Study Background and Research Questions

• Background
  • NSF Study (2015-2018), funded by the STEM+C program, grant # 1542963
  • Exploratory study, researcher-practitioner partnership

• Research questions
  • What are the learning and teaching concerns around making HS CS (and CSP in particular) accessible to students with learning and attention disorders?
  • What adjustments are needed to make the course more accessible for them?
  • To what extent do students who learn differently complete the course and demonstrate positive attitudes about their experiences?
Students Who Learn Differently (we want them in CS!)

- **Specific learning disabilities** (e.g., disorders in reading, written expression, math, and language) that contribute to academic underachievement

- **Attention disorders** (e.g., attention deficit hyperactivity disorder, or ADHD) that cause academic & social challenges

- Students with learning disabilities make up the largest group of all students receiving special education services (35%) under IDEA (Individuals with Disabilities Education Act)\(^1\)

- Most students with learning and attention disorders spend 80% of the school day in general education settings (like CS classes)\(^2\)

- Students with disabilities are underrepresented in CS and in STEM broadly\(^3\)

- These students are “**significantly underrepresented** in Advanced Placement courses”\(^2\)

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\(^1\) Institute for Education Sciences National Center for Education Statistics (2017). *The Condition of Education.*


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Did you know?

1 in 5 school age children in the US have learning and attention disorders\(^2\)

The system for diagnosis is **not** perfect (under & over-diagnosis)
What is AP Computer Science Principles (CSP)?

A course designed to “attract and serve a more diverse population of students” than other CS courses have done in the past (Kick & Trees, 2015)

Assessment Format:

- Two Written Performance Tasks (40% of Overall AP Score)
  - Create – Applications from Ideas
  - Explore – Impact of Computing Innovations
- End-of-Course Exam (60% of Score)
  - 74 questions/2 hours

2016-17 launch stats

Largest AP Course Launch Ever—
AP Computer Science Principles

- 2,500+ SCHOOLS
- 25,000+ STUDENTS
- 49 STATES
- 2,600 TEACHERS TRAINED

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MCSDP 08-16
Research Study Team

- **Interdisciplinary Team**: education researchers, special education & learning strategy specialists, teachers, a school psychologist, a curriculum specialist, and HS students who learn differently

- **Exploratory research**: striving to make high school computer science more accessible for students who learn differently

- **We believe**: tackling problems of practice requires collaboration
The Setting: Wolcott School (Chicago)

- Independent, college preparatory high school for students who learn differently (i.e., those with diagnosed learning and attention disorders)
- Students have strong intellect
- Students diagnosed with language, reading, writing, math, and/or attention and executive functioning challenges
Study Approach: Four Steps

Collaborative, exploratory, student-centered approach to learn from students’ unique insights into the challenges those with learning and attention disorders may face in CS

1. Review Lessons & ID Potential Challenges
2. Create & Implement Alternate Strategies
3. Collect Student & Teacher Experience Data
4. Reflect & Revise Instructional Strategies

Applying what is known about practices that support students who learn differently (+ specialist expertise) NOT changing the rigor, nor simplifying the material; Providing greater access to the learning experience
Study Approach: Step 1

- Review lessons in all 5 Units of Code.org’s CSP materials (Teaching facing, Student facing)
- Identify potential barriers to learning for those with learning and attention disorders

**Lesson 6: Sending Numbers**

**Objective:** Students will be able to:
- Calculate the range of values that can be represented using binary numbers of a given size
- Use the Internet Simulator to send and receive a list of numbers that represent coordinates on a cartesian grid
- Use the Internet Simulator to send the list of points that make up the drawing to a friend

**Preparation**
- (Optional) Tokens
- (Optional) Extra copies of the Sending Numbers for Graphing - Worksheet

**Links**
- Heads Up! Please make a copy of any documents you plan to share with students

**Activity Guide - Binary Message Devices**

**Scenario:** You are going to build a device out of classroom supplies to send information to a classmate on the other side of the room. There are some basic rules and constraints:
- Stay on your side. You may not walk to the other side of the room.
- No language. That means no writing or talking to communicate.
- No projectiles!

**Challenge 4:** Complex Messages (16 - n possible messages)

Could we keep increasing the number of messages forever? Could our devices be used for questions with 16, 32, or 1,000,000 possible responses? Some things to think about...

- Our alphabet only has 26 letters, yet we can spell many words.
- Our number system only has 10 digits yet we can represent many numbers.
- Think back to your simple two-state device. Could you simply use it differently, rather than modifying it?

**Discuss with your partner**
- How could you use your device to respond to much more complex questions (for example one with 1,000 possible responses).
- Use the space below to describe the system you develop in such a way that another group could pick up your device and use it to send messages this way.
What We Found: Five Categories of Potential Challenges

- In lesson review/analysis, learning specialists identified lesson activities that could pose potential challenges for students related to **five broad disorder categories**

- For each lesson activity identified, they wrote one or more “lesson adjustment” recommendation to address each challenge

![Pie chart showing proportions of challenges]

- Language: 29%
- Attention/Executive function: 26%
- Reading: 27%
- Written expression: 13%
- Math: 4%

Proportion of Code.org CSP lesson activities that may cause challenges for students (Total N=230)
CSP Task Challenges: Language Disorders

Students with **Language disorders** may find the following types of tasks and activities challenging:

- Comprehending, recalling or retrieving new terminology (vocabulary)
- Comprehending discussion prompts
- Comprehending and gaining knowledge from the teacher and peers through discussion
- Processing and retaining information presented verbally without any visual supports
- Oral formulation (putting thoughts into words, expressing thoughts with the correct words and phrases to articulate them)

29% of lesson activities that may may cause challenges for students with disorders are related to **Language**.
Students with **Reading disorders** may find the following types of tasks and activities challenging:

- Reading and comprehending activity directions and instructions
- Reading and comprehending CS content/information (particularly, dense and complex text like articles and busy websites)
- Scanning and reviewing work (written and code-based)
- Reading related to assessment (reading and comprehending multiple-choice and open response questions)

27% of lesson activities that may cause challenges for students with disorders are related to **Reading**.
Students with **Attention and related Executive function disorders** may find the following types of tasks and activities challenging:

- Maintaining focus and attention during video viewing
- Sustaining attention during whole-class or small group discussion
- Planning and determining an approach to activities while working independently
- Concentrating to complete work
- Breaking down large tasks into smaller steps
- Initiating projects
- Reading social cues from their peers/teacher

26% of lesson activities that may cause challenges for students with disorders are related to **Attention/Executive function**.
Students with **Written Expression disorders** may find the following types of tasks and activities challenging:

- Expressing thoughts/ideas in writing (and in a way others can understand)
- Writing ideas quickly and accurately
- Writing code and other programming elements (e.g., using correct spelling, capitalization, and syntax; naming functions; recalling commands and variable types)
- Listing work steps or activity components
- Writing assessment responses (open and multiple-choice)

13% of lesson activities that may cause challenges for students with disorders are related to **Written expression**.
CSP Task Challenges: Math Disorders

Students with **Math disorders** may find the following types of tasks and activities challenging:

- Comprehending and using mathematical principles (e.g., binary system)
- Interpreting and understanding data represented in different graphs and charts
- Converting units of measurement (e.g., 20 minutes into hours = 0.3 hours)
- Using and understanding grid coordinates
- Solving mathematical problems
- Identifying number patterns

4% of lesson activities that may cause challenges for students with disorders are related to **Math**.
Study Approach: Steps 2, 3, and 4

- 1:1 student interviews in the 2016 – 2017 school year; **164** total interviews with **13** students
- Students as collaborators in the process, offering unique insights into the challenges students like them face
The Wolcott CSP Course Student Population

- N=13 student participants; most students diagnosed with at least 2 disorders
- 4 sophomores; 2 juniors (1 dropped); 7 seniors
- Varying levels of prior experience with CS

2016 – 2017 AP CSP Students: Diagnosed Disorders

- ADHD: 62%
- Writing: 54%
- Reading: 46%
- Math: 31%
- Language: 15%
Student Interviews: Methodology

- Each of the 13 students were interviewed approximately every two weeks from September to May
- On average, we conducted between 7 - 15 interviews per student, * excluding the 1 student who dropped the course, using a semi-structured interview protocol to ask questions to explore key challenges and supports from the student perspective related to:

  - **Challenges encountered**: What was tricky for you in the CS class in the last week? (General) For lesson xxx, what was most challenging/tricky for you? Why? (Targeted) What did you do to navigate that particular challenge?

  - **Things that were easy**: What came easiest for you in the lesson? Why?

  - **Positive elements of thinking differently**: What traits do you have as a result of how you learn that make you well suited for CS?

  - **Helpful teacher supports**: Last week/in Lesson xxx, did your teacher do anything that you found particularly helpful for you to engage with the materials? What’s a specific example?

  - **Attitudes toward CS**: Last week, how much did you enjoy the activities? Why?
### What We Found: Seven Main Types of Academic Challenges

Inductive approach: Emergent themes

<table>
<thead>
<tr>
<th>Challenge</th>
<th>N=13 students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus, Attention, Tempo</td>
<td>10</td>
</tr>
<tr>
<td>Reading</td>
<td>7</td>
</tr>
<tr>
<td>Written Expression</td>
<td>8</td>
</tr>
<tr>
<td>Programming</td>
<td>6</td>
</tr>
<tr>
<td>Binary</td>
<td>5</td>
</tr>
<tr>
<td>Organizing &amp; Planning</td>
<td>4</td>
</tr>
<tr>
<td>Collaboration</td>
<td>3</td>
</tr>
</tbody>
</table>

Number of students who experienced each of the following challenges:
Academic Challenges: Sustained Focus, Attention, and Tempo

10 of 13 students experienced challenges with sustaining focus, attention, and tempo.

- Understanding new material and completing work in allotted time
- Completing independent work quickly
- Resisting distraction from peers and computer applications
- Sustaining focus to complete long-term projects and independent work
- Focusing in the AP Exam and exam prep

With my ADHD, it's harder for me to sit there, focus, and try to follow along unless I'm actually doing something... then I'll be on task.
Academic Challenges: Reading

8 of 13 students experienced challenges with reading.

• Reading lesson activity instructions
• Understanding instructions or writing prompts in activities and Performance Task projects
• Understanding AP CSP practice and the actual exam questions
• Comprehending website information

Reading instructions is really hard...because they're telling you a bunch at a time.

The instructions were not that clear so I had a lot of trouble figuring out what to do.
Academic Challenges: Written Expression

8 of 13 students experienced challenges with written expression.

- Content generation (quantity of writing)
- Transcription (transposing thoughts into words)
- Planning (preparing for writing projects)
- Motivation (attitude)

I have to write 100 words on 2 or 3 things and 250 words on 2 things, maybe 3 things. It’s a lot of writing and I have to make it like I’m saying different things. It’s not enjoyable.

Getting the write-up done [for the Create Performance Task]. That was the toughest part...I’m very hands on and creative so I can do the app and what not. And when it comes to write up and all the words on the page, it’s like black and white. Really tough to focus and just sit and get it done.
8 of 13 students experienced challenges with programming.

- Identifying and/or fixing coding errors
- Understanding and using commands
- Writing syntax
- Math work in a programming context

I think I wrote a code that was 30-something lines and there was an error at one point and I couldn't tell where it was...It took me 2 days to figure out.

I messed up my parentheses...I didn't do the parentheses for the loop, so I kept getting really weird, wonky outputs and I wasn't sure what was happening.
7 of 13 students experienced challenges with math related to binary.

- Understanding the binary system
- Decimals and converting to/from binary
- Seeing patterns of 1’s and 0’s

I didn’t understand how binary counting works until two days into that section on binary.

Like the binary questions, I could not do for the life of me. Like the ones that are math, thinking in your head, trying to figure out how many zeros are in like, you know or like figuring out going from hex to binary?...I can’t do that.
Academic Challenges: Organization and Planning

6 of 13 students experienced challenges with organization and planning.

- Prioritizing and time management
- Staying organized
- Initiating work

My issue is with organization. Not only that, but I'm having trouble with something and it's like, instead of do it, I literally just kind of put it to the side for now. It's bad, but I do it.

Earlier in the semester I forgot to turn in some stuff. So my grade sunk like a rock for a bit...I have this habit of forgetting to just turn in things.
Academic Challenges: Collaboration

6 of 13 students experienced challenges with collaboration.

- Social skills (negotiation, compromise, work distribution)
- Trust in partner’s ability

People started getting frustrated. There were arguments and it wasn’t very productive.

I got extremely frustrated with them cause they didn’t know what they were doing... Basically there was a ton of work on my half... And then the fact that I wasn't doing it fast, they thought they did everything right even thought I blatantly told them that you messed up. And they were blaming me.
Overlap Among Academic Challenges

**Written expression** – overlaps with:
- Organizing & planning (planning and organizing thoughts and time for written responses in projects and lesson activities)
- Reading (comprehending text, then summarizing in own words, in writing)
- Programming (using binary, writing syntax)
- Sustained Focus, Attention & Tempo (while writing: staying on topic, staying on task, keeping on pace while translating thoughts to words)

**Reading** – overlaps with:
- Binary (reading binary)
- Sustaining focus, attention, and tempo (understanding instructions)

**Binary** – overlaps with:
- Sustained Focus, Attention & Tempo (keeping track of all the 0’s and 1’s)
General strategies, and lesson-specific adjustment recommendations for the Code.org CSP lessons

http://outlier.uchicago.edu/accessCSP/#project-resources
Positives: Thinking Differently in Computer Science

Capturing student creativity and talent: Creativity in problem-solving and persistence

I think that I'm really good at **figuring out problems**...finding different ways to go about a problem. I think that helps with the coding.

You're **thinking outside the box**. You're thinking differently than everyone else.

A lot of us have always been on the outside....So I think that type of thing puts me and other kids with learning differences at an advantage because we are able to **critically think in more of a creative solving way**, instead of just the logical.

I will keep trying and doing whatever I need to do in order to succeed. Asking for help, stepping out of my comfort zone, raising my hand when there's 400 kids. I don't really care as long as I'm understanding it so I can succeed.
AccessCSP
Identifying ways to make high school CS accessible for students with learning and attention disorders:
http://outlier.uchicago.edu/accessCSP/#project-resources

AccessCSForALL
Including students with disabilities in high school computing education:
https://www.washington.edu/accesscomputing/accesscsforall

AccessComputing
Connecting high school, college, and graduate students with disabilities with mentors and professionals:
https://www.washington.edu/accesscomputing/

Project TACTIC
Teaching elementary level computational thinking through inclusion and collaboration:
https://ctrl.education.illinois.edu/TACTICal
Talk about students with learning and attention disorders as an important dimension of broadening participation in STEM.

If students face barriers simply accessing and communicating information in CSP, they will likely turn away from CS (→ NOT CS for All)

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