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Abstract

College students who have an autism spectrum condition study in STEM fields at a higher rate than their neurotypical peers, and they face documented challenges in postsecondary education. Given the proportionally higher representation of autism in STEM majors, it is important to study what works best, from an educational standpoint, for this diverse group of students. The purpose of this qualitative study is to document the experience and insight of college faculty about unique learner qualities related to autism and the qualities most needed in STEM fields. In-depth interviews were conducted with 12 STEM faculty members about their experience teaching students on the spectrum, and thematic analysis was conducted to identify shared faculty perceptions. Faculty views converged on certain observable strengths, challenges, and general traits needed in their fields. The discussion summarizes findings and includes implications for teaching and postsecondary programming.

Keywords: Autism spectrum disorders; High functioning; Postsecondary; STEM

In popular culture, there is a stereotype that science and technology fields are populated by people who have autism[1] or autistic traits more than other fields. Although stereotypes oversimplify, there is empirical evidence that persons on the autism spectrum, estimated at 1.4% of the population (Christensen et al., 2016), are more likely to study and work in STEM than their neurotypical peers (Ruzich et al., 2015; Wei, Yu, Shattuck, McCracken, & Blackorby, 2013). Given the relative prominence of STEM study for college students with autism and the barriers to postsecondary achievement for this group (Taylor, Henninger, & Mailick, 2015), it is important to identify educational practices that work so that students can meet their goals and the field can benefit from the contributions of diverse minds.

In a cross-disciplinary study of the STEM workforce, the National Science Board (2015) concluded that opening pathways to STEM education is essential for the prosperity of individuals and the nation as a whole. During the Barack Obama administration, the U.S. Department of Education embarked on a pro-STEM initiative aimed at increasing engagement with STEM education at all levels and improving access for historically underrepresented groups (U.S. Department of Education, n.d.). Part of this effort has included the mandate to diversify,

[1] To respect the communities about whom we write, we use the terms *autism* and *autism spectrum* almost exclusively in this article instead of the DSM-5 diagnostic term *autism spectrum disorder*. This choice reflects our wish to respect preferences in the autism community. In addition, we have retained the APA practice of person-first construction in order to adhere to conventions of the readership of this publication; however, we are aware that person-first language is not always preferred by autistic advocates.

including more women, minorities, and persons with disabilities in STEM (Gutieri, 2014; Nilsson, 2017; Wang & Degol, 2017). Evidence suggests that "representation of students with disabilities decreases longitudinally over the course of the STEM education process" from the primary grades through high school and postsecondary education (Moon, Todd, Morton, & Ivey, 2012, p. 10). Due to the push to increase minority representation in STEM studies, scholarship has emerged about how to entice undergraduates to commit to STEM (President's Council of Advisors on Science and Technology, 2012), but none have focused exclusively on students with autism, a group with interest in STEM and challenges in college.

Autism Representation in STEM Majors

A postsecondary degree is associated with "increased earnings (Carnevale and Desrochers 2003), improved health (Mirowsky and Ross 2010), and increased job satisfaction (Wolniak and Pascarella 2005)" (Sanford et al., 2011, p. 13) as well as lower unemployment. For students on the spectrum, the benefits also include "improved self-esteem, valued social roles, [and] increased community participation and involvement" (Hart, Grigal, & Weir, 2010, p. 142). Therefore, it is especially important to increase representation among students with autism as graduates of postsecondary programs. Identifying barriers to and supports for achieving educational goals is a necessary step to increase employment opportunities.

Students on the autism spectrum study in all fields, but they participate in STEM in significantly higher percentages than the general population, with 34% of college students on the spectrum enrolling in STEM versus 22% of the general population (Wei et al., 2013). Learners with autism also participate in STEM education at higher rates than individuals in 10 other disability categories, although their overall participation in postsecondary education is third lowest among this group (Wei et al., 2013). A higher rate of autism has been found in college students studying mathematics (Baron-Cohen, Wheelwright, Burtenshaw, & Hobson, 2007), and this linkage has influenced the development of the empathizing–systematizing (E-S) theory of autism. The E-S theory explains autism as a combination of both a lower level of social functioning and average or superior level of systemizing ability, defined as "the drive to analyze or construct systems" (Baron-Cohen, 2009, p. 71). This theory has been used to hypothesize that persons with autism have mathematical talent.

Students with autism who were enrolled in STEM at the community college level experienced greater success than those enrolled in other majors; they "were more likely to persist" in a program and "were twice as likely to transfer . . . to a 4-year university" compared to other majors (Wei et al., 2014, p. 1159). Students were more likely to try out STEM in college if they had upper level mathematics course in secondary school, so current educational recommendations include boosting engagement of students on the spectrum in these courses (Wei, Yu, Shattuck, & Blackorby, 2017). It is important to note that the majority of students with autism do not study STEM; however, there is a statistical link between autism, preference for STEM study, and academic success (Wei et al., 2014).

Postsecondary Educational Supports for Autism

Postsecondary students on the spectrum have similar aspirations as the general population: They seek to be independent and take responsibility for own lives (Anderson, MacDonald, Edsall, Smith, & Taylor, 2016). These students also face considerable academic

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and social challenges (Gelbar, Shefyck, & Reichow, 2015; Zeedyk, Tipton, & Blacher, 2014; Gobbo & Shmulsky, 2014) and poorer outcomes, including lower graduation rates and higher degrees of unemployment than the general population (Taylor et al., 2015). Research efforts have been ongoing to study the nature of autism-related postsecondary challenges and the best approaches for success.

Students, their parents, and educators report that prominent needs of college students with autism fall into three domains: social functioning, self-determination, and self-regulation. Specific challenges identified include "developing interpersonal competence and age-appropriate capacity for intimacy" (White et al., 2016, p. 36), "maintaining motivation for school, time-management, organization of materials, and managing intense emotions and academic stress" (p. 37). When interviewed, parents and university personnel said that autistic features such as difficulty with executive function, social skills, and personal care lead to adversity in the postsecondary setting (Dymond, Meadan, & Pickens, 2017).

A systematic review categorized three groups of strategies currently used at postsecondary institutions: skill instruction, educational supports, and faculty supports. The recommendations most salient for instructors come from the latter two categories and include note-taking accommodations, exam accommodations, organization supports, seating choice, using routines in class, breaking down large assignments, and using a student's strongest interest area as a motivator. For the complete overview of postsecondary practices related to students with autism, see Zeedyk, Tipton, and Blacher (2016).

According to parents of students on the spectrum and university personnel who work with students, better outcomes could be achieved with improvements such as increased autism education and inclusive transition planning (Dymond et al., 2017). Self-identified students on the spectrum from a postsecondary honors program said that they benefited from small classes, clear expectations from instructors, and instructors who are willing to meet with them individually (Yager, 2016). Faculty members have reported that college students with autism are best served by teaching practices that that incorporate structure, predictability, and proactive strategies to address student stress or apparent anxiety (Gobbo & Shmulsky, 2014). Accommodations suggested for use in STEM courses include universal design for learning, online course management systems, clear and explicit directions, and mobility accommodations as needed (Moon et al., 2012).

The existing literature suggests many teaching approaches that have the potential to improve postsecondary educational experience and outcomes for students on the spectrum (Gobbo, Shmulsky, & Bower, 2018). Because a high proportion of students with autism study in STEM fields, it is worthwhile to explore effective teaching practices within those fields. The first goal of this research was to learn how college STEM faculty, who are the primary point of connection between students and academics, perceive students who have this profile and what they have discovered about teaching this diverse group. The second goal of this study was to collect STEM faculty perceptions about what skills and abilities are necessary for success in their fields. Taken together, these two research aims can be analyzed to better understand student strengths and areas of challenge vis-à-vis STEM study. It is hoped that by describing student attributes and STEM-field needs, this work can provide instructors with a place to start when thinking about how to make their curricula more accessible to students.

Research Questions

This study was designed to answer the following research questions.

1. Based on classroom teaching experience, what do college faculty in STEM fields perceive as strengths and challenges of students who have autism?
2. What skills and abilities do STEM faculty think are most needed for STEM careers?

Method

This was a qualitative study designed to probe first-hand experience in order to answer the research questions. We took an ethnographic approach to the nature of knowledge, seeking the lived experience of STEM faculty who work exclusively with a neurodiverse student population. The value of this approach is that faculty were free to describe their experience in detail. Because qualitative studies are inductive and results are based on researcher interpretations (Maykut & Morehouse, 1994), we used a multistep analysis process to ensure validity.

This qualitative interview study consisted of semistructured interviews with 12 instructors from the researchers' institution who, at the time of data collection, taught in STEM fields and self-identified as having experience germane to the research questions. Instructors are students' predominant connection to academics in the undergraduate years, so their views and approaches can uniquely influence educational outcomes; in addition, they see students multiple times per week during a semester, so they are in a unique position to observe student behavior. Participants who were interested in the study self-identified as having direct experience teaching students with documented diagnoses of an autism spectrum condition, which was then confirmed in the interview. The semistructured interview methodology was selected so that participants could bring up novel ideas and observations about teaching this population.

Participants

The convenience sample of 12 faculty members were recruited from a liberal arts college that serves students who learn differently; it was estimated that 35% of the student population had a documented autism diagnosis at the time of the study. Researchers visited the regular meetings of academic departments offering courses in STEM fields and presented a general overview of the study followed by an email invitation. Interested faculty members responded, and one-on-one, private interviews were set up for all 12 who expressed a desire to participate. Participants received a $25 gift certificate for their participation. Participants represented the fields of biology, chemistry, computer science, and mathematics and had an average of 13.6 years of postsecondary teaching experience (the demographic data sheet is included in Appendix A). Faculty members teach, on average, five to seven STEM courses per academic year. Once they had agreed to participate, each potential participant was asked screening questions to determine if they would be included in the study.

A gateway question for this research is whether participants were qualified to speak about college students who have autism. It was not possible to objectively confirm that each participant had direct experience with a student known to be on the spectrum; however, participants were selected for the study based on the nature of the institution from which they came, the self-selecting recruitment procedure, and their accurate descriptions of autism.

Participants self-selected as "having experience teaching students with ASD"[2] during the

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recruitment phase, establishing their initial belief that they had relevant experience. To validate that impression, interview questions probed the participants' knowledge about autism. If any responses had shown a lack of familiarity with the autism spectrum, the interview would have been excluded from analysis. All 12 participants described autism in ways that closely matched diagnostic criteria outlined in the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association [APA], 2013), which supported their qualification to speak on the subject.

At the beginning of the interview, participants were asked the following questions: "What are the first three words you think of when you hear autism," and "in your own way of thinking, what is ASD?" Responses included challenges with social functioning, communication difficulties, difficulty with nonverbal cues, intense focus, and sensory sensitivity. Responses to the two initial interview items align closely with the DSM-5 descriptors, including "deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach . . . to reduced sharing of interests, emotions or affect"; "deficits in nonverbal communicative behaviors used for social interaction"; "difficulties adjusting behavior to suit various social contexts; "highly restricted, fixated interests that are abnormal in intensity or focus"; and "hyper- or hyporeactivity to sensory input" (APA, 2013, p. 50). The alignment between interviewee answers to questions about autism and published autism features supported the validity of subsequent responses.

Interviews

Researchers met participants in their private offices for audio-recorded interviews lasting between 45 and 60 minutes. The interview script, included in Appendix B at the end of this article, contains 27 open-ended questions asking participants to recall and share their experiences teaching students on the spectrum. The research draws on work by Gobbo and Shmulsky (2014) for the interview protocol. The current research extends earlier work by specifically investigating STEM faculty. The first five questions were designed to confirm participant eligibility by validating their baseline knowledge of autism. Subsequent question groups directly addressed each of the research questions. Questions pertaining to lab work and field work were used only if time and experience permitted. The questions were developed by two of the coauthors and tested on the third author. Subsequent edits were completed by all coauthors. All participants completed the full interview protocol.

Analysis

Audio recordings were transcribed and analyzed using multistage thematic analysis (Braun & Clark, 2006). Transcription was completed by an outside transcription service and reviewed by the coauthors for accuracy. Transcripts were between nine and 15 pages each. In Stage 1, each researcher read the transcripts independently. They noted words and themes that appeared several times or that were expressed with intensity. After independently reviewing the transcripts, the researchers met to compare emerging themes. Themes identified by multiple researchers were carried forward and maintained in notes, and those that were only noted by one researcher were dropped from analysis. Therefore, final themes were developed by group consensus of common ideas across the transcripts. These ideas appeared multiple times per participant and were expressed with intensity across multiple participants.

[2] Although *autism* is the preferred term throughout this article, we use the clinical term *autism spectrum disorder* (ASD) in direct quotations of interview questions or answers.

In Stage 2, researchers sorted the transcript data by research question using NVIVO; this enabled researchers to look at all responses within a particular category, such as "strengths" or "social behavior." The above process of independent reading, group review, and identification of themes based on consensus was repeated.

In the final stage of analysis, researchers compared themes found in Stages 1 and 2. Wording and level of detail varied, but no substantive discrepancies were found. This provided the opportunity to improve and further clarify early themes. The results section reports themes that emerged from this multistage analysis.

Steps taken to establish validity included audio recording interviews to have a precise record of participant speech, transcribing interviews word for word, independent review of transcripts by two researchers, multistage review, and flagging discrepancies. At the time of analysis, more than one participant had left the college; therefore, member checks were not performed.

Results

Diversity in Profile

Experienced STEM faculty members emphasized the variability in student profiles. When asked about general strengths and challenges, most participants were quick to point out that "students with ASD are all really different." Variability came up throughout the interviews, both in regard to student profile and effective teaching strategies. Diversity was commonly noted in the level of visibility of autistic features, creativity, abstract thinking, and critical thinking. To illustrate these ideas stated by multiple participants, one faculty member said:

> In terms of sensory sensitivity, social challenges, and difficulties with concrete thinking . . . some of those seem to exist in everybody who's on the spectrum. But the extent to which they exist varies wildly, so you often have students on the spectrum who are highly social but still have some social difficulties. They have no problem interacting with others, but they may struggle to read nonverbal cues and social contexts . . . . You hear it said, "If you know one person with ASD, then you know one person with ASD," and I think that's very much the case.

Several respondents said that some students on the spectrum are noticeably concrete thinkers, taking instructions and social statements literally. Other students, however, were seen as having a strong ability to make creative connections and think abstractly. Both of these seemingly opposite variants were associated with autism; the first is an outcome of rigidity, and the second is linked to seeing the world in a different way. The following section describes college students with autism as seen by STEM faculty, but it is presented with the qualification, which is emphasized by participants, that all students are unique and do not fit a single profile. Themes are first presented in this section and are discussed in further detail in the discussion.

Research Question 1: Strengths and Challenges

Strengths. Participants who were interviewed for this project pointed out several strengths that students who have autism bring to their classrooms. Strengths were observed in three areas: attention to detail, the ability to follow directions, and recognition and use of patterns.

Attending to detail. Several faculty observed attention to detail as a prominent strength in college students on the spectrum. Multiple examples were given of students' ability to focus

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on details and resist distraction, especially in situations of innate interest. One participant said, "Then they are really going to be detail focused." Participants also discussed this tendency in relation to the completion of assignments, indicating that students "followed rules to a T" and that "their assignments are completed to the letter."

Participants noticed that attention can impede progress as well. They noticed that focus on detail can "become a fixation" or that students might "insist on detail when the level of detail is unnecessary" to understand the broader topic. This confirms the notion that college students on the spectrum may have difficulty with self-regulation as they take STEM courses.

Following complex directions. Related to students' attention to detail is perceived skill at following directions. In several interviews, participants mentioned students who have autism appear particularly strong in staying on task and following directions. Students were described as being "very good at procedures." This ability and tendency was also described by one faculty member as following a long set of directions doing it "exactly the way you asked them to do it without variation." This strength can also have a negative side. For example, one instructor said that this can at times cause a rigidness that may inhibit critical thinking skills, a finding that is discussed later under challenges.

Recognizing and using patterns. Participants observed that some students who have autism stand out in their ability to recognize patterns quickly and accurately. This skill is essential to understanding problems and identifying possible solutions in any field. Faculty members who were interviewed referred to students' "aptitude with procedures and pattern recognition" and "their ability to think things through in a linear way, understanding patterns." One such description mentioned this in connection with an intuitive ability to see possible solutions to problems.

Participants noted that students who have autism can demonstrate a great deal of diligence shown by consistent work habits, readiness to learn, and persistence. They suggested that these traits may be, at times, catalyzed by the student's deep interest in the subject. One route to maximizing student strengths, according to participants, is to include students' specific interests in the course when possible.

Challenges. In addition to faculty perspectives about student strengths, the research uncovered what faculty see as the challenges faced by college students on the autism spectrum in the context of STEM courses. Challenges noted by participants included expressing frustration, social functioning, and rigidity or inflexibility.

Expressing frustration. Participants observed that students who have autism display frustration, and by logical extension experience frustration, in response to academic and social challenges. Several faculty relayed specific anecdotes about inappropriate expressions of frustration in the classroom. Outward expressions of frustration were seen as having a negative impact on the classroom dynamic: "The issue of frustration can . . . manifest as a social problem because students who have a certain level of outward display of that frustration can make other people maybe feel a little uncomfortable." Faculty noted that an emotional display can be further complicated if the student expressing frustration is not immediately aware of how others perceive him or her, and students on the spectrum tend to have more difficulty in this area.

Social interaction. STEM instructors reported and discussed social challenges at length. Some students were described as "socially awkward" or "uncomfortable." Another described a

"complete overload in social situations and what appears to be stress or anxiety expressed by the students." Participants noted that STEM classrooms, particularly those that emphasize group work or lab work, can place a high demand on social skills, which is challenging for certain students and may impede participation.

Participants observed that students who have autism may overparticipate or underparticipate in discussion, both of which present social challenges. One faculty member said: "[Some] students seem not to know how to socially interact within the classroom with other students and with the instructor, whether it be talking too much, too little, inappropriate comments, [looking like they] aren't paying attention but actually are."

In terms of classroom management, students who do not perceive when they are talking too long or speaking off topic require redirection to keep the class running smoothly. Participants mentioned that these students can be resistant to efforts at redirection made by the instructor or other students. On the other hand, they observed that some students do not appear to participate and are not drawn into discussions. Low participation can cause rifts on group projects and impede the instructor's assessment of how the student is doing.

Rigidity and inflexibility. Participants observed that some students who have autism show inflexibility in routines and rigidity in thinking patterns, two features that align with autism features. A behavioral giveaway of autism, in the words of one participant, is "rigid adherence to what they [students] perceive as rules, lack of flexibility, and scripted social interactions." Participants said that some students had difficulties in laboratory projects and other group work when materials or sequences had to be altered during a process. Similarly, problems come up when a procedure, assignment, or activity does not "go according to script" and students have to shift the direction of their thinking. As one participant put it, the student may miss "discovering something new" because of inflexibility in thinking.

Participants identified several strengths and weaknesses from their experience as STEM instructors. Their perspectives and insight align with existing literature about the features of autism. With equal depth, faculty were able to identify strengths and weaknesses to highlight important components of neurodiversity in the classroom. In the next section, participants' views of traits needed for STEM fields are summarized.

Research Question 2: Skills and Abilities for STEM Careers

Participants were asked: "What skills and abilities are most needed for STEM careers?" The most cited answers were attention to detail, persistence, social skills, critical thinking, and interest in novel thinking.

Focus on details. Across a range of STEM fields, participants agreed that being able to manage details was critical to a successful STEM career. Within these careers, participants said that there are many streams of information; thus, it is necessary to separate relevant from irrelevant streams and focus on minute details. For example, as one participant said, "I think the ability to hyper-focus and deal with some of the fine minutia of details that sometimes people glean over."

Persistence. Participants reported that a high degree of persistence and focus is needed in their fields.

> In . . . [STEM fields] you're expected to work until the thing is finished, and that doesn't really matter how many hours it took you to do it. . . . That kind of a stick-to-itiveness, the

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> "I'm going to plod along and plod along and plod along until I finish," at which point I'm done and am now moving on to the next thing.

Being able to persist through possible discomfort at not knowing an exact path or step were seen as beneficial to advancing the field. Persistence was also deemed necessary to be successful through boring, repetitive processes.

Social skills. Adequate social communication skills were identified as important in STEM careers. Regardless of the field, participants underscored the need to communicate with others both informally and formally with comments like: "While it is possible in some fields in the sciences to work on your own, really the sciences are collaborative and they work a lot better if you're communicating well with other people."

Critical thinking. Participants identified critical thinking and problem solving as important in STEM careers. This could involve a number of aspects including analyzing situations, choosing tools, making connections between topics and disciplines, and applying knowledge in novel ways. In one such example, a faculty participant stated:

> You have to be able to think critically. You have to be able to analyze things. You have to be able to look at what you've done and question it. You have to be able to see, "Well, am I missing anything from this? Is there more I could've done?"

Novel thinking. Participants noted that following established processes is important in STEM, but they also said there is a need for novel thinking and curiosity. Advancements in the field can only happen by applying knowledge in new ways.

> You can't figure out what it is you need to do without having to think about what is possible to do. And then you can't look at what you've actually done without imagining whether that's good enough, or what it means.

Curiosity was identified as necessary for advancement in the field. One such illustrative response was: "Innate curiosity is required for the sciences. Well, it's related to curiosity but, you know, you want to figure things out, you want to go in and explore things, you want to answer questions."

This study collected STEM faculty views in two broad areas: the strengths and challenges of students who have autism and the abilities perceived as necessary for success in STEM fields. Taken together, these two research aims can be analyzed to better understand a subset of students who study STEM at a proportionally high rate and how their profiles may convey certain strengths and areas of challenge in STEM study. Focus on details, persistence, social skills, novel thinking, and critical thinking are areas that STEM faculty identified as being especially important for success in their fields. The discussion explores how these areas of ability intersect with faculty perceptions of the profiles of students on the spectrum.

Discussion

STEM education is promoted nationwide, and research supports the idea that people who have autism are engaged in science and technology at higher rates than neurotypical populations. The purpose of this study was to describe STEM faculty's experience teaching students who have autism to survey their views about essential STEM skills and abilities.

Faculty views are relevant in this study for two reasons. First, faculty are in a unique position to observe how neurodiverse students function in the classroom because they are present with students for large chunks of time over a semester. Second, faculty members are a student's primary connection to academics, and faculty traditionally have wide latitude in designing lessons, assigning work, grading, and other practices that impact students. This is not to say that faculty are entirely independent; college policies, curriculum committees, and department policies create parameters within which they must operate. However, given the influence held by faculty, it is valuable to learn their mindset about autism in an effort to describe the postsecondary landscape within which students on the spectrum learn.

Because students who have autism study STEM at higher rates than the general population (Ruzich et al., 2015; Wei et al., 2013), this study focused on the views of STEM educators. College faculty who participated in this study came from in the fields of computer science, biology, mathematics, physics, and chemistry. They were experts in fields other than autism, yet they demonstrated nuanced knowledge of student profiles based on interview questions about student strengths and challenges. Participants also commented on the skills and abilities needed for success in STEM fields. The following section connects faculty views about essential STEM skills and abilities and their perceptions of autism.

Attention to detail and rigidity and inflexibility are characteristics that faculty observed in students who are on the spectrum, and such characteristics are potential assets in STEM fields. Faculty discussed the need for precision in STEM activities such as measuring chemicals in a laboratory, solving a lengthy math problem, or debugging computer code. People who can harness their attention on details will have a better chance of success, and students on the spectrum were noted to have strengths in this area.

Rigidity and inflexibility, a feature of autism, was noted to have an upside in STEM. At least one participant observed that when rigidity enabled a student to stick with a problem or persistently follow a procedure, it became a strength. Persistence was also identified as necessary for success in STEM, so rigidity and inflexibility may work in favor for the STEM-interested student. Rigidity and inflexibility can, however, impede problem solving, especially novel problems. The key may be to recognize when persistence is helping versus impeding progress and to develop skills to change track if needed.

According to participants, social skills are essential in STEM fields and a key area of challenge for students who have autism. Although some STEM jobs require greater social ability than others, social skills are needed in STEM jobs because science and technology are not isolated pursuits, according to participants in this study. Through numerous anecdotes about life in the classroom, faculty concurred that students on the spectrum had significant difficulty in this area. The educational implication is that social skill development must be explicitly supported and that social conventions should, perhaps, be revisited.

Social learning can happen in the classroom, advising, and through special programming or disability services. For example, faculty and advisors can give one-on-one, explicit advice for how a student can communicate effectively with peers and professors in person and via email, social media, and texts. Disability services or career services can offer workshops on interviewing and internship preparedness designed to address autism-related themes. The themes suggest that students on the spectrum would be well served to have mentors to help students as

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they learn new systems. At the same time, educators can promote knowledge of autism in an effort to normalize behaviors that might be confusing to those who are not familiar with this form of neurodiversity.

According to STEM faculty, critical thinking and interest in novel thinking are essential for success in STEM, and they are highly variable among students who have autism. In this area, faculty were especially reluctant to profile, repeatedly pointing out that students vary widely in their ability to think abstractly and make creative leaps. They noted that some students excel at conceiving of a problem in an entirely novel way, whereas others are more concrete-minded, appearing not to be comfortable with divergences from the norm. Given the importance of divergent thinking in STEM, it will be important to figure out how to boost this kind of thinking in individuals who are interested in STEM but have difficulty making leaps beyond the known.

Support recommendations for postsecondary students on the autism spectrum have been derived from a growing understanding of the problems faced by these students, which include difficulty with social interaction, self-regulation, and executive-function abilities (White et al., 2016). In other words, recommended approaches focus on ameliorating problems which are documented by the students themselves (e.g., Gelbar et al., 2015) as well as those who are close to them (e.g., Dymond et al., 2017), and this current research adds a faculty perspective.

Teaching implications of this research include the importance of developing and using strategies to support social interaction and critical thinking. Both areas were raised as potential barriers for students, so teaching these skills directly and intentionally may increase course accessibility. Critical-thinking instruction may be familiar to faculty, but the notion of teaching social skills may be less obvious. It is hoped that this research underscores the need for social-skill instruction adapted to be appropriate at the postsecondary level.

Although approaching autism education from the perspective of identifying and solving problems is important—the problems are significant and impactful—a more complete approach may be to include strengths-based innovation as well. STEM faculty are critical informants for understanding how students can engage within STEM classrooms. The accounts of STEM faculty in this study suggest that college students on the autism spectrum have notable strengths that may enable them to excel in academic pursuits that fit their profiles.

Teaching implications of this research include finding practical ways to engage students' strengths. If students have the opportunity to identify and develop their strengths, the potential for empowerment is greater than an accommodations framework that focuses only on providing support for areas of challenge. Educators may develop exercises or questioning rituals that help students describe what they are good at. More broadly, educators can ask themselves: "Where do my students excel," and "how can I plan lessons to get students using their strengths more?" From an educational policy perspective, it may be worth continuing to debate the optimal balance of emphasizing baseline learning for everyone versus a more individualized approach that cultivates unique strengths while enhancing weaker areas.

Limitations

A limitation of this study is its retrospective design in which faculty were asked to recall impressions about teaching students who have autism. The content of their responses may have been influenced by other factors such as the perception of the interview purpose and the

faculty member's own evolving view of autism. Therefore, findings must be seen as the iterative thought process of a group of experts and not generalizable fact. Similarly, the proximity of questions in the interview about autism characteristics and traits needed in STEM may have been mutually reinforcing, creating a higher degree of overlap than would have been found if the questions were asked at different times. Finally, the validity of the study is dependent on the experience of faculty members with students who have autism. Every effort was made to ensure that respondents were qualified to speak on the subject; however, the method to determine eligibility did not objectively confirm diagnoses of individuals about whom participants spoke.

Future Research

Research priorities will be most meaningful if they are developed with input from people who have autism (Autism Self Advocacy Network, 2018), and future research should include their insight whenever possible. More research is needed to describe the postsecondary academic outcomes and employment outcomes for individuals on the autism spectrum who study STEM and other discipline areas. The optimism shown by the STEM faculty participants suggests worthwhile areas for future pedagogical research. It will be beneficial to study what college students themselves say about their experience and needs regarding autism. To date, the majority of research is based on perspectives of people in the orbit of these students but not the students themselves. For STEM programs aiming to diversify participation, it will be beneficial to identify additional supports needed to achieve this goal and track the results of including more culturally and neurologically diverse participants.

Conclusion

Students with autism are diverse learners who gravitate to STEM fields at a disproportional rate. In this study, STEM faculty, who spend a significant amount of time with neurodiverse students in the classroom, expressed optimism about the suitability of STEM for interested students on the spectrum. Overlaps between features of autism and essential STEM skills and abilities were presented to spur pedagogical discussion, innovation, and future research. It is hoped that postsecondary education for students will be improved by raising awareness of the profile and its variants and offering practical suggestions to educators. Postsecondary institutions will continue to have an important role in achieving the social justice goal of equal access to STEM education and the scientific goal of developing diverse thinkers who can innovate and advance knowledge in important ways.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: Author. doi:10.1176/appi.books.9780890425596

Anderson, K. A., MacDonald, T. A., Edsall, D., Smith, L. E., & Taylor, J. L. (2016). Postsecondary expectations of high-school students with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities*, *31*(1), 16–26. doi:10.1177/1088357615610107

Autism Self Advocacy Network. (2018). Position statements. Retrieved from http://autisticadvocacy.org/about-asan/position-statements/

Baron-Cohen, S. (2009). Autism: The empathizing–systemizing (E-S) theory. *Annals of the New York Academy of Sciences*, 1156, 68–80. doi:10.1111/j.1749-6632.2009.04467.x

https://ir.library.illinoisstate.edu/jste/vol53/iss2/4
DOI: https://doi.org/10.30707/JSTE53.2Shmulsky

Baron-Cohen, S., Wheelwright, S., Burtenshaw, A., & Hobson, E. (2007). Mathematical talent is linked to autism. *Human Nature*, *18*(2), 125–131. doi:10.1007/s12110-007-9014-0

Braun, V., & Clark, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. doi:10.1191/1478088706qp063oa

Christensen, D. L., Van Naarden Braun, K., Baio, J., Bilder, D., Charles, J., Constantino, J. N., . . . Yeargin-Allsopp, M. (2016). Prevalence of autism spectrum disorder among children aged 8 years—Autism and Developmental Disabilities Monitoring Network, 11 sites, United States, 2012. *MMWR Morbidity and Mortality Weekly Report: Surveillance Summaries*, *65*(13). doi:10.15585/mmwr.ss6503a1

Dymond, S. K., Meadan, H., & Pickens, J. L. (2017). Postsecondary education and students with autism spectrum disorders: Experiences of parents and university personnel. *Journal of Developmental and Physical Disabilities*, *29*(5), 809–825. doi:10.1007/s10882-017-9558-9.

Gelbar, N. W., Shefyck, A., & Reichow, B. (2015). A comprehensive survey of current and former college students with autism spectrum disorders. *Yale Journal of Biology and Medicine*, *88*(1), 45–68. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4345538/

Gobbo, K., & Shmulsky, S. (2014). Faculty experience with college students with autism spectrum disorders: A qualitative study of challenges and solutions. *Focus on Autism and Other Developmental Disabilities*, *29*(1), 13–22. doi:10.1177/1088357613504989

Gobbo, K., Shmulsky, S., & Bower, M. (2018). Strategies for teaching STEM subjects to college students with autism spectrum disorder. *Journal of College Science Teaching*, *47*(6), 12–17.

Gutieri, F. (2014, October). Where are the data? *Scientific American*, *311*(4), 40–41. doi:10.1038/scientificamerican1014-40

Hart, D., Grigal, M., & Weir, C. (2010). Expanding the paradigm: Postsecondary education options for individuals with autism spectrum disorder and intellectual disabilities. *Focus on Autism and Other Developmental Disabilities*, *25*(3), 134–150. doi:10.1177/1088357610373759

Maykut, P., & Morehouse, R. (1994). *Beginning qualitative research: A philosophic and practical guide*. London, England: Falmer Press.

Moon, N. W., Todd, R. L., Morton, D. L., & Ivey, E. (2012). *Accommodating students with disabilities in science, technology, engineering, and mathematics (STEM): Findings from research and practice for middle grades through university education*. Atlanta: Center for Assistive Technology and Environmental Access, College of Architecture, Georgia Institute of Technology.

National Science Board. (2015). *Revisiting the STEM workforce: A companion to Science and Engineering Indicators 2014* (NSB Report No. NSB-2015-10). Alexandria, VA: Author. Retrieved from https://www.nsf.gov/nsb/publications/2015/nsb201510.pdf

Nilsson, M. R. (2017, March–April). Diversity in STEM: Doctor, heal thyself. *Journal of College Science Teaching*, *46*(4), 8–9.

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering and mathematics*. Washington, DC: Author. Retrieved from https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

Ruzich, E., Allison, C., Chakrabarti, B., Smith, P., Musto, H., Ring, H., & Baron-Cohen, S. (2015). Sex and STEM occupation predict Autism-Spectrum Quotient (AQ) scores in half a million people. PLOS ONE 10(10): e0141229. doi:10.1371/journal.pone.0141229

Sanford, C., Newman, L., Wagner, M., Cameto, R., Knokey, A.-M., & Shaver, D. (2011). *The post-high school outcomes of young adults with disabilities up to 6 years after high school: Key*

findings from the National Longitudinal Transition Study-2 (NLTS2) (NCSER Report No. 2011-3004). Washington, DC: National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education. Retrieved from https://nlts2.sri.com/reports/2011_09/nlts2_report_2011_09_complete.pdf

Taylor, J. L., Henninger, N. A., & Mailick, M. R. (2015). Longitudinal patterns of employment and postsecondary education for adults with autism and average-range IQ. *Autism*, *19*(7) 785–793. doi:10.1177/1362361315585643

U.S. Department of Education. (n.d.). Science, technology, engineering and math: Education for global leadership (Archived information). Retrieved from https://www.ed.gov/stem

Wang, M.-T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, *29*(1), 119–140. doi:10.1007/s10648-015-9355-x

Wei, X., Christiano, E. R. A., Yu, J. W., Blackorby, J., Shattuck, P., & Newman, L. A. (2014). Postsecondary pathways and persistence for STEM and non-STEM majors: Among college students with an autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *44*(5), 1159–1167. doi:10.1007/s10803-013-1978-5

Wei, X., Yu, J. W., Shattuck, P., & Blackorby, J. (2017). High school math and science preparation and postsecondary STEM participation for students with an autism spectrum disorder. *Focus on Autism and Other Developmental Disabilities*, *32*(2) 83–92. doi:10.1177/1088357615588489.

Wei, X., Yu, J. W., Shattuck, P., McCracken, M., & Blackorby, J. (2013). Science, technology, engineering, and mathematics (STEM) participation among college students with an autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *43*(7), 1539–1546. doi:10.1007/s10803-012-1700-z

White, S. W., Elias, R., Salinas, C. E., Capriola, N., Conner, C. M., Asselin, S. B., . . . Getzel, E. E. (2016). Students with autism spectrum disorder in college: Results from a preliminary mixed methods needs analysis. *Research in Developmental Disabilities*, *56*, 29–40. doi:10.1016/j.ridd.2016.05.010

Yager, S. (2016). The challenge of students with autism spectrum disorder (ASD) in honors programs. *Honors in Practice*, *12*, 79–94. Retrieved from http://digitalcommons.unl.edu/nchchip/246/

Zeedyk, S. M., Tipton. L. A., & Blacher, J. (2016). Educational supports for high functioning youth with ASD: The postsecondary pathway to college. *Focus on Autism and Other Developmental Disabilities*, *31*(1), 37–48. doi:10.1177/1088357614525435

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Appendix A

Demographic Data Sheet and for Identifying Effective STEM Classroom Techniques for College Students with ASD

Demographic Data
Date: _____

Name: _____

Courses taught during the past three terms:

_____
_____
_____
_____

How long have you been teaching at the post-secondary level?

_____

Appendix B

Interview Script for Identifying Effective STEM Classroom Techniques for College Students with ASD

Responses to be audio recorded; probes will include: "Can you give an example," or "can you tell me more about that?"

Script

I am going to ask you questions about your work with college students who have ASD. The aim of the study is to find out what faculty have noticed. Working here makes you particularly qualified because of the student population here. It's okay if you know a little or a lot about ASD. All perspectives have the potential to contribute. We did a study a few years ago about faculty perceptions of ASD, and it filled a gap in the field—faculty weren't "experts" in the traditional sense, but their collective insight was really helpful.

Mostly the questions are about your direct experiences. Some questions will ask you to generalize if you feel comfortable with it. For the sake of student privacy, please don't use names. You can pass on any question.

Ready?

1. Have you had students with ASD spectrum disorder (ASD) in your classes?
2. Would you think about writing down their names on a piece of paper so you can think about them during the interview?
3. How did you find out they had ASD?

   If minimal response, cue with: "Were you more likely to find out from a student disclosing, a College faculty or staff member, reading a file, or your own observation?"
4. What are the first three words you think of when you hear "ASD?"
5. In your own way of thinking, what is ASD? We're not looking for diagnostic criteria but how you see it.

The first questions are about students.

6. Looking at your list of names, what academic strengths have you seen in students who have ASD?
7. How about critical thinking strengths?
8. Social strengths?
9. Do you think these strengths are typical for learners who have ASD?
10. Looking at your list again, can you think of what has gotten in the way of these students meeting your course objectives?
11. Are there recurring social issues that you have seen or heard about?
12. What critical thinking challenges you have noticed?

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For the rest of the talk, we'll focus on your experience as a STEM instructor.

13. What are the major roles you've had in STEM?
14. Thinking about your field in particular, what are a couple of traits that make people successful? For instance in psychology having deep curiosity about people and a linear, logical way of thinking can really help.
15. Based on what you have seen in class, what ASD-related traits would be strengths in your field?
16. What traits would get in the way of success?

Now we'll talk about teaching.

17. Can you think of something specific you did in class that worked well for students who have ASD?
18. In general, what kinds of approaches have you found to work for this group?
19. Can you think of something specific that didn't work?
20. In general, which types of activities or assignments have been least successful?
21. Earlier you mentioned _____ critical thinking challenges. Have you found ways to work with these challenges? *If "yes," say, "can you describe something you've done?"*
22. In terms of the social side of class, how much have you pushed students who have social challenges? When have you pulled back?
23. Have you done **lab work** with these students? *{if yes, answer next two bulleted items; if no, proceed to question #25 about field work}*
    1. What strengths have you seen in the lab? (Specific example)?
    2. What challenges have you seen? (Specific example)?
24. Have you done **field work** with these students? *{if yes, answer next two bulleted items; if no, proceed to last section}*
    - What strengths have you seen in the field? (Specific example)?
    - What challenges have you seen? (Specific example)?

We're down to the last couple of questions…

25. Part of the reason for this study is that it's a national priority to include more learners with disabilities in STEM programs and fields. As you probably know, the graduation rate for these students is lower than for traditional learners. What do you think are the top three things faculty can do to help close the achievement gap in STEM?
26. What 3 things can institutions do?
27. Anything else you would like to share on the subject?