May 2021

Understanding Computer Science Students' Characteristics and How They Affect Their Performance in Class

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UNDERSTANDING COMPUTER SCIENCE STUDENTS' CHARACTERISTICS AND HOW THEY AFFECT THEIR PERFORMANCE IN CLASS

by

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A Thesis Submitted in

Partial Fulfillment of the

Requirements for the Degree of

Master of Science

in Computer Science

at

The University of Wisconsin-Milwaukee

May 2021

ABSTRACT

UNDERSTANDING COMPUTER SCIENCE STUDENTS' CHARACTERISTICS AND HOW THEY AFFECT THEIR PERFORMANCE IN CLASS

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The University of Wisconsin-Milwaukee, 2021

Under the Supervision of Professor Christine Cheng

Autism Spectrum Disorder (ASD), a neurodevelopmental disorder, is characterized by significant impairments in social communication and interaction. Theories regarding the cognitive development of ASD individuals suggest that high-functioning individuals are adept at analyzing and constructing systems so they may find STEM occupations more appealing. Researchers found that young adults with ASD in STEM fields were more likely to concentrate be science or computer science majors in college than the general population.

In 2001, Baron-Cohen et al.[1] published the seminal paper on the Autism Spectrum Quotient (AQ), a self-administered questionnaire that measures autistic traits in adults. In the paper, they established that there is a significant difference between the AQ scores of high functioning autistic adults and adults of the normal population (35 vs. 16.4). Subsequent studies have confirmed the result. Interestingly, among Cambridge University students that Baron-Cohen et al. recruited, Math and Computer Science majors had the highest AQ scores (21.5 for Math majors, 21.1 for CS majors and 17.6 for all university students).

In this thesis, we explored the findings about Computer Science majors further. Part of our motivation stems from research that shows high-functioning autistic young adults tend to

pursue STEM majors. Moreover, among those who majored in STEM fields, Computer Science was the top choice [2].

We recruited UW-Milwaukee students enrolled in Computer Science 250 (CS 250) the Introduction to Programming class, and Computer Science (CS) and Computer Engineering (CE) majors who have applied for graduation in Spring 2020 and Fall 2020. All students were asked to answer the AQ and their AQ scores were compared to their grades.

Our results are as follows. The average AQ score among all the participants is 23.04, which was comparable to Baron-Cohen et. al.'s findings. The beginner CS students average AQ score is 22.8 while that of the graduating students is slightly higher at 23.8. There was no significant difference between the AQ scores of males and females. We observed no correlation between AQ scores and CS 250 class grades. On the other hand, the AQ scores of graduating students has a weak positive correlation to their CS-GPA (GPA of their required CS classes).

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1. Introduction

Background of the study

Autism spectrum disorder (ASD) is a lifetime developmental disability. A person with autism has trouble communicating or understanding what other people think or feel. People with autism focus on or do the same thing over and over again. Autism is a neurodevelopmental disorder that has a profound effect on several areas of an individual's development and functioning of the brain that can cause significant social, communication and behavioral challenges. It can also affect how individuals comprehend what they see, hear and sense [3].

Leo Kanner first described the disorder in 1943 [4]. Autism spectrum disorders symptoms can be present in a variety of combinations and may accompany other disabilities [5]. Some people with autism spectrum disorders have normal levels of intelligence, while most have some level of intellectual disability, ranging from mild to severe. This range is often referred to as high-functioning autism spectrum disorders to low-functioning autism spectrum disorders.

The Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) classifies autism spectrum disorder as a disorder within a broader group of Pervasive Development Disorders (PDD) characterized by qualitative impairments in social interaction skills and communication skills, and the presence of stereotypical behaviors, interests, and activities. ASD refers to the DSM-IV-TR diagnostic categories of Autistic Disorder, Asperger's Disorder, and Pervasive Developmental Disorder-Not Otherwise Specified [4].

Autism is defined in terms of abnormalities in social and communication development, in the presence of marked repetitive behavior and limited imagination. Asperger syndrome (AS) on the other hand, is considered similar to autism; however, individuals diagnosed with AS lack language or cognition delay, they usually do not have the same degree of difficulty in the development of age-appropriate self-help skills, adaptive behavior and curiosity about the environment in childhood. Thus, making them high functioning individuals on the spectrum.

Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) individuals have symptoms that are similar to, but not identical to, those displayed by individuals with ASD. People who display significant social or communication impairments, or stereotyped behaviors or interests, but who do not meet the criteria for any other Pervasive Developmental Disorder, are generally diagnosed with PDD-NOS [6].

According to the Centers for Disease Control and Prevention, about 1% of the world population has Autism Spectrum disorder. Autism Spectrum Disorder occurs in about 1 in every 54 births, and four times more often in boys than girls. Families of all racial, ethnic, and social backgrounds in the world are affected. Prevalence of ASD in U.S. children increased by 119.4 percent from (1 in 150) to (1 in 54). In 2017 an estimated 5,437,988 (2.21%) adults in the United States have ASD [7]. Autism is the fastest -growing developmental disability [8]. According to epidemiological studies, the prevalence of ASD appears to be increasing globally. Possible explanations for this increase include improved awareness, expansion of diagnostic criteria, better diagnostic tools and improved reporting [9].

Autism conditions and symptoms lie on a continuum of social-communication disability, the signs and symptoms of each individual are distributed along this continuum of lesser

severity in the case of normal individuals or greater severity with ASD, where individuals with AS act as the bridge between autism and normality [10]–[12]. Such continuum enables the possibility of developing a research study that involves quantitative tool rather than a diagnostic approach.

Theories regarding the cognitive development of ASD individuals suggest that they tend to have significantly greater ability toward systemizing compared to empathizing. “Systemizing” means to develop a rule-based system to explain the world around them, while “empathizing” refers to social and emotional reactions to other people’s thoughts and feelings. The systemizing-empathizing theory suggests that ASD individuals are average or above on systemizing but below average on empathy [13]. Systemizing requires the thinking or skills needed to analyze and construct systems, which also are necessary for many (STEM)- related fields, suggesting that high-functioning autistic individuals may find STEM occupations more appealing [14].

Autistic people have soft skills that include attention to detail, prolonged concentration, lack of bias, pattern analysis, and a blunt communication style [15]. Such skills are valued in the technology field where details matter, tasks follow a common framework and ambiguities tend not to exist. Autistic people have a great capacity for processing information and are better at detecting “critical” information [16].

According to [2], when compared with the general population and other disabilities groups, individuals with ASD are more likely to pursue STEM majors. In addition, the researchers found that young adults with ASD in STEM fields were more likely than the general population to concentrate on science [12.12 vs. 8.3 %] and computer science [16.22 vs. 6.6 %].

In fact, post-secondary students with ASD were more likely to persist in a 2-year community college and were twice as likely to transfer from a 2-year community college to a 4-year university than their peers in the non-STEM fields [17].

Individuals on the autism spectrum experience substantial challenges to getting competitive employment opportunities that match their interests, skills, and talents. They experience substantial unemployment and underemployment. It is more difficult for adults with ASD to gain and maintain employment [18] with most studies showing between 20% and 30% of the ASD population being unemployed and only 14% of adults with autism in the U.S. work for pay.

Employers have increasingly focused on expanding efforts to improve access to employment for job candidates on the autism spectrum to benefit from their diverse talents. Many large and small employers have adjusted their recruitment, hiring, and onboarding policies to increase access for this population.

Four companies, namely, Microsoft, SAP, JPMorgan Chase and EY established an autism-focused hiring initiative, which shares valuable information and provides guidance to employers who are interested in hiring ASD individuals. The Autism@Work Playbook was developed by [19] from the University of Washington Information School. It examined how the firms established their programs and how they sustained them. The researchers analyzed key organizational strategies, employment, and resourcing models, and hiring practices.

Colleges are adding special programs to support students on the autism spectrum. Such programs can help autistic students not only survive but thrive. At least 60 universities and colleges in the United States have added some form of support programs that offer services

that include academic advising, helping students develop social skills into becoming independent and ending in developing professional skills and prepare them to gain work experience internships and job shadowing. Here are some of the support programs [20]:

- Arkansas State University – EduCare program
- University of Tennessee at Chattanooga (UTC) - Mosaic program
- California State University – The College Link Program
- Eastern Illinois University – STEP program
- Western Kentucky University – Kelly Autism Program
- Michigan State University – BOND Program
- Marquette University – On Your Marq

Computer Science departments around the country should also consider how they can assist ASD students so they can be successful in their major and how best to prepare them for future employment. But it is not clear what should be done. Basic information like the number of ASD students enrolled in their programs are not readily available because of privacy concerns. Students are unlikely to disclose their diagnosis to their instructors. In this thesis, we have chosen to focus on students' autistic traits instead and how these traits might affect their academic performance.

Research approach

The quantitative data used in this research is collected using a tool called Autism Spectrum Quotient (AQ). The Autism Spectrum Quotient (AQ) is a self-administered questionnaire developed by Baron-Cohen [1]. It has been used widely to measure autistic traits in adults on five subcategories namely social skills, attention to detail, attention switching, communication, and imagination. The AQ has 50 statements; participants indicate whether they agree, slightly agree, slightly disagree, or disagree with each one. A meta-study conducted by Ruzich et al. [21] noted that the average AQ score for autistic adults with at least average IQ is about 35 while those for the regular adult population is about 17. It should be emphasized that the AQ is not a diagnostic tool; rather it measures traits that are often associated with individuals in the autistic spectrum. More details on AQ will be illustrated in the research methodology chapter of this study.

This study involves recruiting two types of participants:

- Students enrolled in Computer Science 250 (CS 250), the Introduction to Programming class offered by the Computer Science Department. Students in this class are mostly freshmen and some are sophomores. Most of the students approximately 31 students were Computer Science or Computer Engineering majors but also, there is other majors like, Mathematics, Information Science and technology, Actuarial Science, and Finance/Computer Science.
- Computer Science (CS) and Computer Engineering (CE) majors who have applied for graduation in Spring 2020 and Fall 2020.

The collected data is further analyzed via statistical analysis tools to find correlations between the AQ scores and students' performance in CS 250, their gender, and the classes in their majors.

Research Objective

This research study has several goals:

- Establish a baseline for the AQ score, as well as the scores of the five subcategories, of the Computer Science and Computer Engineering students at UW-Milwaukee.
- For CS 250 students, determine if there is a correlation between individuals' AQ scores, their gender, and their class grades.
- For graduating Computer Science and Computer Engineering students, determine if there is a correlation between individuals' AQ scores and their CS-GPA (I.e., the average grade of their required CS classes).
- Compare the AQ scores of CS 250 students (I.e., the "novices") and the graduating Computer Science and Computer Engineering students (I.e., the "experienced ones").

2. Literature Review

Autism Spectrum Diagnostic Tools

There are many tools for assessing Autism Spectrum Disorder in individuals. They range from simple parents' / caregivers' observations to formal assessments by physicians. Here are some examples:

Autism Diagnosis Interview – Revised (ADI-R) [22]

ADI-R is an investigator-based interview for caregivers of children and adults for whom autism is a possible diagnosis. The instrument focuses on behavior in three main areas: reciprocal social interaction; communication and language; and restricted and repetitive, stereotyped interests and behaviors.

Modified Checklist for Autism in Toddlers, Revised (M-CHAT) [23]

M-CHAT is a two-stage parent-report screening tool with 20-questions designed for toddlers between 16 and 30 months old.

Childhood Autism Rating Scale (CARS) [24]

CARS is designed as a clinician rating scale to be completed after a direct observation of the child by a professional who is familiar with autism and trained to rate the CARS items. It is suitable for use with any child over 2 years of age.

Gilliam Autism Rating Scale (GARS) [25]

GARS assists teachers, parents, and clinicians in identifying and diagnosing autism in individuals ages 3 through 22. It also helps estimate the severity of the child's disorder.

Autism Spectrum Quotient (AQ)

Back in 2001, there were no brief, self-administered instruments for measuring the degree to which an adult with normal intelligence has the traits associated with the autistic spectrum. Baron-Cohen was the first to introduce such a tool, called the Autism Spectrum Quotient (AQ). AQ assumes that behaviors associated with ASD lie on a continuum, where individuals with a diagnosis of ASD would be expected to be at one end, and unaffected individuals with few ASD symptoms or characteristics would be at the other end. Thus, AQ is designed to provide a continuous measure of autistic traits that can be used to indicate where an individual with normal IQ falls on the ASD continuum. The autistic traits measured by AQ fall into five categories: social skills, attention to detail, attention switching, communication, and imagination.

Baron-Cohen and his collaborators conducted a study at Cambridge University and tested the AQ on four different populations: (i) high functioning autistic adults (HFA), (ii) non-clinical adults (adults from the general population), (iii) Cambridge University students and (iv) winners of the UK Math Olympiad competition [1]. What they found was on average HFA individuals scored considerably higher than the non-clinical adults (mean scores: 35.8 vs 16.4). The university students' average score was similar to the non-clinical adults (17.6 vs 16.4) but those with STEM majors have higher numbers than those with humanities majors (18.5 vs 16.7). In particular, the math majors had the highest numbers followed by CS majors. The Math Olympiad winners had an average score very much like the math majors. As seen in table 1.

	n	Mean AQ Score
Group 1: HFA/AS	58	35.8
Group 2: non-clinical adults (controls)	174	16.4
Group 3: University students	840	17.6
a: STEM major students	454	18.5
b: Humanity major students	276	16.7
c: Mathematics majors	85	21.5
d: computer science majors	23	21.1
Group 4: Math Olympiad winners	16	24.5

Table 1: Mean AQ Score by Groups (Baron-Cohen et al., 2001)

Table 2 displays AQ and subcategories scores interpretation.

	High score (More autistic)	Low score (Less autistic)
AQ total score	more autistic adult	less autistic - normal adult
Social skills	less sociable adult	more sociable adult
Communication skills	less communicative	more communicative
Imagination	less imaginative	more imaginative
Attention to detail	more aware of details	less aware of details (big picture)
Attention switching	harder to switch between subjects/ tasks	easier to switch between subjects/ tasks

Table 2: AQ subcategories score interpretation

A meta-study was conducted by Ruzich et al. [21] to estimate a reliable mean AQ score for non-clinical (general population) and ASD individuals. Detailed analysis was conducted on a sample of 6900 non-clinical participants and 1963 clinical ASD individuals collected from 73 articles. Analysis results showed that non-clinical individuals had a mean AQ score of 16.94,

while the clinical population diagnosed with ASD had a mean score of 35.19. The results are found to be in good agreement with [1] results.

As already noted, AQ is not a diagnostic tool but a descriptive tool that quantitively measures autistic traits often associated with individuals in the autistic spectrum. It may be useful for identifying adults who should undergo further evaluation.

This was illustrated by Ashwood et al. [26] who conducted the AQ test on 476 ASD patients and found out that AQ did not predict their diagnosis due to their low scores. They found that the presence of ASD is not an independent predictor of AQ scores but Generalized Anxiety Disorder (GAD) does predict higher AQ scores. Thus, GAD may contribute to false positives. Researchers explained that the AQ may be sensitive to anxiety because several AQ items take the form of self-evaluations, e.g. “I find it difficult to work out people’s intentions.” Anxious individuals commonly lack confidence in their social abilities, and it is possible that this low self-esteem might manifest as ASD typical answers. Thus, their results suggest that AQ may not be able to substitute for specialist clinical assessments.

A short form of the AQ that uses 28 items from the full measure was developed and compared with the original AQ form [27]. The other short forms of the AQ were all developed for a predictive purpose, i.e., screening. These are the 20-item [28] and 10-item [29] forms and the 21-item and 10-item forms derived from the AQ-Japanese version [30].

AQ for young adults [31] and children [32] have been developed. The Autism Spectrum Quotient has been translated into approximately two dozen languages and published validation studies exist for versions in Dutch [33], French [34], Canadian French [35], Italian [36], Japanese [37], Mandarin [38], Polish [39], Korean [40], Brazilian [41], and Turkish [42].

Validity and Reliability of Autism Spectrum Quotient (AQ)

A reliability study was conducted on 1005 introductory psychology students by Hurst et al. [43] to assess (1) the AQ distribution, (2) the internal consistency of the AQ five subcategories [ensures that the 10 items in each subcategory deliver consistent scores for the same subcategory], and (3) the factor structure of AQ using factor analysis [is a statistical tool to eliminate factors that don't add value to the results]. It has been shown that AQ autistic traits followed a normal distribution which agrees with [1] findings; however, the factor analysis results suggested the use of 3 subcategories namely social skills, details/patterns, and communication/mindreading because improved internal consistency was observed when using the 3-factor version of the AQ. Based on their findings, enhancement of the psychometric properties of the AQ was suggested.

Hoekstra et al. [33] evaluated the reliability of AQ with confirmatory factor analysis in a large general population and student sample. Three patient groups were considered: (1) ASD, (2) Social Anxiety Disorder (SAD), (3) Obsessive-Compulsive Disorder (OCD). Improved internal consistency was observed when using a 2-factor version of the AQ; hence, two reliable subcategories of AQ were suggested focusing on social interaction difficulties and attention to details and pattern. Moreover, AQ scores were observed to follow a continuous distribution with ASD Individuals falling in the upper end of the distribution with high AQ and factor scores, while SAD and OCD Individuals scores were between the general population and ASD Individuals scores. Therefore, it was suggested in the study that AQ can be used to evaluate where an individual lies on the autism spectrum. However, we should not ignore the fact that AQ should not be utilized as a diagnosis tool but as a measure of autistic traits.

Armstrong and Iarocci [44] assessed the convergence validity between the AQ and Social Responsiveness Scale (SRS). SRS is a 65-item parent or teacher rating scale designed to measure the severity of ASD spectrum symptoms among individuals. Twenty-three high functioning individuals with ASD were recruited for the study. Results showed a highly significant correlation between the AQ and SRS ratings, which endorses the convergence validity between the two measuring Instruments.

Correlation Between Sex and STEM Occupation with AQ

In the first study on the use of AQ by Baron-Cohen et al. [1], it was observed that the mean AQ score and the mean AQ subcategory scores, except for attention to detail, were higher among male students than female students. Also, it was observed that the mean AQ score was highest among math majors followed by the computer science students. Humanities and social sciences students had the lowest score.

A meta-study of half a million people in the UK conducted by Ruzich et al. [45] assessed the AQ scores and examined the correlation between the AQ and age, sex, occupation, and UK geographic region. It was found that sex and occupation had an effect on AQ scores: males had an AQ mean score of 21.55 while females had an AQ mean score of 18.95, and individuals who had STEM careers had an AQ mean score of 21.92 while individuals in non-STEM careers had AQ mean score of 18.92. On the other hand, it was observed that age and geographic region were not correlated with AQ.

Ruzich et al. [21] also found a sex difference in autistic traits among the nonclinical population where males' AQ mean score was higher at 17.89 and females' mean AQ score at 14.88. On the other hand, no sex difference in AQ mean scores was seen among the clinical ASD population.

Pisula et al. [39] studied sex and area of study differences in AQ scores among students in Poland. The AQ score and all AQ subcategory scores in males were higher than in females excluding the attention to detail subscale where no sex difference was observed. As for the area of study differences, results showed that sciences students had a higher mean AQ score than medical and social sciences students, and higher attention to detail and imagination subcategory scores than humanities students.

However, not all researchers, were able to confirm the presence of sex differences in AQ scores. In [33] AQ scores among science students were observed to be higher than social and humanities sciences students which confirms the area of study effect; however, sex difference was found to have no effect on AQ scores among students. Similarly, no sex differences in AQ scores were found in [46] and [47] studies in the AS/HFA group. In another study conducted by Wakabayashi et al. [48], males scored higher than females; however, no significant sex differences were found in high functioning autistic individuals. In addition, no sex difference in AQ score was found in [43] and [49]. In fact, the results from [43] showed that females scored slightly higher than males in AQ score and all subcategory scores excluding the imagination subcategory, although the differences were not statistically significant. Moreover, Lai et al. [50] conducted a comparative study between 33 males and 29 females and found out that more autistic traits have been reported by females than males. Though, such difference was only

observed in the self-reported data and no sex differences were noticed in the childhood age. It has been also reported that females exhibited lesser socio-communication symptoms than males.

Kunihira et al. [51] conducted a similar study on a large sample of Japanese students and found out that all AQ subscales scores were higher in males than in females with exception of the attention to detail subcategory; hence; the sex difference effect appears to be cross-cultural independent.

Based on the above studies, the effect of area of study differences on the severity of autistic traits is validated in which autistic individuals tend to pursue STEM majors more than other majors such as humanities and social sciences. However, the effect of sex differences on autistic traits between individuals is still in question as no sex differences were found in some studies, while other studies reported that autistic traits are higher in females than males; thus, further research is required to validate and confirm the effect of sex differences.

Autism Spectrum Disorder in Computer Science

Computer Science is the study of computers and computational systems. Unlike electrical and computer engineers, computer scientists deal mostly with software and software systems; this includes their theory, design, development, and application. Principal areas of study within Computer Science include artificial intelligence, computer systems and networks, security, database systems, human-computer interaction, vision and graphics, numerical analysis, programming languages, software engineering, bioinformatics, and theory of computing.

Grandin, a Ph.D. professor with Asperger's Syndrome addressed the topic directly in her essay, "Choosing the Right Job for People with Autism or Asperger's Syndrome," stating: "*It is important that high functioning autistics and Asperger's syndrome people pick a college major in an area where they can get jobs. Computer science is a good choice because it is very likely that many of the best programmers have either Asperger's syndrome or some of its traits"* [52]. When asked about the connection between AS and information technology, she went so far as to say*, "We wouldn't even have any computers if we didn't have Asperger's!"* [53].

The largest and most comprehensive data set which included information about high school and post-secondary experiences for more than 11,000 students was reviewed by Wei et al. [2]. Almost 10% of these students had a disability of which 660 individuals of them were diagnosed with ASD. Moreover, 34% of these ASD individuals were pursuing STEM majors; in particular, 12% of this group were enrolled in the computer science program. Findings of this review show that a higher percentage of ASD individuals pursuing STEM majors are more likely to enroll in computer science major than their overall peer group.

The study in [54] recruited sophomore, junior and senior students who had a declared Computer Science as their major. The Gilliam Autism Rating Scale (GARS) third edition was used as a questionnaire. The GARS instrument was developed to identify individuals who could be on the autism scale. It consists of 56 items grouped into six subcategories: Restrictive/Repetitive behaviors, social interaction, social communication, emotional responses, cognitive style, and maladaptive speech . each item is answered by circling a response from zero to three with zero indicating not at all like the individual, one is not much like the individual, two being somewhat like the individual, and three being very much like the individual.

The participants' answers were calculated, and the Autism Index was their total score. The greater the Autism Index score, the more significant the behaviors and characteristics, and the higher the probability that the participant is on the autism spectrum. The results of this study showed that out of 60 responses, 19 scored in the very likely category (32%) and another 30 in the probable category (50%). This means that 82% scored either probable or very likely ASD. The study also supports the commonly held belief that individuals with ASD tend to major in Computer Science.

Literature review gap

Our review of related literature indicates that no study has investigated possible correlations between AQ scores of Computer Science college students and their grades, and whether there is a difference between the AQ scores of beginner Computer Science students and those who are about to graduate. Accordingly, this research study will fill this gap

3. Research Methodology

The design of Autism Spectrum Quotient (AQ)

The AQ contains 50 questions, made up of 10 questions assessing 5 different areas: social skill (items 1,11,13,15,22,36,44,45, 47,48); attention switching (items 2,4,10,16,25,32,34, 37,43,46); attention to detail (items 5,6,9,12,19,23,28, 29,30,49); communication (items 7,17,18,26,27,31,33, 35,38,39); and imagination (items 3,8,14,20,21,24,40,41, 42,50). The score for each statement is 1 point.

The items may be classified into two groups with approximately half of them phrased to produce an "agree" response from neurotypical individuals and the rest to produce a “disagree” response.

Items: 2, 4, 5, 6, 7, 9, 12, 13, 16, 18, 19, 20, 21, 22, 23, 26, 33, 35, 39, 41, 42, 43, 45 and 46 are scored: Definitely Agree (1) | Slightly Agree (1) | Slightly Disagree (0) | Disagree (0)

Items: 1, 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 40, 44, 47, 48, 49 and 50 are scored: Definitely Agree (0) | Slightly Agree (0) | Slightly Disagree (1) | Disagree (1)

A copy of the AQ is provided in the Appendix.

At the beginning of the survey, participants were also asked about their name, age, gender, and declared or intended major.

Research recruitment (enrollment)

After obtaining IRB approval in Spring 2020. IRB#: 20.260-UWM , recruitment emails were sent out to two groups: (1) students enrolled in Computer Science 250 (CS 250), the Introduction to Programming class offered by the Computer Science Department during Spring 2020 and Fall 2020, and (2) the Computer Science (CS) and Computer Engineering (CE) majors who have applied for graduation in Spring 2020 and Fall 2020. A total of 52 students participated.

Statistical Analysis

Mean AQ score

The mean AQ score of the participants and their mean score for each of the five subcategories of the AQ test are calculated. The mean AQ scores and subcategory scores for the male students in CS 250, the female students in CS 250, and the graduating students are also computed. The numbers are used in several statistical tests.

Normality Test

Initially, a normality test is conducted on the collected data to check if it follows a normal distribution. This step is necessary before most statistical tests as the latter assume that data is normally distributed.

In this research study, the Shapiro-Wilk test is used to verify data's normality. The Shapiro-Wilk W test was developed by Shapiro and Wilk (1965) for sample sizes of up to 20.

Later on, it was shown that it can handle sample sizes as large as 2000 [55]. The Shapiro–Wilk test tests the null hypothesis that a sample is normally distributed. The test computes the W-statistic value in which a small W-value indicates that the sample is not normally distributed. If the p-value associated with the test is less than alpha, the null hypothesis is rejected; that is, it indicates the sample data is not normally distributed. Conversely, if the p-value is greater than alpha, the null hypothesis cannot be rejected; thus, the sample data follows a normal distribution.

The test statistic, W, uses the following formula:

$$W = \frac{(\sum_{i=1}^{n} a_i x_{(i)})^2}{\sum_{i=1}^{n}(x_i - \overline{x})^2}$$

where $x_{(i)}$ (with parentheses enclosing the subscript index i) is the ith order statistic, i.e., the ith-smallest number in the sample; $\overline{x}$ is the sample mean.

The null hypothesis is

H_o: the data are not normally distributed

while the alternative hypothesis is

H_A: the data are normally distributed.

T-Test

The T-test is a statistical test that is used to determine if there is a significant difference between the means of two groups. It is used as a hypothesis testing tool that assumes the means are equal as the null hypothesis. Based on applicable formulas, the calculated values are compared against the standard values and the assumed null hypothesis is accepted or rejected accordingly.

In this study, the first t-test is conducted to check if some statistical difference exists between the mean AQ scores of male and female students in CS 250. Multiple t-tests are also implemented to determine if, for each of the five AQ subcategories, any significant difference exists between the mean scores of the two groups. In addition, a t-test is conducted to identify any significant difference between the mean AQ scores of the CS 250 students and the graduating students.

Since the sample sizes of male and female students in CS 250 are unequal, and the variances of the AQ scores are unequal, Welch's t-test is used as it is more reliable in this context [56].

Welch's t-test defines the statistic t by the following formula:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{{s_1}^2}{N_1} + \frac{{s_2}^2}{N_2}}}$$ where $\bar{X}_j$, s_j and N_j are the jth sample mean, sample standard deviation and sample size, respectively, j ϵ {1,2}.

When comparing the mean scores of the male and female students in CS 250, the null hypothesis is:

$$H_o: \text{AQ ScoreM} = \text{AQ ScoreF}$$

while the alternative hypothesis is:

$$H_A: \text{AQ ScoreM} \neq \text{AQ ScoreF},$$

where AQ ScoreM , AQ ScoreF are the mean AQ scores for male and for female participants, respectively. If the p-value is less than the significance level (alpha), the null hypothesis is rejected; otherwise, the null hypothesis cannot be rejected. A significance level of 0.05 is used.

Two-way analysis of variance (ANOVA)

Analysis of Variance (ANOVA) is a statistical method used to test differences between two or more means. The difference between ANOVA and t-test is that t-test is restricted to two populations only while ANOVA can be used for three or more populations. ANOVA uses the F-test to check whether the variability between group means is larger than the variability of the population within the groups. If that ratio is adequately large, we can conclude that not all the means are equal. There are two types of ANOVA test: a) One-way ANOVA is used when the testing data has one independent variable with multiple levels (groups) and one dependent variable, b) two-way ANOVA is used when the data has two independent variables with multiple levels and one dependent variable.

In this research study, we use the two-way ANOVA to determine whether gender and/or AQ score have an effect on CS250 students' performance in class (numerical course grade).

The dependent variable is the performance in class, while the two independent variables with their levels are as follows:

Gender with 2 levels: a) Male and b) Female

AQ score with 4 levels:

a) 11 - 17 b) 18 - 24 c) 25 - 31 d) greater than 31

The following table shows the setup for two-way ANOVA test:

		AQ scores for participants			
		11 - 17	**18 - 24**	**25- 31**	**> 31**
Gender	**Male**	**CS250 students' performance in class**			
	Female				

Table 3: two-way ANOVA test setup

Three null hypotheses are tested:

H_o: The population means of the gender are equal.

H_o: The population means of the CS250 students' AQ scores are equal.

H_o: There is no interaction between gender and CS250 students' AQ scores.

The alternative hypotheses are:

H_A: The population means of the gender are not equal.

H_A: The population means of the CS250 students' AQ scores are not equal.

H_A: There is an interaction between gender and CS250 students' AQ scores.

Initially, the main effect considers the independent variables one at a time to identify if the independent variable influences the dependent variable. The interaction between the independent variables is ignored in this part. Then it checks if the effect of one independent variable depends on the value of another independent variable. That is called the interaction effect. The degrees of freedom here is the product of the two degrees of freedom for each independent variable. Finally, three P-values are computed. For example, if the P-value for gender is less than alpha, then gender is considered a main effect.

Correlation

Correlation (r) is a statistical technique used to assess the relationship between two variables. Its numerical value *r* describes and measures three characteristics [57]: (i) the linear correlation of the two variables, (ii) the direction of the relationship (r > 0 means positive correlation; r < 0 means negative correlation) and (iii) the strength of the relationship ($-1 \leq r \leq 1$) where a perfect correlation equals 1, and value of zero means no correlation. We use the formula below for our hypothesis testing:

$$r_{xy} = \frac{\sum x_i y_i \; - \; n\bar{x}\bar{y}}{\sqrt{(\Sigma {x_i}^2 - n\bar{x}^2)}\;\sqrt{(\Sigma {y_i}^2 - n\bar{y}^2)}}$$

where: n is sample size

x_i, y_i are the individual sample points indexed with i

$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$ (the sample mean); and analogously for $\bar{y}$

The null hypothesis is H_0: $r = 0$ while the alternative hypothesis is H_A: $r \neq 0$.

In this study, the Pearson Correlation coefficient is used to measure the degree and the direction of the linear relationship between the students' class performance and their AQ scores. For the CS250 students, their class performance is based on their final numerical grades for the class. For the graduating students, we considered all the required classes in their major, computed their average letter grade for these classes and named it CS-GPA.

The following are the required classes:

Class name	Class number	Credits
Survey of Computer Science	COMPSCI 150	3
Introductory Computer Programming	COMPSCI 250	3
Intermediate Computer Programming	COMPSCI 251	3
Introduction to Computer Organization and Assembly Language Programming	COMPSCI 315	3
Discrete Information Structures	COMPSCI 317	3
System Programming	COMPSCI 337	3
Data Structures and Algorithms	COMPSCI 351	3
Introduction to Software Engineering	COMPSCI 361	3
Social, Professional, and Ethical Issues	COMPSCI 395	3
Introduction to the Theory of Computation	COMPSCI 417	3
Programming Languages Concepts	COMPSCI 431	3
Computer Architecture	COMPSCI 458	3
Computer Networks	COMPSCI 520	3
Algorithm Design and Analysis	COMPSCI 535	3
Introduction to Operating Systems	COMPSCI 537	3
Capstone Project	COMPSCI 595	4
Professional Seminar	EAS 200	1
Digital Logic	ELECENG 354	3

Table 4: Computer Science major required classes

4. Results and discussion

Study population

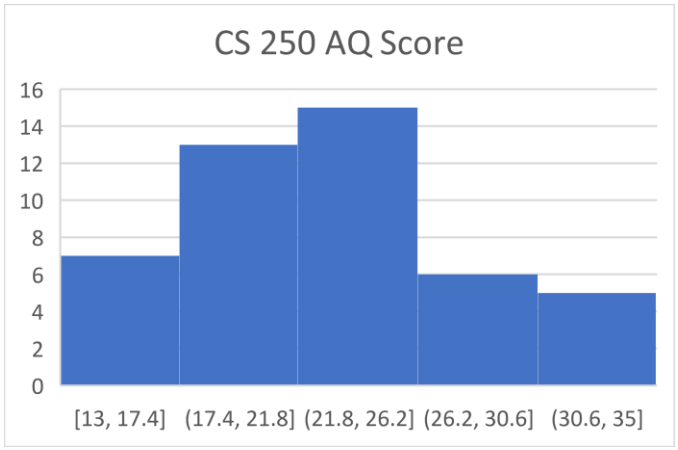
The sample of 52 adults includes 46 students from the CS250 class with 37 males and 9 females, and 6 male graduating students. Their ages ranged from 18 to 39 years.

Normality check

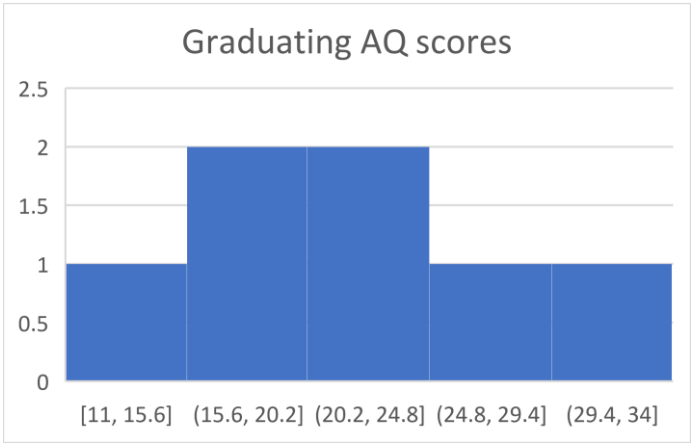
The Shapiro-Wilk W test was conducted on the collected data. When the p-value of the Shapiro-Wilk Test is greater than 0.05, we can assume the data is normal for both groups as shown in Table 5. Figures 1 and 2 show the AQ score histograms for both CS 250 students and graduating students, and the AQ score histogram of CS250 students by gender.

	Shapiro-Wilk		
	Statistic	df	p-value
CS250_All_AQ	0.972	46	0.318
Graduating_All_AQ	0.951	6	0.744
CS250_Male	0.963	37	0.254
CS250_Female	0.975	9	0.932

Table 5: Shapiro-Wilk Normality Test

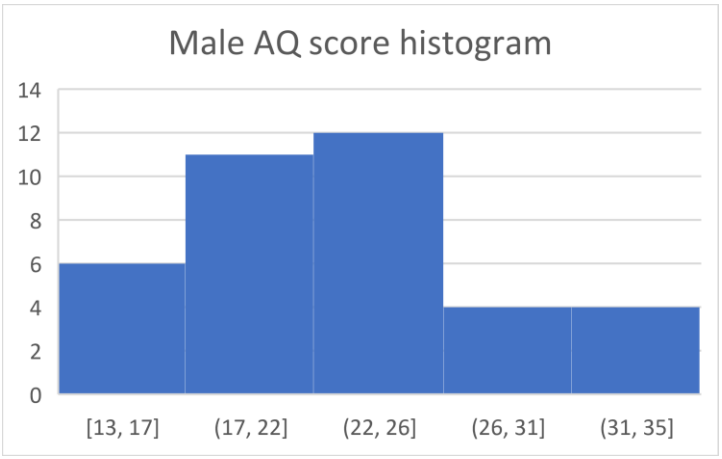


(a)

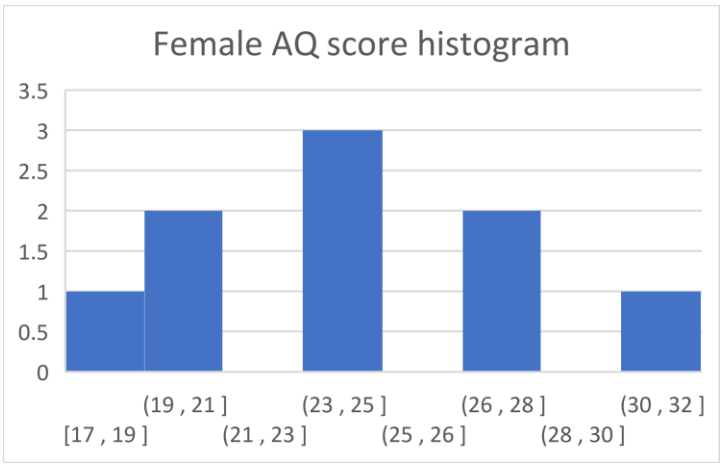


(b)

Figure 1: AQ score histogram charts: (a) CS250 Students, (b) Graduating Students



(a)



(b)

Figure 2: AQ score histogram charts: (a) CS250 male students, (b) CS250 female students

Descriptive statistics:

Mean AQ and subcategory scores

A descriptive analysis for the AQ scores is shown in table 6.

The mean AQ score of the CS 250 students is 22.8. The CS250 male students' mean AQ score is 22.6, while the female students' mean of 23.9 is slightly higher. The mean AQ score for the graduating students' group is 23.8. These numbers are closer to the mean AQ scores for the general adult population than that of autistic adults, which are 17 and 35 respectively in [21]. The numbers are also quite similar to the mean AQ scores of computer science and math majors (21.1 and 21.5 respectively) in Baron-Cohen et al.'s study [1].

	N	Minimum	Maximum	Mean	Std. Deviation
Everyone AQ	52	13.00	35.00	23.04	5.56
CS250_All_AQ	46	13.00	35.00	22.8	5.56
Graduating_All_AQ	6	16.00	34.00	23.8	6.21
CS250_Male_AQ	37	13.00	35.00	22.6	5.79
CS250_Female_AQ	9	17.00	32.00	23.9	4.62

Table 6: AQ characteristics by group and gender

Table 7 shows the mean subcategory scores were for CS 250 students, the male and female students in the class, and the graduating students. A quick inspection shows the mean scores of the four groups are not that different. CS250 males have the highest "Social Skills" mean score, while the CS 250 females have the highest mean scores on both "Attention to Detail" and "Attention Switching" subcategories which agrees with [51] and [50]. The

graduating students have the highest mean score in the “Communication Skills” and “Imagination” subcategories.

		N	Minimum	Maximum	Mean	Std. Deviation
Social Skills	CS250 ALL	46	0.00	8.00	3.96	2.02
	CS 250 Male	37	0.00	8.00	4.05	2.15
	CS 250 Female	9	2.00	7.00	3.56	1.42
	Graduating ALL	6	0.00	8.00	3.83	3.37
Communication Skills	CS250 ALL	46	0.00	8.00	3.35	2.13
	CS 250 Male	37	0.00	8.00	3.38	2.16
	CS 250 Female	9	0.00	6.00	3.22	2.11
	Graduating ALL	6	2.00	8.00	4.17	2.14
Imagination	CS250 ALL	46	1.00	7.00	3.07	1.65
	CS 250 Male	37	1.00	7.00	2.97	1.72
	CS 250 Female	9	2.00	6.00	3.44	1.33
	Graduating ALL	6	2.00	6.00	3.83	1.72
Attention to detail	CS250 ALL	46	1.00	7.00	6.74	1.65
	CS 250 Male	37	1.00	10.00	6.46	2.21
	CS 250 Female	9	3.00	10.00	7.89	2.26
	Graduating ALL	6	1.00	10.00	6.33	2.94
Attention switching	CS250 ALL	46	2.00	9.00	5.72	1.71
	CS 250 Male	37	2.00	9.00	5.70	1.65
	CS 250 Female	9	3.00	9.00	5.78	2.05
	Graduating ALL	6	3.00	8.00	5.67	1.63

Table 7: Subcategory AQ characteristics by group and gender

Table 8 displays AQ and subcategories scores for our students in both groups along with Baron-Cohen's CS students. a quick check on the table shows that our students' scores are quite close to Baron-Cohen's students.

	Social skills	Communication skills	Imagination	Attention to detail	Attention switching	Total AQ
Baron-Cohen CS students	3.7	4.3	3.4	5.7	4.8	21.1
CS 250 students	3.96	3.35	3.07	6.74	5.72	22.8
Graduating students	3.83	4.17	3.83	6.33	5.67	23.8

Table 8: Mean AQ and subcategory score for Baron-Cohen's CS students and our students

Figure 3 displays subcategory means score for CS20 males, females, and the graduating students.

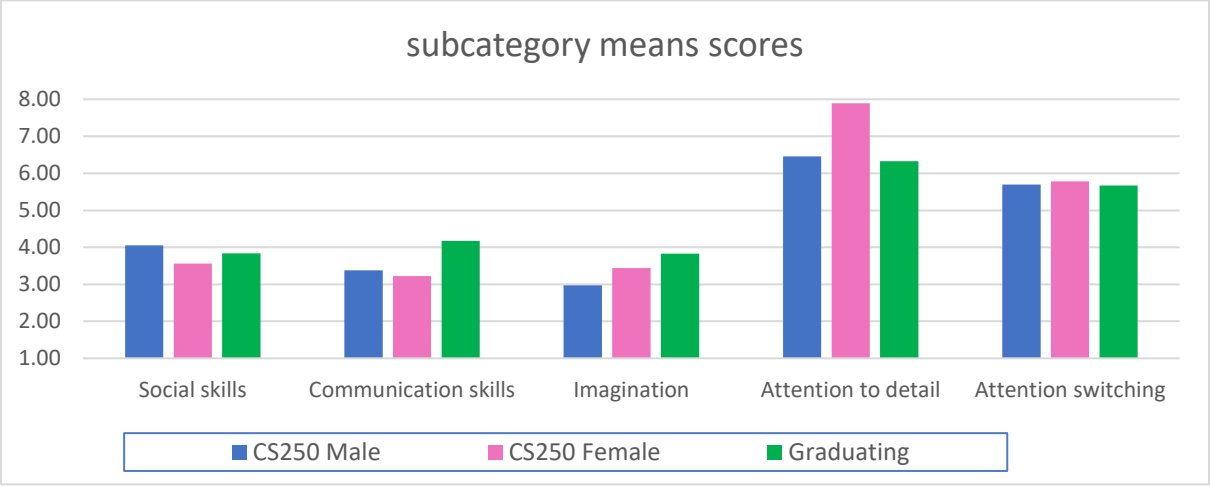


Figure 3: Subcategory means scores by group

Statistical Mean comparison

Independent Samples T-test

The t-test is conducted to determine if any statistical difference exists between the mean AQ scores of the male and female students in CS 250. As shown in Table 8, the p-value = 0.53 which is greater than our alpha of 0.05. Thus, we cannot reject the null hypothesis and conclude that no significant difference exists between the means.

Five other t-tests were run to check for any statistical difference between the mean scores of the two groups for each of the five subcategories of the AQ test. As shown in Table 9, again, the p-values for all the categories are greater than 0.05 so we conclude that there is no significant difference between the means of the two groups.

	t-test for Equality of Means				
	df	p-value (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
CS250_All_AQ	44	0.53	-1.32	-5.51	2.87
CS250 Social Skills	44	0.51	0.49	-1.03	2.02
CS250 Communication Skills	44	0.85	0.16	-1.46	1.77
CS250 Imagination	44	0.45	-0.47	-1.71	0.77
CS250 Attention to detail	44	0.09	-1.43	-3.09	0.23
CS250 Attention switching	44	0.91	-0.08	-1.37	1.22

Table 9: T-test on CS250 by gender

To see if a student's level of study (beginner or advanced) has an effect on the mean AQ score and the mean subcategory scores, we conducted several T-tests to compare the means between all CS250 students and the graduating students. The results are shown in Table 10. All

the p-values are greater than 0.05 so we conclude that there is no significant difference between the means.

	t-test for Equality of Means				
	df	p-value (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
EveryOne_AQ	50	0.68	-1.01	-5.91	3.90
EveryOne_SocialSkills	50	0.90	0.12	-1.79	2.04
Everyone_Communication Skills	50	0.38	-0.82	-2.68	1.04
EveryOne_Imagination	50	0.29	-0.77	-2.21	0.68
Everyone_Attention To Detail	50	0.69	0.41	-1.64	2.45
Everyone_Attention Switching	50	0.95	0.05	-1.43	1.53

Table 10: T-test on all participants by level of study

Two-way ANOVA

Two-way ANOVA is used to determine whether gender and/or AQ scores have effect on the performance in class of participants. First, we tested the CS250 group with gender and AQ scores as independent variables and their CS250 class grades as the dependent variable, the p-value is 0.79 for the gender, 0.66 for the AQ scores, and 0.82 for the interaction between gender and the AQ score for each student, the values are all greater than alpha 0.05, thus we cannot reject the null hypothesis and conclude that gender and AQ scores are not main effects on the class performance and there is no interaction between them. Table 11 below shows the results of Two-way ANOVA.

Tests of Between-Subjects Effects				
Dependent Variable: CS250_course grade				
Source	df	Mean Square	F	p-value
Gender	1	12.45	0.12	0.74
AQ score	3	230.65	2.14	0.11
Gender * AQ score	3	2.32	0.02	0.99

Table 11: Two-way ANOVA CS250 students

Correlation

Pearson Correlation coefficient is used to measure the relationship between CS 250 students' class performance and their AQ scores as well as their five subcategory scores. The greater the r- value the stronger the relationship. But, as Table 12 shows, the resulting r-values are very small. That is, there is no significant relationship between the students' grades and their AQ scores. While there is a negative weak correlation between the students' grades and their communation skills in which it means that those who have high class grades are better in communication skills because a high score in the "communication skills" subcategory means that the individual lacks communication skills (higher autistic traits).

	Pearson Correlation (r)
CS250_All_AQ	-0.09
CS250 Social Skills	0.02
CS250 Communication Skills	-0.28
CS250 Imagination	-0.05
CS250 Attention to detail	0.002
CS250 Attention switching	0.08

Table 12: Correlation between CS250 students class performance and their AQ scores

As for the graduating students, the results are different. There is a positive weak relationship between their CS-GPA and their AQ score (r =0.27). While there is a moderate relationship between their CS-GPA and "Attention switching" subcategory (r = 0.35), and a strong positive relationship between their CS-GPA and their "Social Skills", "Imagination" subcategories (r= .54, r= 0.59). Also, the students' CS-GPA has a negative strong relationship with their "Attention to detail" subcategory score (r = -0.56), and almost no relationship with their "Communication Skills" scores, as seen in Table 13.

	Pearson Correlation (r)
Graduating_All_AQ	0.27
Graduating Social Skills	0.54
Graduating Communication Skills	-0.03
Graduating Imagination	0.59
Graduating Attention to detail	-0.56
Graduating Attention switching	0.35

Table 13: Correlation between Grad. students CS-GPA and their AQ scores

Discussion of results

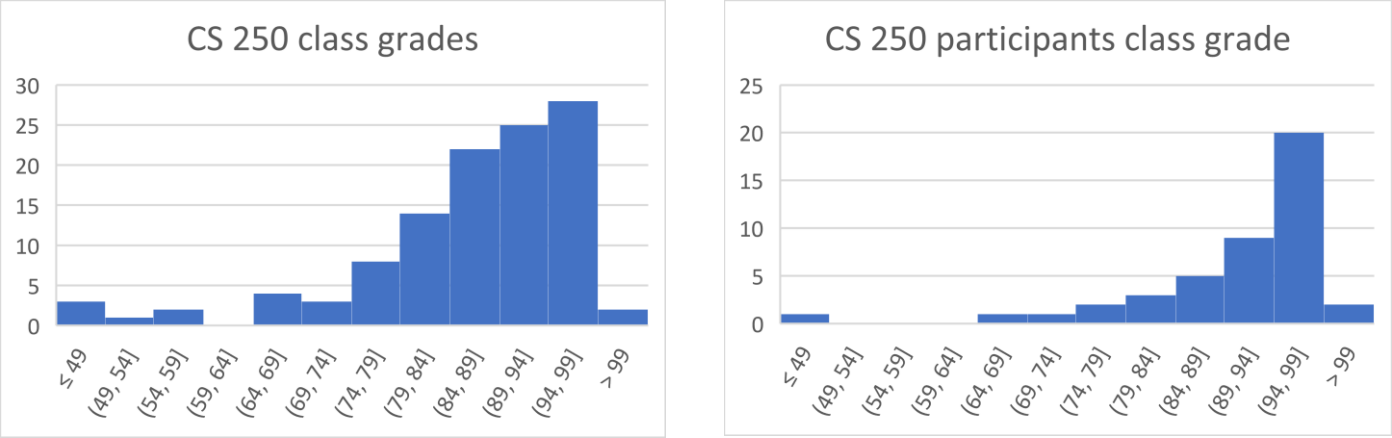
This study's main weakness is its relatively small sample size (46 CS 250 students and 6 graduating students). It was conducted during the pandemic, so the recruitment was done online via email. It was challenging to get students to participate in the study. More studies are needed to verify the robustness of our results.

The study examined AQ scores for CS250 and graduating CS and CE students. The graduating students' group mean AQ score of 23.8 is higher than the CS250 students' group mean AQ score of 22.8. Curiously, while there was barely any correlation between the CS 250 students' scores with their class grades, there was a weak positive correlation between the graduating students' scores and their CS-GPA. These results suggest that the graduating students may have more autistic traits than the beginner CS 250 students and it led to some performance gain. An interesting question is -- do the graduating students have intrinsically more autistic traits than the beginner students? Or did the CS classes the graduating students took during their 4 to 6 years of study made their autistic traits "stronger"?

The absence of gender effect on AQ score suggests that the autistic characteristics between males and females CS students are similar. Also, the number of female participants (n = 9) is much smaller than the number male participants (n = 43), a reflection of the current gender distribution in CS/CE majors at UW-Milwaukee.

The lack of strong correlation between CS250 students' AQ scores and their class performance can partly be explained by the fact that the class average was relatively high (86%)

and majority of the participants performed well in the class as shown in the histogram charts of Figure 4.



(a) (b)

Figure 4: Histogram Charts: (a)CS 250 class grades, (b) participants class grade

The strong positive correlation between the graduating students' CS-GPA and their "Social Skills" and "Imagination" subcategories' scores means that the higher their CS-GPA, the less sociable and less imaginative they are. On the other hand, the negative strong relationship between the graduating students' CS-GPA and their attention to detail means that the higher their CS-GPA the less detail-oriented they are. Finally, the students' CS-GPA had no correlation with their communication subcategory scores.

We are somewhat surprised by these results. Maybe the students with the higher CS-GPA spent more time focused on their school work instead of socializing so they had higher class performance but lower social skills and imagination. Furthermore, maybe these students are good at seeing the big picture instead of getting bogged down by details. Their ability to comprehend the context of their work helped them achieve a higher CS-GPA.

Main limitation of this study was number of participant was relatively small. It was done during the pandemic, so the recruitment was done online via email end of semester. It was difficult to get students to participate in the study. More studies are required to validate the strength of our results.

5. Conclusion and Future recommendation

We have used the Autism Spectrum Quotient (AQ) in our research study to investigate possible correlations between AQ scores of the CS students and their grades, and whether there is a difference between the AQ scores of beginner CS students and those who are about to graduate. The AQ measures the amount of autistic traits in adults. The higher the score the more autistic traits the individual has.

Although our sample was small (n =52), our findings show that the AQ score of Computer Science students at UWM are closer to that of the general adult population than that of autistic adults. There is no significant difference between the AQ scores for the male and female students. Also, the AQ score of the Computer Science students at UWM are quite close to Computer Science students at Cambridge University [1].

There was no correlation between the AQ scores of the CS 250 students and their class grades while the AQ scores of the graduating students have a weak positive correlation with their CS-GPA.

Since autism is increasing worldwide, Computer Science departments will likely have more ASD students in their programs. These departments will have to consider how they

modify their classes and teaching methods to accommodate all types of students. That is, they have to think about how they will make their classes more inclusive for everyone. For example, for projects, they might want to offer individual or group options to all students so that any ASD students in their midst who finds social interactions hard can still succeed. That is achieved by Integrating principles of universal design into classroom and evaluation techniques. Here are some of the principles of Universal Design that can help ASD students [58]:

Principle 1: Accessible and (equitable use): Make time to meet with the students with ASD and learn about their needs.

Principle 2: Flexibility in use, participation, and presentation: Make classrooms allow for different learning styles. Provide alternatives to group work.

Principle 3: Being straightforward and consistent: Be direct. Avoid synonyms and code words. Let the student know the rules and expectations.

Principle 4: Material Explicitly Presented and Readily Perceived: Ensure class material is presented clearly. ASD students are visual learners, so graphs, web organizer, and other visuals may assist with learning.

Principle 5: Supportive Learning Environment: Students with ASD who feel welcome and appreciated perform at their best. Provide direct, constructive, explicit, and supportive feedback.

Principle 6: Minimizing or Eliminating Unnecessary Physical Effort: Many people with ASD report sensory overload reactions. Sounds, noises, and visual distractions that may annoy

all students may be very painful to some students with ASDs causing them to need to leave the room. If you have a squeaky door or noisy student, try to correct the situation rather than ignore it. Students with ASD may require preferential seating to minimize the impact of sensory distractions.,

Principle 7: Learning space accommodates both students and methods: If a room is too small this may be very problematic for a student with ASD who may be more sensitive to touch and issues of physical space. Choose a room that meets the needs.

Some specific directions to improve our work include:

- Recruiting more students to answer the AQ so results are more robust and expand the study to other CS programs in the country.
- Investigate if AQ scores change when students enter college and when they leave college, especially for CS students.
- Interview ASD college students and collaborate with organizations that support ASD adults to understand their challenges.
- Compare CS students with students in other majors (i.e Humanities and social sciences).
- Study students Attention-deficit/hyperactivity disorder (ADHD) along with ASD and compare the AQ scores of both groups.
- Study students' class behaviors (i.e check their ability to work in groups) and find any correlations with their AQ scores.

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Appendix

The Autistic-Spectrum Quotient

1. I prefer to do things with others rather than on my own.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
2. I prefer to do things the same way over and over again	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
3. If I try to imagine something, I find it very easy to create a picture in my mind.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
4. I frequently get so strongly absorbed in one thing that I lose sight of other things.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
5. I often notice small sounds when others do not.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
6. I usually notice car number plates or similar strings of information.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
7. Other people frequently tell me that what I've said is impolite, even though I think it is polite.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
8. When I'm reading a story, I can easily imagine what the characters might look like.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
9. I am fascinated by dates.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*

10. In a social group, I can easily keep track of several different people's conversations.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
11. I find social situations easy.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
12. I tend to notice details that others do not.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
13. I would rather go to a library than a party.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
14. I find making up stories easy.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
15. I find myself drawn more strongly to people than to things.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
16. I tend to have very strong interests, which I get upset about if I can't pursue.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
17. I enjoy social chit-chat.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
18. When I talk, it isn't always easy for others to get a word in edgewise.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
19. I am fascinated by numbers.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
20. When I'm reading a story, I find it difficult to work out the characters' intentions.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
21. I don't particularly enjoy reading fiction.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
22. I find it hard to make new friends.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
23. I notice patterns in things all the time.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
24. I would rather go to the theater than a museum.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
25. It does not upset me if my daily routine is disturbed.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
26. I frequently find that I don't know how to keep a conversation going.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
27. I find it easy to "read between the lines" when someone is talking to me.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
28. I usually concentrate more on the whole picture, rather than the small details.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
29. I am not very good at remembering phone numbers.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
30. I don't usually notice small changes in a situation, or a person's appearance.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
31. I know how to tell if someone listening to me is getting bored.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
32. I find it easy to do more than one thing at once.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
33. When I talk on the phone, I'm not sure when it's my turn to speak.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
34. I enjoy doing things spontaneously.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
35. I am often the last to understand the point of a joke.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*

36. I find it easy to work out what someone is thinking or feeling just by looking at their face.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
37. If there is an interruption, I can switch back to what I was doing very quickly.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
38. I am good at social chit-chat.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
39. People often tell me that I keep going on and on about the same thing.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
40. When I was young, I used to enjoy playing games involving pretending with other children.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
41. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
42. I find it difficult to imagine what it would be like to be someone else.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
43. I like to plan any activities I participate in carefully.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
44. I enjoy social occasions.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
45. I find it difficult to work out people's intentions.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
46. New situations make me anxious.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
47. I enjoy meeting new people.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
48. I am a good diplomat.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
49. I am not very good at remembering people's date of birth.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*
50. I find it very easy to play games with children that involve pretending.	*definitely agree*	*slightly agree*	*slightly disagree*	*definitely disagree*