Reimagining Accessibility and inclusion in K-12 CS Education through curriculum and professional development

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Introduction and Statement of Problem

Internationally, computer science (CS) education is entering K-12 instructional settings at a rapid pace. This push to bring CS into K-12 education is widely attributed to its potential to engage young learners in creative problem solving (Webb et al., 2017; Yadav et al., 2016), and empower them to pursue technology-mediated career paths (Webb et al., 2017). Despite this emphasis, little research and development efforts have focused specifically on the inclusion of K-12 students with disabilities in CS education (Ladner & Israel, 2016). Without a specific focus on inclusive pedagogies, tools, and curricula, many students with disabilities will be left out of these critical opportunities.

In any discussion of inclusion of students with disabilities in K-12 CS education, it is important to recognize that disability is a complex construct with interactions between a person's personal characteristics, their environment, and social attitudes both in and outside the disability or education communities. Ableism and internalized ableism are present across communities. Thus, we need to be cautious in our definitions and conceptions of disability in this work. Our hope is that we set a trajectory wherein instructional tools, curricula, professional development, and other resources can be developed and studied in a manner that promotes learner empowerment for all learners. Rather than considering the range of learners as an afterthought in the development of K-12 CS related tools, curricula, and professional development, consideration of all learners should be at the forefront of these development efforts. Research that does exist points to multiple barriers to inclusion and participation. A few of these barriers include:

- <u>Preconceptions about students' abilities and belonging in CS education and CS-related careers</u>: There is no way to discuss students with disabilities in K-12 CS education without recognizing that many of the opportunities provided to students with disabilities are based on their teachers' possible biases and perceptions of students with disabilities. Because of broad definitions around inclusive education, which influence at times clear and agreed understanding of inclusive practices (EADSNE, 2011: Florian, 2012), many teachers may attribute students' challenges to their disability rather than to lack of effective pedagogical practices (Florian and Linklater, 2010). Thus, instructional decisions about who belongs in CS education may be attributed more to preconceptions around disability than to knowledge about students' capabilities and interests in CS.

- Limited teacher knowledge: Teachers' limited understanding of how to support students with disabilities in K-12 CS education, inaccessible tools and curricula are reported in the literature (Israel et al., 2020; Ladner & Israel, 2016). Additionally, since many teachers are also new to teaching CS, they are considered "twice new": New to CS education and new to inclusive subject-specific practices within CS education. At the same time, we must be sensitive to the fact that teachers are overburdened, and professional learning experiences around inclusion need to be carefully planned and integrated within wider school considerations.
- Lack of accessible tools, curricula and materials: Given the wide range of disabilities, designing tools and materials with accessibility features for some learners may not be accessible to students with different disabilities (e.g., students with visual impairments vs those with cognitive disabilities). Thus, design for accessibility and inclusion is a complex task.
- Lack of data on inclusion and participation of students with disabilities in K-12 CS instruction: Without data on the level of participation of students with disabilities in K-12 CS education, it is difficult to understand the extent to which students with disabilities are kept out of CS education. Depending on location/state or country, and approach to special education/inclusive education, students may continue to be segregated and kept out of CS instruction. However, there is no current way of assessing the extent to which students with disabilities are provided access to K-12 instruction.

These barriers limit the accessibility, inclusion, and participation of students with disabilities in K-12 CS education. Despite these barriers, emerging research suggests that using instructional strategies such as Universal Design for Leaning (UDL) in the design of products, mechanisms, services, and supports can help overcome these challenges (Burgstahler, 2009; Israel et al., 2020; Ray et al., 2018).

The good news is that despite these barriers, students with disabilities can be successful in CS education, especially when provided with accessible instructional experiences and as an extension can be successful in pursuing careers in CS (Stein, 2018). Research shows that the key, as with all learners, is to provide students with accessible and engaging teaching and learning approaches through the use of instructional approaches such the use of Universal Design for Learning, balancing explicit instruction with open inquiry instruction, and addressing accommodations and modification needs (e.g., Bouck et al., 2020; Israel et al., 2020; Ray et al., 2018; Snodgrass et al., 2016). Thus, our purpose is to reduce barriers to inclusion and promote inclusive practices that allow all students to participate in K-12 CS education.

Vision Statement

Disability is a form of diversity that is part of the human condition and should not be considered through a deficit model. It should be celebrated and all Computer Science students should be empowered to learn and leverage their strengths. Accessibility and inclusion should be a priority in design, not an afterthought.

Goals and Action Steps

We propose the following goals to achieve our vision. First, we adopt a prospective approach to accessibility in K-12, where we examine indicators for designing accessible and inclusive curricula, assessments, and other implementation practices. However, there are also many existing implementations with various levels of accessibility. We therefore also adopt a retrospective approach, where we identify best practices in making existing curricula, assessments, professional development, and other implementations more accessible. Lastly, we need to characterize the kinds of professional development that teachers need to enact accessible, inclusive CS instruction.

Goal 1

Examine indicators for designing accessible and inclusive informal and formal K-12 CS curricula, assessments, and other implementation practices. (A Prospective Approach)

For K-12 CS education to be available to all learners, new curricula must be proactively developed to maximize inclusivity and outcomes for the broadest range of learners possible. Given the current state of CS education, however, this approach is rarely taken. When tool and curriculum developers design instruction for accessibility and inclusion, those materials benefit all learners. A few examples of such programs include Bootstrap: Algebra, an integrated programming + math curriculum, who designed their platform to be accessible for learners with visual impairments (Schanzer et al., 2020). Unfortunately, this type of focus on accessibility is not the norm. Therefore, the K-12 CS education field would benefit from a set of indicators for designing accessible and inclusive informal and formal K-12 CS curricula, assessments, and other implementation practices. Although accessibility features do exist, there is a lack of guidelines for applying these specifically to CS education tools and curricula, and there is no connection between these features and the design of accompanying UDL-based instructional materials.

A key component to the design and implementation of such indicators is to prospectively approach curricular design by disallowing a deficit model of disability and explicitly embracing a more contemporary understanding of disability as a natural part of human diversity. Historically, a deficit model situates disability as an individual ‘problem’. Rather, a social or relational model situates disability as a lack of access and opportunity resulting from environmental, social, technological, attitudinal, and design barriers that are ubiquitous in a society designed by an able-bodied majority. It is precisely because of a deficit model that educational processes and practices have not previously considered built-in accessibility and inclusion. It is also why many students require accommodations and must adapt to the demands of their curricula, rather than the curricula being designed with the needs of these diverse students. By disallowing this model at the onset of curriculum development and considering diverse learning needs for a variety of students with disabilities, both curricula and assessments can be implemented from the ground up ensuring embedded inclusivity and access features based on UDL principles. In this way, disability is approached from a social/relational model, aimed at removing barriers to facilitate student access and success.

Such a fundamental paradigm shift can also support reimagining the scope, breadth and focus of an inclusive CS curriculum. By identifying the dominant influences that have shaped curriculum development, further research can reflect on the starting points for considering the content and context of an inclusive CS curriculum from a Disability Studies perspective. An inclusive curriculum informed by social justice philosophies can consider the subject capability (in this context CS) by 'incorporating goals, content, and materials that reflect people with disabilities' individual lives, and their collective history and culture' (Symeonidou, 2020). In this way 'the quintessential curriculum studies questions: What knowledge is of most worth? Who decides? Who benefits?' (Baffington-Adams & Vaughan, 2019) can be addressed. Reflections around what substitutes core content knowledge can be accompanied by discussions of how that content knowledge will be embedded in a way that marginalization and focus on individual differences is avoided.

Pressures around achieving high academic standards are focusing on particular input approaches that may disadvantage some learners. There is the opportunity to consider ways that CS knowledge can be assessed in inclusive ways that allow for evidence -based as well as multisensory ways of expression and communication.

Action Items:

- Develop a set of guidelines for accessible, inclusive CS curricular resources
  - There are currently guidelines and resources related to accessibility and UDL. These guidelines and resources should be used to develop resources specifically focused on their application for the design of accessible, and engaging K-12 CS instructional materials. These guidelines can be divided into selection of accessible tools, UDL-based lesson planning, student-facing computational materials, accommodations and modifications, and assessment development.
- Through a design-based research (DBR) process, design a set of prototype learning experiences/instructional units that demonstrate the use of these aforementioned guidelines. Given that there are a great deal of currently available resources, this action step will be developed as a demonstrative example rather than for wide-scale curriculum development purposes.

Prototype units will focus on UDL as well as on addressing a wide range of functional needs.

As part of the DBR process, conduct participatory design studies for and with people who might use the guidelines and prototype instructional materials, including a range of stakeholders.

- Conduct a set of mixed-methods studies on the implementation of the inclusive K-12 CS educational curricular materials.

Goal 2:

Identifying and adopting inclusive best practices for making existing curricula, assessments, professional development, and other implementations more accessible and engaging for all learners, including those with disabilities (A Retrospective Approach)

To reorient CS education toward accessibility and broader participation, retrospection techniques to help make existing practices more accessible should be devised and implemented. While relatively a small step forward compared to the radical change in the system, this approach provides practical steps that can be taken immediately. As compared with proactively building tools and curricula with accessibility and inclusion in mind, this retrospective approach requires the development of guidelines for examining and identifying barriers within curricula, including lesson design, student-facing instructional materials and technologies, and assessments. The guidelines should ask the question of whether the current practices were designed with the consideration of the following adaptions: i) flexible instructional materials that have broad engagement opportunities, highlighting ways where UDL principles can enhance learning and participation, ii) recommendations for additional accommodations in categories of presentation, response, setting and scheduling (Beech, 2010), and iii) suggestions for integration of assistive technologies. For example, the measurement of academic achievement of students should consider that some students with disabilities have been taught using modified curriculum or resources, so such assessments should account for materials they were not exposed to thoroughly.

To develop and implement these guidelines, it is important to take into consideration evidence-based teaching practices, the experiences of students with disabilities in CS education, and the needs of stakeholders (curriculum developers, educators, and students). Additionally, we aim to provide guidance for adopters by applying these guidelines to iteratively refine and redesign aspects of pre-existing curricula to illustrate their usefulness.

Action Items:

- Develop guidelines and checklists for identifying barriers within existing K-12 CS curricular resources. These can include accessibility barriers, design and implementation barriers, limited information about flexible instructional and assessment materials, etc.
- Develop a set of guidelines and resources for increasing accessibility, participation, and inclusive practices within preexisting curricular materials.

- Reach out to curriculum developers who would be interested in partnership in a deep-dive into accessibility and inclusive design within their curricular materials.
- Redesign aspects of pre-existing curricula as an illustration of how to increase access and inclusion using redesigned pre-existing materials.
- Use a design-based research (DBR) approach to iteratively develop and refine these instructional materials to increase accessibility and meaningful participation of students with disabilities using learner-centric participatory design process.

Goal 3:

Develop guidelines for teacher professional development related to accessibility, inclusion, and UDL-based informal and formal K-12 CS education.

Preservice and inservice teacher CS professional development (PD) in inclusion and diversity is influenced by contextual priorities such as the focus of the national or regional standards, curricula, and assessment priorities. At the same time there is the need for theoretical clarity about the knowledge, skills, and understanding that teachers need to develop and demonstrate as inclusive educational practitioners. Further theoretical clarity on inclusive K-12 CS practices can be achieved by working in partnership with a community of teachers informed by international teaching networks, a deep exploration of effective professional development and adult learning research, as well as a study of personal stories and lived experiences of students with disabilities. While 'conceptualizations of difference and additional support needs may be different' (Florian, 2012) in that international arena, such collaborations can support further understanding of underlying inclusive assumptions of difference as an essential aspect of human development and 'learning transformability' rather than fixed notions of ability (Hart et al., 2004).

Professional teachers and instructors influence classroom-based student outcomes due to their professional preparation, teaching experience, disposition, and mindset. Content or disciplinary preparation embedded with inclusive pedagogical strategies allows teachers and instructors to better support every learner and ensure they are given the opportunity to learn and grow. Professional development (PD) for CS K-12 teachers is an opportunity to grow and learn within a unique community of committed professionals. Effective, domain specific PD incorporates latest research findings, curates best practices, and provides guidance for choosing technology solutions to complement instruction. PD guidelines for CS K-12 teachers and instructors should strive to meet the needs of teachers, while being learner -centric. We advocate a human-centered experience design approach when developing PD for CS K-12 teachers and instructors serving all learners, including those students with disabilities. In addition, PD funds are scarce for most teachers and instructors and PD developers should use an evidence-based and data-based approach when developing PD resources.

Action Items:

- Develop guidelines for professional development for teachers that maximize flexibility (self-paced, self-learning, asynchronous, communities of practice).
    - Teachers and instructors have limited time for professional learning, so PD should be designed and developed around this constraint. As adult learners, teachers and instructors are more self-directed and self-regulated in their learning, and exhibit higher levels of agency than their student learners. Self-paced, self-directed learning can be efficient: teachers regulate their time and capacity based on their schedules and life events. It can also be effective because each teacher learns based on their individual learning characteristics. Self-directed PD that is designed and developed using the principle of modularity can offer a high level of flexibility for time-constrained teachers. Modular learning units are short (usually between 7-15 minutes in length), cover a narrow concept, leverage prior knowledge, correct misconceptions, provide multiple opportunities for review and completion, and offer low stakes formative assessments. Where possible, modular learning units should exhibit low interdependence among themselves, so that teachers and instructors can learn specific concepts without prior knowledge. On the other hand, complex concepts can be deconstructed into less-complex concepts, and then sequenced in specific ways to build back up to the complex concept. All modular content should be accessible and universally designed.
    - On-demand learning or just-in-time learning are two frameworks that can guide the development of PD for CS K-12 teachers who work with students with disabilities. Modules and associated learning materials should be available at any time on any device, so that teachers and instructors can learn with maximum flexibility and convenience. On-demand capabilities promote anytime-anywhere learning, allowing teachers and instructors to take advantage of non-instructional time. Providing the right learning at the right time can lead to better knowledge retention and higher value-add. Traditional PD tends to deliver a high volume of content in a short amount of time. This inevitably leads to knowledge decay, as teachers and instructors only use some of the content. Providing small amounts of content at the right time (or just-in-time, aligned with the scope and sequence of curricular instruction), can minimize knowledge decay.
    - This process should incorporate effective PD practices such as scaffolding, varying levels of practice, reflection, and a plan to incorporate PD knowledge into specific curricular units, through differentiated lesson plans. Knowledge delivered through PD attains its highest value when it is implemented in the right context AND leads to student learning and growth. On-demand and JIT (Just-In-Time) learning allow teachers and instructors to access CS K-12 concepts and incorporate them into their lesson plans in an efficient and effective manner.

    - PD activities can include multi-modal activities, discussion threads, peer feedback, peer review, communities of practice, triage, implementation and adjustment, as well as case studies and scenarios.
- Translate these guidelines for inclusive and accessible K-12 CS educational approaches into materials that can be integrated into PD. This includes the content knowledge, pedagogies, and tools required to teach inclusive, accessible K-12 CS in different contexts and environments (including use of common CS platforms and tools, including accessibility features in those tools, and materials)
- Develop a generalizable, curated repository of both newly-developed and existing resources related to inclusive, accessible K-12 CS education for students with various functional needs (sensory, cognitive, physical, etc). Tie this repository to online communities of practice for continued knowledge sharing.

    Motivated teachers and instructors of CS K-12 are lifelong learners and seek out PD that improves their teaching effectiveness and increases student learning and growth. Search costs for effective PD by busy professional teachers are high and are constrained by their teaching and life duties. In addition, PD like other information products, is not always fully understood or realized until the user/consumer uses the product or service. Educational technology is in constant flux and teachers and instructors need an efficient and effective way to update their skills, knowledge, and conceptual understanding of K-12 CS education that includes students with abilities. A proxy for potential value is an evidence-based curation and peer review system that aggregates the collective experiences of users, with clear measures of values on several dimensions (cost, time, student outcome, adaptability etc.).

    As the number of reviews for a particular PD program increases, it should indicate some measure of average value. By using filtering criteria such as CS concept, duration, grade level, functional need or accessibility focus, UDL implementation, etc., in conjunction with peer reviewed measures of value, teachers and instructors can quickly find PD resources that have a high probability of being useful, and improve student learning outcomes. In addition to peer review, potential PD programs should also contain reviews from a critical panel to ascertain and inject some semblance of validity and generalizability. Too often, PD is not critically analyzed and teachers and instructors are left to their own devices to determine value, wasting time and other valuable resources. A PD repository should also provide learning trajectories and learning pathways for teachers and instructors of K-12 CS who serve students with disabilities. A recommender system can provide suggested scope and sequence of PD, so that teachers and instructors can strategically use their PD budget to improve their teaching effectiveness and increase student learning and growth.

    - A major outcome of PD is to improve teaching outcomes. One strategy is for teachers and instructors to choose specific skills, knowledge, and conceptual understanding they want to develop and then find commensurate PD program. The

PD repository should contain an inventory of skills, knowledge, and concepts, so that both PD developers and participants (teachers and instructors) have a clear understanding of hoped-for outcomes. Every PD program in the repository can then be tagged and categorized, with end goals, allowing teachers and instructors to pick and choose the right PD program.

A PD repository with the above-mentioned attributes can potentially be used by policy makers and researchers to evaluate the skills, knowledge, and concepts that drive student outcomes and growth. The data from this repository can be used for levels of professional certification and the development of high-quality PD programs.

Expertise needed

Building the team – identifying key stakeholders needed for participatory design/design-based research in this project

- To address the diverse needs of students and teachers for inclusive and accessible K-12 CS education, it is imperative that stakeholders use an evidence-based framework to create or adapt curricular materials for a range of specific contexts. Such a framework may be effective, if the design process is participatory in nature and evidence is derived from the perspectives of key stakeholders through their lived experiences, best practices, and knowledge of the ecosystem. Design inputs may be gathered from these stakeholders for creation of a baseline, general-purpose curriculum which pays attention to common learning outcomes, while remaining cognizant of the unique needs of implementing it effectively for students with diverse learning needs. The baseline content can then be extended to specialized contexts with minimal overlap.

A diverse stakeholder ecosystem, may be drawn from both the Global North and South, and can inform the development of an effective CS learning experience for diverse learners in K-12. In addition, groups can be regional (composed of several countries) and local (based in a state or province). Since the sociocultural context is important for learning and growth, localized learning experiences that leverage community and cultural capital can create authentic CS learning experiences that engage and motivate learners. Stakeholders can be be categorized into the following:

SUPPLY SIDE:
Government Bodies: Policy Makers, Regional, National, and Local Education Boards, Curriculum Standards bodies, Curriculum content creators, and Curriculum Assessors.
Non-Government Organizations: Informal Learning Providers, Not-for-Profit enterprises engaged in CS education and advocacy, organizations leading disability training & employability opportunities for and disabled people
Practitioners: PreK-12 School Teachers & Assistants – Special and general education, Out-of-School instructors & Tutors, Higher Education Instructors for CS related subjects
Academia: Researchers from the field of Education, CS Education, Learning Science, Special Education and Teacher education
Industry: Assistive Technology/Tools providers, educational technology developers (hardware, software, platform providers for CSEd), Hiring Managers, Philanthropic funding sources (foundations and corporations)

DEMAND SIDE:
Students: K-12 CS and university students with disabilities who have both opted into CS education or have not opted into CS pathways due to accessibility issues with course offerings.
Caregivers: Parents/Caregivers of school going children (K – 12, ages 5 to 18) with a wide range of disabilities.
CS Practitioners: Members of the community with disabilities who are successful in CS related careers.
Education Career officers: Supporting students in education making decisions about STEM-related career pathways
Industry: there is identifiable need for more diversity across tech companies; there are also job opportunities across the STEM workforce; there is higher percentage of people with disabilities who are not in employment in relation to individuals without disabilities.

Accessible and equitable CS learning experiences for K-12 learners emerge from the aligned, coordinated collaboration between the various stakeholders in the ecosystem, with a goal to maximize student learning and growth. An integral process-component of accessible experience design, is inclusive, participatory design. All stakeholders should be involved in the design of learning experiences, including K-12 students. The design process should be iterative, transparent, and timely, so that milestones, goals, and objectives provide adequate momentum for attainment and completion. The end goal of such a design process should be to develop a minimum viable learning experience, which can then be improved through subsequent versions.

Conclusion

Given our commitment to CS for All in K-12 CS education, it is crucial to develop inclusive and accessible K-12 CS educational materials that can be used both in formal and informal instructional settings. As many educative resources have already been development without a focus on inclusion and accessibility, we proposed both a retrospective approach that accounts for these curricular materials and a prospective approach for newly developed curricular materials. Additionally, because implementation of inclusive and accessible K-12 CS education can only occur with teachers who have the expertise to enact such instruction, we also focus on the development of professional learning for teachers. Thus, proposed to iteratively develop and study both curricular materials and teacher professional development.

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