crucial that they learn not only to analyze the values, priorities, and contexts in a computing technology's inception and development. Implicit in the fact that they are analyzing others' creations so extensively are first, that students only analyze computing technologies' ethical and social impacts after they are out in the world, and second, that only computing technologies designed or created by others are worth this level of scrutiny."*

Relatedly, another expert said that *"Encouraging educators to weave impact discussions into programming instruction—rather than treating ethics as a separate or add-on topic—will support deeper integration of ethical reasoning across the curriculum."* More specifically, this expert pointed out that this can happen through more cross-strand connections that support reflection on ethics and social impacts during computing practices*:*

> *"[My] review also highlights the need for more explicit cross-strand integration—encouraging teachers to embed ethical inquiry directly into programming and technical instruction….One of the more significant*

missed opportunities is the relative isolation of concepts across domains. For example, "Impacts of Algorithms" is treated separately from "Programming Fundamentals." Yet one of the most powerful teaching strategies is to embed ethical reflection into technical practice. When students write algorithms, they should also be supported in asking: Who might be impacted by this? What assumptions are built into the logic? Who benefits and who is left out? "

This was also noticed by another expert who stated: *"much of the material about ethics and social impacts is presented as somewhat standalone and not in direct relation to the technical content standards."* For this reviewer, separating ethical and social impacts issues into an "Impacts" section added to this notion that thinking about these issues is separate from technical content and practice. More specifically, they explained:

"Though some of the ethics material is inserted among the 'technical' sections of the respective parts of the curriculum, the explicit inclusion of a separate "Impacts of" section in many of the thematic areas reinforces the impression that thinking about the impacts of technology is separate from, rather than an integral part of learning about the technical aspects of computing….It reinforces the idea that tech-ethics is "extra", nice-to-have content, but not an integral part of CS. It's an add-on, as opposed to a natural and non-negotiable part of what it means to engage with CS. I realize that this is likely not the intention of the authors of those content standards/the curriculum as a whole and also that it may not always be possible to tightly integrate ethical issues and content related to socio-technical aspects with specific technical concepts. Nevertheless, if we want to truly engrain socio-technical and ethical thinking into technical decision-making, it's helpful to break down this barrier where possible even in the way in which this content is presented."

The ASICS team acknowledges that dissolving the various "Impacts" sections in the drafts is not feasible as it would require a large structural change. We recommend an approach that more tightly couples the technical content with the ethics and social impacts content in non-impacts subsections, which can then be referenced and built upon in the "Impacts" subsections. This recommendation is in line with the internal logic of the "Ethics and Impacts" pillar to consistently be present in each topic, and each relevant subtopic. Furthermore, this recommendation can provide guidance to teachers working to implement the standards. As the expert above put it:

"In my experience, CS ethics material is the material that CS instructors are least familiar with and often struggle to relate to the technical content they teach. That makes it harder for them to deeply integrate it with the technical material they present to students. A good curriculum should make that integration as easy as possible by co-locating it with the relevant technical content standards wherever possible. This will make it easier to put the material where students will be most likely to recognize its relevance and will likely improve student engagement and retention of material."

The importance of this was further emphasized by another expert who explained:

"based on these standards, students will be exposed to a wide range of ethical and social impacts. However, I foresee a mismatch or disconnect when they identify all these impacts, but the practices they are learning consistently prioritize efficiency and less consistently prioritize usability and the addressing of the impacts they identified"

Toward such ends, one review gave various specific suggestions to incorporate into the standards draft (listed as "targeted suggestions" above).

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	Targeted 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 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.	**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 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, "*expand beyond formal reports to include oral presentations to diverse audiences including community members, school leaders, policy makers*", with the intention to "*have students take seriously the question of audience and usability of their data investigations.*"

With a view that the standards should encourage *student agency* in relation to issues of ethics and impacts in computing and not simply promote awareness, a number of reviewers pointed out that the standards could be improved in terms of how students are prepared and positioned to respond to impacts of computing "after the fact". That is, students may come to understand

various risks, harms, or complex social implications associated with computing, but what do they do after they come into this knowledge?

Just as **Recommendation 9** encouraged the standards to more deeply intertwine practices of critical design and inquiry *within* the design process (i.e., before a system is designed, during its design, and after deployment), taking the position of "designer" who is acting with ethics and impacts in mind, this recommendation acknowledges that not all students will become designers of technology, and need to be prepared, more generally, as citizens and community members able to respond to the impacts of computing broadly speaking. Incorporation of practices that support agentic responses to impacts of computing in this way are of particular importance for K12 CS standards given that only about 2% of K12 students are likely to end up in technology related careers, but all of them will live in a society where they will need to be able to respond to the impacts of computing.

In line with this ethos, one expert stated:

> *"Mitigating or preventing these harms requires political/regulatory and legal remedies, not normative evaluation by children. Thus, instead of telling young people they need to be more ethical, the social impacts parts of the K-12 CS curricula should instead focus on engendering criticality, citizenship, and support for a social or public sphere perspective towards computing."*

Experts pointed to a number of practices on this front: voice and advocacy, refusal, and reimagining.

One expert, framing voice and advocacy as "resistance", shared the following related to advocacy and refusal:

> *"What about resistance and refusal? I'm wondering how both tactics can be incorporated into the standards. For instance, might refusal to participate in a computing system–either as its designer, user, or both–be mentioned as a possibility alongside more normative discussions of "ethical design" that seeks to do the least amount of harm. [...] I think it'd be helpful to expand the ways students engage with–or stop engaging with–extractive systems rather than only thinking of ways to make them more fair. For example, is a more accurate facial recognition system deployed by a fascist government a better solution than never deploying the system at all?"*

The same expert noted, in relation to the Career Exploration subtopic, how that area might be a good opportunity to explore how students might come to understand the ways that workers are currently organizing and engaging in collective action, both within the tech industry and beyond it.

Another expert noted the importance of creative expression and voice when it comes to supporting students to respond to the the impacts of computing, stating:

> *"In the high school strands especially, there is an opportunity to move beyond analysis and evaluation toward creative and agentive practices. Rather than simply investigating impacts, students should be encouraged to interpret and express their understanding through digital storytelling, podcasts, visual art, video essays, or other narrative forms. This kind of work is supported by a growing body of literature on*

narrative, culturally responsive pedagogy, and youth media production. Such projects not only deepen learning but also empower students to shape public dialogue about technology."

Experts also pointed to the importance of students being able to engage in practices related to reimagining computing systems and associated social futures. Also known as speculative practices, "reimagination centers on rethinking the present and the past to critically reimagine computing for the future"[1]. In relation to this, one expert shared:

> *"I was struck that the words "imagine" and "imagination" do not appear in the document. What role might–and perhaps should–imagination play in the standards? More specifically, I'm curious if practices like speculative design might be offered as ways to think and create beyond current limitations and invite novel (if not immediately feasible) computing responses/solutions to pressing social problems."*

Multiple experts praised standard MS-ALG-IM-09 (*"Modify an algorithm to address a specific social impact, ethical issue, or bias"*) which reflects a stance towards reimagining computing systems. As one expert put it, this offers a "*pro-active 'reclaim' approach.*" This could be used as a model to integrate speculative practices into other relevant subtopics, such as History of Computing (see **Recommendation 8**) and Career Exploration (see **Recommendation 12**).

[1] Morales-Navarro, L., & Kafai, Y. B. (2023). Conceptualizing approaches to critical computing education: Inquiry, design, and reimagination. In Past, present and future of computing education research: A global perspective (pp. 521-538). Cham: Springer International Publishing.

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	Targeted 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. **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	**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 *"Examine how users consent to their data being collected by computing systems."* **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-0211.13 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. **11.12 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 *"justify which data you included and excluded and why that was ethical (or potentially unethical)"* **11.16 DAA-DI**: consider adding a grades 6-8 standard "Explain how data

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.	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"?

Data do not speak for themselves, much less have a representational foundation for material and social phenomenon when processed through or being used to train large language models or other "AI" applications. Many experts pushed against the idea that data should be treated as neutral or value-free, seeing this as one of the central ways to address issues of bias in computing:

> *"Much of computer science, as an academic discipline, largely embraces those neutral framing of data, and so it is authentic to the discipline, but information science, and many areas of data science, are quite nuanced about the way that data definitions can warp and bias what we observe and don't observe — especially because not all phenomena are observable or digitizable. Adding standards to address this root cause of much bias would be important."*

These concerns were echoed by another expert:

> *"Data always flattens and simplifies, and students should be aware of the fact that the choices they make in terms of how they operationalize their variables shapes (and sometimes distorts) how others perceive the world (or the represented phenomenon)."*

Importantly, the experts want teachers and students to understand how data sets themselves come with (are selected for) a priori assumptions or values, often related to how humans and nonhumans are classified:

> *"I want to see more about bias and data sets. A topic that seems to be missing, for example, is attention to the politics of classification and how these inform data sets. For example, what racial categories are used and how does that matter in this data set? Students need to be positioned to question the classification*

assumptions in data to understand who and what has gone missing because of the categories employed in addition to the topics related to biased data in the standards."

The reviewers suggested a number of ways for how students can engage with data as value-laden. We think framing these as data practices or critical data practices can help to highlight the importance of centering teachers' and learners' agency.
Data manipulation is important for making them useful in analysis. But with the increased amount of data, data sets can be manipulated in ways that may be intentionally harmful (e.g., including deceptive data points) or can be analyzed in ways that are misleading (e.g., p-hacking or data fishing). What is more, because data do not speak for themselves but must be contextualized within narratives, whether produced by social media algorithms, academics for a journal article, or the popular press, it is important for teachers and learners to understand how data can be presented in ways that may be more or less misleading. As one reviewer put it:

"An incredibly important lesson that could be added to Data Investigation is understanding how data can be manipulated and how data storytelling can be intentionally misleading, i.e. how to lie with data with an emphasis on understanding how to understand when you're being lied to."

Thus it is important for the standards to talk about 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. As this reviewer notes, storytelling (either creating narratives or critically evaluating narratives) is one of many practices that teachers and learners can use to think about how data are partial and situated, presented differently to different audiences.

In addition to understanding how data are analyzed and presented, some reviewers thought that it is important for teachers and learners to 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. Given that all of our online interactions and activities are treated as data points that are aggregated and sold to businesses to help make behavioral predictions about users and consumers, it is important that teachers and learners have a sense of how valuable our clicks, time spent on an app, and social media usage are treated as commodities to shape our future online interactions and behaviors. And, it is, thus, important for teachers and learners to understand how they might protect their data legally (e.g., copyright) and in their everyday activities (e.g., limiting cookies). As one reviewer noted:

"I think that privacy should be a bigger component of Data and Analysis. "Where does data come from?" should be a really important question here. I suppose this is covered under "Impacts of Data Science" but I feel like it should be more explicitly in the pipeline of data collection rather than an afterthought… Ownership (e.g. copyright) and consent should also be part of Impacts of Data Science re: data collection, not just privacy."

Another thing to consider here is "data sovereignty", which describes how groups of people, including Indigenous communities, can put in place policies and regulations that limit how their data are collected, kept, and analyzed, and by who.

Indeed, it is important for teachers and learners to 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 and the state to ensure ethical data collection, store and use. As one reviewer noted:

> *"In the "Impacts of Data Science" subtopic, a focus on the responsibility of industry to develop and distribute products and systems ethically can be integrated into standards like HS-DAA-IM-16 (data collection) or HS-DAA-IM-17 (regulation on data usage)."*

Importantly this can be connected to the study of history and research ethics (e.g., Tuskegee Syphilis Study, Facebook emotional contagion study, Cambridge Analytica study, and the r/ChangeMyView study), with students asking questions about how research ethics should be responding to changing data practices and collection and analysis techniques. For example, should the companies that are making large language models pay for the data they are using if it is copyrighted material? Can our data be used in training sets without our consent?

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:*"Examine how computing careers in for-profit, not-for-profit, and government vary."* **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.

While acknowledging the Career Exploration subtopic effectively broadens the conversation from a more traditional "explore tech careers" approach, experts saw opportunities to both expand and deepen student learning in this area.

One expert highlighted a way for students to understand pro-social applications of computing that lie outside the traditional 'tech work' paradigm of being a software developer or engineer at a large technology firm. They pointed to the importance of helping students understand how computing careers look different in their purpose and social role across different sectors:

> *"One consideration often overlooked in discussions of careers are the many careers outside of large, visible for-profit enterprises. Federal and state government, not-for-profits big and small, even small for-profit businesses, all use computing, and students should be aware that careers exist across all of these sectors. The U.S. Digital Service is a good example of an effort to make these more visible, but it is hard to compete with the well-funded recruiting efforts of big tech."*

Relatedly, another expert pointed out that "real world" applications of computing in adult lives aren't limited to the world of work, somewhat troubling the premise that the subtopic should simply focus on careers, sharing the following:

> *"It is important to highlight connections to the world of work for learners. But real-world connections of all sorts might be highlighted for greater impacts -- computing is not just used in careers, people use computing in their hobbies, to participate in civic life and affinity groups, and to conduct inquiry across a range of disciplines."*

While those recommendations aim to expand the scope of what's covered in the subtopic, others focused on deepening and nuancing the kinds of understandings related to the intersection of computing, professional life, impacts, and ethics.

One shared that the subtopic, in line with values of broadening participation, should support students to understand and explore issues of diversity and marginalization within the tech sector:

> *"No standards acknowledge the lack of diversity and equity within many technology-related industries and companies. It would seem important, especially at the High School level, to support learners to be critical thinkers about and agents within the workplaces they might consider joining, which could help them find companies with inclusive cultures, protect their own well-being, know their rights, and support them to find resources, affinity groups etc."*

Finally, in line **Recommendation 2** which speaks to techno-optimism, multiple experts noted that in considering the role of computing in professional life, the standards would be remiss to leave out explorations that encourage students to consider changing labor dynamics related to automation and surveillance:

> *"The focus of career-related discussions of computing frame technologies as "new opportunities for growth across diverse fields" (p. 13). However, as the discourse around AI/GenAI has made clear, computing technologies also replace, displace, and disempower workers. How might the standards make space for discussions of how computing technologies are sometimes used by managers and other powerful administrators against workers through automation and surveillance? And consequently, how might the standards gesture towards collective actions that workers take in response?"*

Aim for Consistent Application of this Vision Across the Standards

Whether the standards writers choose to adopt, adapt, or remix the vision of computing impacts and ethics offered above, or articulate something distinct from it altogether, the expert reviewers encouraged that a clear vision be applied *consistently* throughout the standards. They highlighted three ways to think about consistency, explored in the recommendations below.

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.

Seven experts emphasized that consistency and clarity of vocabulary is important, especially since the standards document may serve as a pedagogical document informing readers of new ideas or ways of thinking about computer science education.

For example, one expert noted that terms like "equity" could have multiple meanings for both writers and readers. Thus, this reviewer suggested introducing the multiple equity frames outlined in the National Academies of Science, Engineering, and Medicine (2025) "Equity in K-12 STEM Education" report to hand-hold readers around the concept of equity. They suggest that the introduction to the report could benefit from details on pages 22-23 of this NASEM report, about the importance of understanding equity as multifaceted across "Five Equity Frames." This helps go beyond presenting "equity" only as an issue of access or reducing gaps between groups, which one expert felt the current standards seem to emphasize.

Related to this need to clarify definitions/concepts (such as "equity") in the document, reviewers noticed some inconsistent use of language and lack of clarity around terminology that should be addressed. More specifically, one expert explained:

> *"the draft was fairly inconsistent in how the words and ideas of 'fairness', 'responsibility', 'equity', 'accessibility', 'bias', 'harm', 'risks', and 'ethics' were used. Sometimes they were invoked in a list, with a subset of these mentioned, but the subsets mentioned in standards often varied in an arbitrary way. This led to a sense that they were being used interchangeably, or that they were meant to refer to a broad set of interrelated ideas. This is potentially okay if there isn't a goal of engaging the differences, nuances and connections between these terms. But if that is a goal of the standards, there should be more care and intentionality about their use. For example, accessibility is a kind of equity specific to disability justice; fairness can be a way of talking about equity, but also connotes the different idea of equality; ethics often refers to traditions of philosophy, which does not engage the broader humanities and social science ideas about inequality, structures, and history. One way to address these more consistently would be to select the set to be used, define them in a preamble section, and then invoke them in standards consistently, when relevant, so that readers have a reference for what is meant."*

Another expert echoed this and shared:

> *"it is currently unclear what the political commitments are of the CSTA Standards when some sections discuss 'fairness, transparency, and accountability' versus 'equity, access, and the ethical' versus 'ethical, legal, and social implications.' I recognize that these inconsistencies arise from how the document is written by small teams, if not individuals! Nevertheless, these are very charged words whose use must not be postponed as a detail that can be simply ironed out. And as I say in other materials, naming equity and accessibility are important such that things like 'ethics' or 'computing and society' are not sanitized in ways that undercut the focus on equity. And, sometimes, these are written as a single competency in a full specialized standard or a subtopic, which makes it feel like an inauthentic engagement."*

Similarly, another expert noted that it would be helpful if terms like "user" and "bias" were clearly defined for readers:

> *"I do want to, though, elevate a wondering about general vocabulary throughout the document (or at least throughout the parts highlighted for my review). Words like "user", "bias", and others noted in the marked-up copy feel like they would be useful for building out a clearer set of definitions. Some are implicit, but some make some reaches around what kinds of consensus is assumed about educators using these standards."*

This need to clarify what "bias" means was shared by another expert:

> *"We have been talking a lot about different terminology to specify applications and impacts of bias. There are many standards that address bias (which is great!) but I wonder if it may be useful to differentiate between data bias as a scientific term and implicit/explicit bias as factors that cause and reproduce it."*

In these ways, experts agreed that clarity and consistency in terminology are key, and should reflect CSTA's commitments and values toward equity.

To further support this clarity and consistency, experts suggested not only adding a glossary of terms, but also providing examples of CS concepts and ethical issues among the standards (or perhaps as an appendix) that may enhance clarity of interpretation. Rhe New York State Computer Science and Digital Fluency Standards was pointed to as a model. More specifically, one expert noted that because the current draft presents standards without explicit examples, readers may find the ideas too abstract and ambiguous to adequately *"guide curriculum providers and educators to the kinds of robust learning experiences standards writers imagine."* It also leaves the ideas indistinct across the Impacts sections (Impacts of Algorithms, Computing Systems, and Emerging Technologies), flattening out the subtle and nuanced distinctions between these.

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.

While one reviewer, a curriculum developer, found the learning progressions for PreK-5 in ALG-IM and CAS-ET to be clear (*"excellent progressions…a very clear sense of how to incorporate these in an accessible and age-appropriate way"*), several other reviewers struggled to identify a consistent scaling up of ethics and impacts-related content across (sub)topics. As one reviewer put it,

> *"I didn't sense across any of the different areas of the standards that there was a perspective on what that learning progression was or a theory about what it needed to be or a developmental perspective on the different capacities for reasoning in sophisticated ways."*

Another reviewer acknowledged that opportunities for ethics and impacts-related inquiry does get deeper and more complex across grade bands, but not necessarily in a way that builds on previously presented ideas and skills. In relation to DAA-IM, she wrote:

> *"They don't feel like they are scaling up on one skill so much as deepening / complexifying in lateral directions over time. Why is analyzing the risks and benefits of AI considered the 5th grade standard, when 5th graders could also do the 1-4th grade standards in a deeper way?"*

Finally, another reviewer cautioned that the absence of unclear learning progressions could generate the mistaken impression that ethical analysis does not progress and scale up over time. As she observes:

> *"Ideas are often introduced once at some level but rarely revisited and refined at higher levels… That's a missed opportunity (allowing students to grow and refine their ethics-related skills) and also sends the wrong signal: namely, that ethics-related content is a one-off add-on that doesn't require a more nuanced treatment which is worth revisiting across the years."*

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
15.1 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).	**15.4 DAA-IM:** Consider introducing the concept of "data bias" at the late elementary level. **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 *"broken out into something like:* *-Describe common societal impacts, ethical issues, and biases of algorithms.* *-Analyze the properties of an algorithm that might lead to negative social impacts and ethical issues including bias.*

Many reviewers voiced concerns that the standards provided limited opportunities for PreK-5 students to grapple with the complexities of the social impacts of computing. As one put it:

> *"The lack of cultural, global, and critical perspectives in primary [grades] is a missed opportunity. There is much research showing that youth can grapple with these things, and don't need overly simplified versions of history."*

Echoing this sentiment, another expert wrote:

> *"I believe younger children can handle and deserve the more complex and more true narrative from the start. To make a clunky social studies comparison, it's analogous to teaching young kids that in 1492 Columbus sailed the ocean blue, but reserving the complexity of colonization till they are older. We don't teach the horrors of colonization to young children because that violence isn't age appropriate, but we also work hard to prevent a one-dimensional narrative from being taught at any age."*

Similarly, (in response to the PRO-TR subtopic), an expert advocated:

> *"I believe the prek-5 grades would benefit from grade appropriate ethics/bias consideration which have only been added to secondary. Younger children can thoughtfully interrogate issues of fairness and justice, and I would suggest that they should in computing, just as they do in other subjects (ELA, Social Studies). I caution against presenting computing as neutral or, worse, a net-good, in elementary school while waiting till secondary grades to add nuance, context, and the more accurate story of computing."*

To support students in grappling with complexity, various reviewers suggested situating the social impacts of computing in students' lived contexts. As one expert put it in the context of group decision-making:

> *"Individual decision-making is prioritized…[but] PK-5 students are ready to grapple with group decision-making connected to technology (for example, related to technology introduction in their classrooms, technology use at home)….While the standards for younger students are generally appropriate, I recommend more attention to how computing tools shape family life and interpersonal dynamics. Young children often have deep lived experience with technology in the home, including parental phone use, shared media consumption, and digital communication. Standards in this band could benefit from drawing on these everyday experiences, offering age-appropriate ways to reflect on how computing systems mediate family relationships. Moreover, when introducing ethics and impact in early grades, it's important to recognize the emotional and cognitive readiness of children. Some topics—such as data surveillance, labor impacts, or online safety—can be addressed, but they must be framed with care and situated within children's lived contexts."*

Another way to put it, is that PreK-5 students are typically familiar with computing technologies such as "*phones*" and "*screen time*" and "*computer use in schools*" and the question becomes how to best support students in reasoning about the social impacts of these in a sophisticated and

complex way. To this end, one expert suggested providing students with well-scaffolded "tools, building blocks, foundational things for the grappling of complexity." At their best, these tools can even help students extend their reasoning about their personal spheres to larger scales of social impacts or to other computational technologies they are less familiar with. We believe The Philosophy for Children movement serves as a good model with many tools and activities on offer for facilitating complex ethical conversations in PreK-5 (see Philosophy Learning and Teaching Organization (PLATO) and activities that have been used with primary grades such as the magic box activity). As tools and building blocks are used to support children's cognitive readiness for engaging with larger scales of social impacts, it is ever-important to maintain age-appropriateness in content for what young children are emotionally ready for. Thus, it is important for the standards to open up inquiry into the multi-dimensional ways that content is introduced while still maintaining age appropriateness.

Reviewers noted multiple standards that modeled this age-appropriate complex engagement well, such as the **ALG-IM** subtopic for PreK-5 (*"yay! This one offers a model where the youngest folks get some complexity"*). Another found similar strengths in **E1-CAS-ET-02** (*"Describe how technologies new to students create both benefits and harms in personal and family life."*) and **E4-CAS-ET-02** (*"Investigate intended and unintended consequences related to emerging technologies."*), while a third expert pointed to the **SAS-IM** overview (*"In early grades, students examine the impacts of computing systems on individuals"*). At the same time, some reviewers identified multiple standards that were too complex either in the levels of inquiry and analysis involved (see **15.10** and **15.11**) or in the density of the standard--combining too many topics into one standard (see **15.12**).

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.

Although the ASICS team is mindful of the limitations of space in the Standards, they believe the Standards would be strengthened if the later grades balanced both the real-world and personal, with the more abstract and global. Experts provided multiple rationales for this recommendation. One reviewer argued that foregrounding students' relationality can enhance their analysis of larger-scale social impacts:

> *"I understand that for the elementary grades, it is important to make connections to their daily lives. However, I don't think that the students' relationality to the ethical and social impacts has to diminish as the*

scale of impacts grows…and I think that further emphasizing students' relationality will buttress, not weaken, the broadened scope and increased complexity of analyses tasks in middle and high school."

Furthermore, one expert cautioned that by backgrounding personal connections and real-world examples in the later grades, the standards present a false dichotomy portraying computing as ultimately an abstract and technical topic separated from real-world and social concerns:

> *"Often in the standards, real world examples are prioritized for Grades PK-5. This is then replaced by "more technical" / "more abstract" standards. But why aren't "real world" examples and connections to student daily lives thematically integrated across all grades in all sections? As is, the standards reproduce a problematic social vs. technical binary and suggest that real computing is different from real world examples".*

Further still, an expert pointed out that the pronounced drop off in computing that occurs in Middle School might be mitigated if Middle School students were given more opportunities to make personal connections to computing topics.

> "*Elementary and high school have standards related to personal interests. Given that the drop off for some demographics in computing happens in middle school, including or reframing a standard that prioritizes this connection for persistence would be great"*

The ASICS team believes the CAS-CE standards offer a good model for cohesion across grade bands (real-world problems are explored in Grades 6-8, and personal interests and aspirations are elevated in Grades 9-12). As one expert put it: "*Relationality is really strong here! [later grades] Would love to see the same level of relationality in the rest of the subtopics."*

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 *Data Science* and *Cybersecurity*. 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 *Cybersecurity* 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. **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)	**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 *"more politically sensitive topics such as national security, definitions of citizenship and adversaries, immigration, and the weaponization of data"* **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)."*

Several experts argued that the natural affinity between the topics in the specialty standards and issues of ethics and social impacts could be leveraged. One expert was especially worried that if this connection is not explicitly elevated in the specialty standards, students will perceive computer science as a set of technical skills detached from ethics. As she put it,

> *"These are all technical skills but it reads like that's what the "real" computer science stuff is since it's in the specialty section. When a student in CS amps up their specialty skills, they should also be amping up their understanding of ethics, responsible use, and the role of computing in society."*

To integrate Impacts and Ethics into existing specialty standards we suggest drawing inspiration from the Specialty Standards that explicitly integrate ethics and social impacts of computing, such as Data Science (S2-DSC-EL-20 through S2-DSC-EL-23) and Cybersecurity (S2-CYB-EC-22 through S2-CYB-EC-26). Although the Data Science and Cybersecurity Specialty Standards were well-received by experts (including the reviewer directly quoted above) other reviewers offered various ethical issues that could be integrated to better provide high school students with what one reviewer called "awareness of the complexity and political stakes" of these topics (see targeted suggestions above). Additionally, experts provided targeted suggestions for specific topics and language that could be used in various Specialty Standards (see also **Recommendation 9** for further suggestions).