

An Accessible Computing Curriculum for Students with Autism Spectrum Disorders

Abdu Arslanyilmaz
YSU, USA
aarslanyilmaz@ysu.edu

Margaret Briley
YSU, USA
mlbriley@ysu.edu

Carolyn Fernberg
Potential Development, USA
carolyn@potentialdevelopment.org

Mary Beth Loto
Potential Development, USA
marybeth@potentialdevelopment.org

Gabriel Beadle
YSU, USA
gbeadle@student.ysu.edu

Jeffrey Coldren
YSU, USA
jtcoldren@ysu.edu

Abstract: CT as an essential 21st-century skill and knowledge will be instrumental to new discovery and innovation in all fields of endeavor, and therefore, computing should be taught to all students alongside reading, writing, and arithmetic. However, no computing curriculum has been designed and developed for students with Autism Spectrum Disorders. The objective of this study is to identify and report adaptations and accommodations needed to make an existing computational thinking (CT) curriculum accessible to students with ASD. This objective is accomplished by analyzing sixth-grade students' characteristics at a school for students with ASD and developing the adaptations and accommodations. The data analyzed and reported for this study consists of systematic documentation of the adaptations and accommodations, including learning objectives, instructional design, information presentation, assessments, feedback, and learning environment.

Keywords: Students with Autism Spectrum Disorder, Computational Thinking, Computing, Accommodations and Adaptations, Accessible Curriculum

Introduction

Computational thinking (CT) is a cognitive activity that enables problems resolved, situations better understood, and values better expressed through systematic application of abstraction, decomposition, algorithmic design, generalization, and evaluation in the production of an automation implemented by a digital or human computing device [1]. CT improves analytical and problem-solving skills, attitudes, and confidence towards programming, and may predict academic success [1]. Therefore, CT is an essential skill and knowledge for all students to be provided with to build the knowledge and skills to productively participate in today's world and make informed decisions about their lives [2]. However, there has only been a limited number of studies in which a computing curriculum is designed and developed for minority groups, and there has been no study to make a computing curriculum accessible to students with Autism Spectrum Disorders (ASD). Therefore, an effective intervention strategy to design and develop adaptation and accommodation strategies on an existing computing curriculum to make it accessible to students with ASD is in urgent need. Accordingly, the purpose of this study is to identify and report adaptations and accommodations needed to make an existing computing curriculum accessible to middle school students with ASD.

Literature Review

Many studies have been conducted to show the successful and effective implementation of computing curriculums into various subjects at different grade levels. It was reported that computing performance in college freshman courses could predict future academic success [3], an introduction to computing course increases students' interest in computing [4], CT could improve quantitative and critical thinking [5], CT can help to abstract, generalize, and write convincing arguments [6], and computing focused curriculum improves students' impression of, interests in, and knowledge about computing [7]. Also, coding was reported to be useful for building different dimensions of CT in nine and ten-year-old students [8], programming was found to lead to near and far transfer of problem-solving skills and improvement of spatial relations ability in fifth and sixth-grade students [9], and integrating computing

into middle and high school classes increases knowledge in algorithmic flow [10] and middle school students' CT skills [11].

However, there has been a scarce number of studies in which an effective computing curriculum was designed and developed for minority groups, and no study was conducted to make an existing computing curriculum accessible to students with ASD. Furthermore, very limited CT-related instructional services have been made available to students with ASD. One of these rare studies was conducted by [12] targeting high school students formally diagnosed with a learning disability or attention deficit disorder (more commonly known as ADHD), where challenges to teaching a CS course to students with ADHD were identified, adjustments were proposed and tested in an attempt to make an accessible CS course for these students. Some of these adjustments that were successfully made and tested were reported to be related to barriers for students in language, reading, written expression, math, and attention [12, p. 47]. However, the target student populations in the study are students with ADHD and learning disabilities, both of which are different than the disability that is the subject of this current study, ASD [12, p. 41]. ASD is a neurodevelopmental condition characterized by impairments in social interaction, communication, creativity, imagination, and organization of daily activities [13].

The Problem and Objective

Therefore, to the best of our knowledge, no study has been conducted to develop adaptation and accommodation strategies to make an existing computing curriculum accessible to students with ASD. The research objective is to make an existing computing curriculum [14] accessible for students with ASD, and report the adaptations and accommodations made. Specifically, we would like to a) analyze participating students' characteristics to identify their needs, b) identify adaptations and accommodations, and accordingly, adjust the existing curriculum to make it accessible to them, and c) systematically report those adaptations and accommodations.

Research Methods and Procedures

Participants: 13 sixth grade students at an inner-city school specifically for students with ASD in an urban city in the Midwest are participating in this study.

Analysis of Students: Students' characteristics were analyzed to make adaptations and accommodations based on students' specific learning and behavioral characteristics as well as needs. Analysis was done using systematic instructional design approach [15]. There were many important factors and traits being considered for each student with ASD, each of whom has unique learning characteristics. The critical characteristics analyzed were their demographics, physical and psychomotor functionalities, intellectual and cognitive development, learning and cognitive styles, speech and language development, reading level, and social characteristics.

Existing Computing Curriculum: In this study, the creative computing curriculum [14] was chosen to apply the adaptations and accommodations. This instructional framework, developed for mainstream students, was chosen because 1) the curriculum is based on a visual block-based programming environment, Scratch, and students with ASD often demonstrate relative strength in visual-spatial relationships [16, p. 39], 2) the curriculum is relatively easy to follow and offers instructional materials and activities to cover all core computing concepts and skills, and 3) research suggests that students who learn differently can be successful on a mainstream curriculum, like this one, after appropriate revisions and accommodations are made [17].

Assessments. Assessment strategies that have been utilized in CT literature have included analyses of student-created artifacts [10], [18], [19]; interviews with students about their artifacts [10], [18], [20]; tests consisting of multiple-choice, fill-in-the-blank, and open-ended questions [10], [19], [21]–[23]; tests with jumbled blocks or lines to put in the correct orders [10], [24]; tests with matching, debugging, and code tracing items [24], [25]; qualitative analyses of classroom observation [19]; interviews with teachers [19]; and design scenarios [18]. These assessment strategies *individually* do not provide a complete report on students' learning of CT [25], and each one individually may not be suitable for every student with ASD. Therefore, a system of assessments (SOAs) utilizing several of these assessments after modifications to make them accessible to students with ASD is included in the accessible computing curriculum for this study.

Adaptations & Accommodations: Adaptations are modifications to instructions and assessments that will benefit the students with ASD, and accommodations are adjustment suggestions for teachers targeting the needs of students and are offered on an individual basis [12]. Adaptations and accommodations were made on an existing CT curriculum [14] to make instructions and assessments accessible to students with ASD.

Adaptations and accommodations were developed using systematic instructional design approach [15]. The first step was to analyze learning objectives for the computing instructional sessions. The following guideline was used when analyzing learning objectives:

- 1- The learning objectives were categorized to determine the minimum level of student characteristics required to accomplish them.
- 2- Task analysis on these learning objectives were conducted to define and describe detailed steps that each student needs to take to accomplish them. The learning objectives were broken down into small discrete steps. Each step was analyzed based on the students' characteristics.

After analyzing learning objectives for each instructional session, adjustments (adaptations and accommodations) for each learning objective was determined for each student while considering each student's characteristics obtained through analysis of students.

Results

Analysis of Students: Based on these analyses, the following critical characteristics were found for the participating students.

- **Demographics:** Two students were identified as female and eleven were male. Two students were identified as having african-american, one as hispanic, and the remaining students as having white ethnicity.
- **Physical and psychomotor functionalities:** Four students had preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus. Four students had some apparent compulsive adherence to specific nonfunctional routines or rituals. Eight students had some level of stereotyped and repetitive motor mannerisms (i.e., hand/finger flapping/twisting, complex whole-body movements).
- **Intellectual and cognitive development:** Two students were found to be significantly below average.
- **Speech and language development:** Four students were found to be significantly below average, six of them below average, and four of them low range in terms of language functions in the areas of receptive and expressive language. In terms of delay in, or total lack of, the development of spoken language, four students were found to be significantly below average, six of them had some difficulties with expressive language, four of them were found to be at low range. Four students were found to be below average in their ability to initiate or sustain a conversation with others. Four students had significantly below average and four of them at low range grammatical structure. Four students showed abnormal use of pitch, intonation, rhythm or stress, and four others showed these at times.
- **Reading Development:** All students were reported to need use visuals, pictures, symbols, objects and manipulatives as an augmentative or alternative communication for reading. Students in general were reported to be at 3rd and 4th grade reading levels.
- **Learning and cognitive styles:** When analyzed students preferred learning channel (visual, auditory, or kinesthetic), one student was found to prefer kinesthetic and visual, three were multi-sensory, three visual, two visual and kinesthetic, and four auditory and kinesthetic learning channels.
- **Social characteristics:** Six students indicated that they prefer studying by themselves individually, five indicated a preference toward studying in groups, and two did not prefer one over the other. Three students were found to be neither internal nor external in terms of locus of control, seven were found to be

internal, and two of the students were external. Nine students showed no trait anxiety, one some, and three showed high level trait anxiety.

- **Functionality level:** Four students were reported to be significantly below average, four needing structure, and six to have variable to appropriate organizational skills. In terms of arrival, departure, and transitions, four students were found to be significantly below average and four having difficulty with transitions if outside of the routine. Four students had transitions difficulty if routine is changed for following classroom routes and schedule. Four students were reported to need systematic prompting in completion of assignments, testing, and homework, and four students were found to need verbal prompts and cues for these tasks.

Adaptations & Accommodations: The adaptations and accommodations were made to a) the learning objective itself, b) instructional design, c) presentation of information/material, d) method, nature and amount of feedback, e) type, nature, method, quantity, and time of SOAs, and/or f) learning environment. Table 1 below shows some of the adaptations and accommodations developed for the students.

Table 1: Adaptations and Accommodations

Concern	Adaptation	Accommodation
i.A- LEARNING OBJECTIVES		
•Anxiety issues; Unusual behavior	• Learning objectives were adjusted and made measurable, achievable, and observable. They were made to reflect visual, oral, and written comprehension. They were modified to target two different audience: session objectives for teachers, and learning objectives for students • Additional ones were added, and some were removed.	
i.B- INSTRUCTIONAL DESIGN		
•Delayed, restricted vocabulary •Lack of expressive language skills •Significant difference in oral language	• Simplify written and verbal instructions • Use visual aids and symbols • Provide models or illustrations of the tasks •Boardmaker symbols as alternative communication were added for key terms, reflection prompts, and visual guides • Directions to aid with design journal were added • Many instructional videos were developed for handouts • Visual guides were made clearer and easier to follow • Instructions were included for students to express their responses in multiple modes of communications	•The language of the instructions targeted for students to read were simplified to 3rd grade reading level •Notes to teacher were added to tolerate students with issues in language skills •Activities were modified to allow students to complete them individually as well
•Cognitive function issues	• Activities were divided into several small sections. • Pre-teaching including the topics, terms, and expectations were added for students who may have trouble understanding or carrying out the activities in the first pass. • The videos were modified to include pauses between different sections for the teacher to stop to explain each section before moving on to the next one. • Session schedule was added to give students some structure and routine • Directions to teachers to model the activities were added • Reflection prompts for oral discussions and for design journals were distributed throughout the activities	•Notes to the teacher were added to offer extended times to students with certain cognitive characteristics.
•Having difficulty comprehending verbal information, following long verbal instructions and remembering	• Visual printable aids, instructional videos, and instructions for teacher to model the activities were added by instructions targeted for the students • A schedule as a step-by-step guide was added for each session. • The instructional activities were divided into a few sections for	•Notes to the teacher were added not to enforce a time limit for students who are having difficulty comprehending instructions and/or completing tasks •Frequent breaks were added for students with cognitive deficiencies

the sequence of instructions	the teacher to follow in smaller sequential and concrete steps. ● Pre-teaching with terms, topics, and expectations for each session was added to go with some students prior to the actual sessions to familiarize them	
●Tendency to persevere on a topic	● Notes to the teacher were added to offer some guidelines for students with these characteristics	●Notes to teacher were included to involve teacher aid or other types of personalized assistance for students having tendency to persevere on a topic
●Does not initiate interaction, but will accept initiations from others	● Activities were modified to assign these students to USATs and/or peers who prefer to study in groups	●Notes to the teacher were included to pair students who does not initiate interaction but will accept initiations from others with students who prefer studying in groups
●Unusual, destructive, self-injuring behavior	● Instructions were simplified in terms of cognitive difficulty and reading level of the language.	●Notes to the teacher were added directing them to facilitate ways to calm students with these characteristics down ●Notes to the teacher to reduce students' anxiety were added ●Notes to the teacher were included to move students who seem agitated and/or uncooperative or being destructive to individual workstations or a calming area
i.C- PRESENTATION OF INFORMATION		
●Unfocused, not interested, bored, difficulty paying attention	● Visual aids and symbols were added for all instructions targeted for students ● Instructional videos were developed and added as an alternative method of information presentation ● Instructions for teacher to model activities were added	
●Having difficulty communicating ●Insufficient, but some social skills ●Find the attention of a peer more motivating	● Instructional language targeted for students were simplified to 3 rd grade reading level ● Sessions instructions were modified to include common/familiar words to draw students' attention, to encourage small- and large-group activities for students who prefer studying in groups, and to share their works with other peers and/or USATs	
●Seem agitated, uncooperative, anxious		●Notes to the teacher were added to move students showing these behaviors to a calming, quiet, or a familiar area.
i.D- FEEDBACK		
●No response, inappropriate behavior	● Notes to the teacher were added to provide positive, meaningful, and immediate feedback for students who show inappropriate behavior and/or unresponsive to reflection prompts	
i.E- SOAs		
●Anxiety, behavioral problems	● Rubrics with objective, observable, and measurable criteria were developed and added into each session ● Session objectives were modified to be observable, objective, and measurable	
i.F- ENVIRONMENT		
●Destructive, repetitive and idiosyncratic speech patterns		●Notes to teacher were added to move students who are being destructive and showing repetitive and idiosyncratic speech patterns to a calming area
●Anxiety issues	● A step-by-step schedule for each session was added	● Notes to the teacher to print verbal, visual directions before transitions and changes and post them in visible areas in the classroom

Discussions & Conclusions

Systematic documentation of adaptations and accommodations to an existing computing curriculum, including learning objectives, instructional design, information presentation, assessments, feedback, and learning environment, were conducted to develop an accessible computing curriculum. This study documents accommodations and adaptations that are needed to make a computing curriculum accessible to students with ASD.

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