Investigating Challenges and Preferred Instructional Strategies in STEM

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Abstract

In this mixed-methods study, undergraduate students identified with a learning disability indicated their preferred instructional approaches to learning in college-level STEM courses. The relationships between preferred instructional strategies and learner characteristics: (a) declared major; (b) learning disability; and (c) gender were examined. Participants (*n*= 48) completed a survey instrument regarding their perceptions and preferences of instructional strategies in their science classes as well as their challenges to learning. An additional focus group (*n*=8) was conducted to further explore how these students prefer to learn in science. The participants' self-reported challenges for learning science content included: (a) difficulty in interpreting complex texts; (b) trouble remembering or recalling content; and (c) content that was not connected to real-world applications. While the challenges faced by the participants did not correlate to the participants' identified learning disability or declared major, the identified challenges differed by gender. The study participants self-reported a preference for direct instruction with hands-on experiential learning opportunities taking place outside of the traditional classroom environment. The declared major and type of learning disability appeared to have no relationship to the most preferred or least preferred instructional method.

Keywords: science education, instruction, postsecondary education, instructional design, STEM

Undergraduates in higher education with an identified learning disability enroll at half the rate of those students without a learning disability. The eight-year completion rate for students with learning disabilities is 34% in comparison to 51% among students without learning disabilities (Cortiella & Horowitz, 2014). Reasons for the completion rate discrepancy range from not seeking accommodations or having access to accommodations, financial concerns, and instructional practices in difficult subject areas. Completing a degree in higher education necessitates coursework in science, technology, engineering, and math (STEM). For most students diagnosed with a learning disability, understanding and obtaining science knowledge has been recognized as a barrier to degree attainment (Brigham, Scruggs, & Mastropieri, 2011).

Internal and external influencers contribute both positively and negatively to learning and succeeding in STEM among higher education students identified with a learning disability. Students' disinterest in STEM (PCAST, 2010), taxing cognitive loads (Goldstein, Naglieri, Princiotta, & Otero, 2014), and affective influences such as lack of self-efficacy (one's self-belief to complete a task) are internal contributors to limited success in science (Osborne, Simon, & Collins, 2003). External barriers for students learning and succeeding in science include the methods and strategies used to teach science as well as the instructor's expertise in science instruction, especially as it relates to students with learning disabilities. Often, science teachers describe inquiry-driven and hands-on instruction as their teaching philosophy; however, instructional practices in the classroom may not match their philosophy of science education (Hofstein & Lunetta, 2004). Many science faculty members struggle with adopting new instructional methods into practice. The preferred and most commonly used option is the traditional lecture. The andragogical approaches and practices of professional scientists teaching non-science majors may be incompatible (passive

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lecturing to active learning or authentic experiential learning to reading text; Gogolin, & Swartz, 1992; Sproken-Smith, Walker, Batchelor, O'Steen, & Angelo, 2012; Udo, Ramsey, & Mallow, 2004). Further, complex texts (found in STEM) can be incompatible with some learning disabilities and does not demonstrate a clear connection between the presented content and the learners' personal experiences with science in the real-world (Scruggs & Mastropieri, 2007).

Androgogy refers to the art and science of teaching adults. Obstacles that faculty face when teaching science include limited andragogical knowledge, time to design and develop a new course, and existing beliefs about science (Sunal et al., 2001). In STEM, accommodations and instructional strategies to foster greater depth of knowledge among higher education students with an identified learning disability tend to be developed through instructor feedback rather than empirical evidence or literature support (Ofiesh, 2007). Studies focusing on the preferred instructional methods, beyond the use of accommodations, of students with a learning disability enrolled in higher education are limited. Studies examining instructional strategies for college science courses are limited (Sparks & Lovett, 2009). Closing the knowledge gap for faculty related to instructional methods and strategies in science for higher education students diagnosed with a learning disability may contribute to increased sustainability towards degree completion. The following study seeks to identify the preferred instructional approaches in science courses and challenges to learning among higher education students identified with a learning disability. The mixed methods study examined students' perceptions and preferences both through survey and a focus group discussion. The following literature review provides the foundation for the study based on the research, theory, and practice of STEM instruction.

Literature Review

Theory and Practice

Cognitive information processing references a theoretical perspective of learning that considers the human mind to process information similarly to the way a computer does (Driscoll, 1994). Information moves from input to long term memory and learning attainment through multiple processes. The encoding of information, organization, and classification of novel and previous knowledge differs from person to person. Cognitive information processing values multiple processes for memory attainment including rehearsal, chunking, encoding, attention, and retrieval.

The selection of instructional practices does not stem from a "one-size-fits-all" learning theory. Instead, individual learners engage with the material as a result of their previous experiences, the learning environment, and individual cognitive structures. The attainment of knowledge is not a single event; rather it occurs on a continuum. Strategies focusing on the utilization of memory, both long-term and short-term, are reported to effect academic performance and retention of material (St Clair-Thompson, Overton, & Botton, 2010). Time constraints on students during tasks with increasing cognitive complexity create greater performance deficits (Speirs, Rinehart, Robinson, Tonge, & Yelland, 2014).

In the field of inclusion education, it is critical to incorporate evidence-based practices to ensure student performance objectives are met. However, theoretical foundations for implementation are often missing or misinterpreted when put into practice. In some instances, the lack of administrative support for these practices does not develop the educator to fully understand the nature of the instructional practice employed (Zundans-Fraser & Auhl, 2016).

Instruction in Science Courses

Differing forms of instruction are necessary when conveying complex scientific theories, concepts, and vocabulary to students. Schroeder, Scott, Tolson, Huang, and Lee (2007) found repeating themes regarding the correlation of student achievement and instruction within science classrooms; for example, the highest gains in achievement came from lessons that connected the information and skills to real-world scenarios and situations. When the material becomes personally relevant to the student, it helps them make more meaningful connections. Curriculum can become more engaging when it has been intentionally designed to connect a student to recognizable, everyday applications of science leading to a positive increase in attitudes towards science and improvement in academic performance (Partin, Underwood, & Worch, 2013).

Learning experiences shaped by meaningful instruction contribute to high quality exposure to science (Gogolin, & Swartz, 1992). When students engage in experiential and/or inquiry-based learning, they are more likely to continue the action and engage in further independent learning (Spronken-Smith, et al., 2012). Singer, Nielsen, and Schweingruber (2012) purported that science courses focused on the traditional discipline-of-science regularly utilize an instruction-centered model; however, when students are engaged in active learning in a student-centered learning environment, the learning gains are significantly higher. When collaborative learning is used in conjunction with lecture-oriented activities, it has been documented to be more effective in increasing student performance than traditional lectures alone (LoPresto & Slater, 2016).

During a science course, the laboratory component may have the greatest influence over a student's perception of the content delivered, the faculty's instruction, and their overall impression of the course. Activities that do not clearly align with the lecture material can convolute learning and may negatively reinforce the desired STEM skills or knowledge (Hofstein & Lunetta, 2004). Sometimes students in a laboratory/inquiry-based setting believe their goal is to follow directions to find the correct answer rather than using the scientific method to investigate a given situation in which there may or may not be a correct answer. Some inquiry-based activities have been identified as a barrier to graduation (Son, Narguizian, Beltz, & Desharnais, 2016).

Debriefing sessions at the end of class and quick reviews at the beginning of the next class aid in knowledge retention and have a direct positive impact on a student's confidence and satisfaction of course material (Stefaniak & Tracey, 2015). Conversely, enhancing or altering instructional materials results in the lowest gains in increasing student achievement. When designing instruction, educators and instructional designers need to understand the learner and their individual learning needs as they have been shaped by previous experiences and neuro-structures (Ertmer & Newby, 2013). With so many instructional approaches in STEM and specifically in science it was important to ascertain what instructional approaches students identified with a learning disability prefer when learning in STEM content.

STEM Education and Learning Disabilities

Inquiry-based learning has been linked to the highest levels of student achievement in science for students diagnosed with learning disabilities (Jarrett, 1999). In contrast, it is assumed that more structure rather than free-choice learning is needed for this student population (Therrien, Taylor, Hosp, Kaldenberg, & Gorsh, 2011). Swanson and Harris (2013) argued three critical instructional choices for teaching science to students with a learning disability which included direct instruction, cooperative learning, and utilizing curriculum-based measures. Each of these strategies has demonstrated improvement in academic performance.

Active learning, where students are actively engaged in their own learning rather being passive participants, contributes to higher student performance scores, in stark contrast to the traditional lecture (Freeman et al., 2014). Active learning has been associated with contributing to increasing memory about the content being taught (Cherney, 2008) and engaging thinking (Bonwell and Eison, 1991). Active learning can take place individually or collaboratively with other students, para-professionals, and teachers.

Students with a reading-centered learning disability face challenges to succeeding academically because of their ability level to interpret and evaluate written text (Schneps, O'Keeffe, Heffner-Wong, & Sonnert, 2010). Many college-level science courses rely on the interpretation of complex texts as a central component of the course activities. As a result, students with a language-oriented learning disability may feel less successful or prepared in class than a neurotypical counterpart. As instructors model reading skills and strategies, they provide and demonstrate tools for learner success. Structure within the instructional plan should also include visual models for the learner to replicate during reading rehearsals. In many courses, the recall of vocabulary is essential to successfully perform on assessments. When vocabulary recall is relied on in the course, faculty must include strategies on enhancing vocabulary recall using rehearsal and review skills (Grumbine & Alden, 2006).

One method for improving learning among students identified with a learning disability is to scaffold instruction. Scaffolding in education means providing supports for a learner as they build knowledge. The utilization of scaffolding in education is important at any level and within any content area; however, since science curriculum has been described as a linear progression, scaffolding understanding plays a critical role in the learner succeeding. As an instructor scaffolds instruction, they equip the learner abilities to engage in critical reflection and tasks involving metacognitive skills (Bybee, 2015). Scaffolding can: (a) increase student engagement with the content; and (b) encourage students to practice scientific skills related to questioning, experimentation, and collaboration with others.

Scaffolding slowly increases learner responsibility while diminishing the instructor's contributions. Scaffolding can be applied to a whole class or an individual learner. Scaffolding with advanced and adult learners requires the application of "fading." When instructing learners with a learning disability, fading occurs as the learner becomes more self-reliant as a direct result of applying academic strategies taught throughout the course. As the learner becomes more confident in utilization of academic strategies, they become responsible for their own learning in the science course (Bybee, 2015).

Fading is an effective instructional method in science courses (McNeill, Lizotte, Krajcik, & Marx, 2006). The use of fading correlates to increases on assessment scores; however, reasoning skills may still be lower than expected. These results are thought to be a direct result of the altered cognitive structures (patterns of thoughts) (McNeill, et al., 2006). As a result, it is important for science faculty to not only model skills and strategies, but other techniques related to knowledge acquisition as well. One suggested instructional approach for science faculty includes mirroring instructional strategies and philosophy of faculty teaching in the arts by including artistic expression to rehearse concepts presented in the course. The arts approach may scaffold learners to engage in abstract reasoning, which is often difficult for students with learning disabilities. In addition, the utilization of visual models or organizers developed either by the faculty member or the student can aid in the rehearsal and encoding of information into the long-term memory system (Hwang & Taylor, 2016).

Universal design of instruction has been documented to produce positive performance outcomes in science courses for all students, even those with a learning disability (CAST, 2016; Rappolt-Schlichtmann, Daley, & Rose, 2012). Universal design refers to designing for accessibility for everyone. In education, one instructional universal design strategy includes intensifying the curriculum. In this approach, the number of curricular topics presented to the students is lessened in favor of each topic being explored in-depth. Lessons are more hands-on and encourage the student to rehearse skills related to designing and implementing a scientific investigation (Cawley, Foley, & Miller, 2003). In this study, students were asked to identify the challenges they faced in learning science as well as their preferred instructional strategies to learn science. By providing data on student perceptions related to STEM instructional approaches, it is anticipated that educators and instructional designers will have evidence for promising practices when designing instruction for higher education students with learning disabilities.

Research Questions

In the current mixed methods study, the quantitative data (survey) informed the design of the focus group (focus group). The combination of the survey instrument and focus group allowed for the exploration of the following themes: self-report of preferred instructional strategies, identification of trends among higher education students diagnosed with learning disabilities, identification of trends amongst students performing at an overall academic level, and differences between declared majors. The research questions included:

1. What are the self-reported learning challenges for students in higher education with an identified learning disability when learning STEM/science content?
2. Which science-specific instructional strategies are preferred by students?
3. Are there differences in preferred instructional strategies in students who have declared a science major versus those who have not?
4. Are there differences in preferred instructional strategies based upon diagnosed learning disability?

Methods

Participants

The inclusion criteria for the study are: (a) undergraduate students enrolled in college full-time; (b) over the age of 18; and (c) a diagnosed learning disability. Inclusion criteria remained consistent with those described by Weis, Erickson, and Till (2016). In the spring of 2017, over 300 students at a learning-disability-serving institution were enrolled in science courses (N=306). Fifty-eight percent of these students are male. Twenty-eight percent of students have declared a STEM-related major. Approximately 16% of eligible students fully participated in the electronic survey (n=48). Of these participants, 17% elected to participate in a focus group (n=8).

A recruitment email was sent to the 306 students. Seventy-three (N=73) participants indicated their desire to participate in the research study. Forty-eight (n=48) of the students fully participated in the survey (66% completion rate) and additional three (n=3) students partially participated in the survey. The remaining 22 students consented to research activity, but did not advance past the consent stage of the electronic survey. Sixty-one percent of students provided demographic information (n=29); 50% identified as female (n=24) and 38% identified as male (n=18). Almost all participants were under the age of 30 (n=40); 58% stated they were 18-23 years old (n=28) and 25% stated they were 24-29 years old (n=12). Only 79% of the respondents self-identified their primary learning disability (see Table 1). However, it should be noted that all students in attendance at the study location did have a learning disability.

Instrumentation

There were two instruments utilized in the study: a survey and a focus group questionnaire. Both the survey and the focus group questionnaire were developed after a review of the literature by author two in consultation with other professors who taught the participants. Then the questions from both the survey and the focus group questionnaire were reviewed and revised in consultation with three professors with expertise in STEM education and educational psychology, adult learning education, and special education. The variety of data collection tools were designed to elicit participants' perceptions regarding instruction in college science courses.

The electronic survey was delivered to participants via email as this was the preferred and expected mode of communication among the participants. The electronic survey comprised of six questions, one rating scale question with Likert scale response option, three open-ended responses, and one ranking question. In addition, the electronic survey included four demographic questions regarding the participant's age, gender, declared major, and primary diagnosed learning disability. The electronic survey questions included a closed rating scale as well as open-ended questions to gather ordinal and nominal data. The question structure of the focus group questionnaire was delivered orally. It did not have a written component. These questionnaires consisted of seven open-ended questions with four planned follow-up questions and the participants' declared major.

Procedure

One week prior to the survey being distributed, potential participants were sent an introductory email containing the purpose of the study and invite participation. An electronic survey was distributed to the student body using the college email system which was available for responses for a total of 18 days. Throughout the 18-day period, three reminder emails were delivered to encourage participation in the survey. After the end of the open window period to take the electronic survey, survey participants were recruited to participate in a focus group.

Focus Groups

To accommodate the students' schedule, two semi-structured focus groups were conducted. The focus groups lasted for approximately 35 minutes and each included eight participants. Criteria for participation in the focus group included full participation in the electronic survey and the completion of a college science course. Students who were currently enrolled in a course taught by the researcher were avoided. The focus group was conducted on the college campus in one of the science lab spaces. The facilitator led the semi-structured focus groups by asking the preplanned questions and follow-up probes to encourage group dialogue. The focus groups were recorded and the notes were transcribed for analysis.

Analysis

Analysis techniques for each question in the survey and questionnaire were determined based on the response type and the technique most suited to answer each research question effectively. Responses from the electronic survey were analyzed using descriptive statistics finding the mean and standard deviation. Additionally, chi square tests of independence were used to identify potential relationships between variables and provided responses. Open-ended responses were coded using a multi-stage coding procedure described by Moustakas (1994).

Focus group recordings were transcribed and coded using the procedure described by Moustakas (1994). A preliminary stage of coding was completed in order to gather a general outline of participant responses and the themes presented in the dialogue. Next, a more detailed stage of coding was completed, which divided participant responses into multiple segments based on participant backgrounds and attitudes towards college science courses. An emphasis was placed onto self-identified challenges to learning science at the college level. In the third stage of coding, information provided by participants regarding helpful strategies to learn science was identified. During the final stage of coding, key themes which connected participant responses in the focus group as well as the responses from the electronic survey to published literature were identified. Data from each focus group session was analyzed separately following the identical procedure.

Results

When asked how they would rate their overall impression of their college science courses, 67% of participants (n=32) rated their impression as Very Good or above. Only one participant rated their impression as Poor. The mean score on a five-point Likert scale for the overall impression of a college science course is 3.83 (±0.96, n=48). Overall impression of a participant's college science course was not influenced by learning disability, X^2 (24, n=48) = 21.522, p=.141, or by gender, X^2 (12, n=48) = 13.654, p=.323. Additionally, overall impression of science courses in college was not influenced by learning disability, X^2 (28, n=48) = 36.079, p=.323. There were significant differences in the self-identified learning disability and the participant's gender, $X2$ (18, n=48) = 31.697, p=.024. There were significant differences between learning disability and the major declared, $X2$ (42, n=48) = 60.843, p=.030.

Research Question One: Challenges to Learning Science Content

Research question 1 was: What are the self-reported learning challenges for students in higher education with an identified learning disability when learning STEM/science content? Participants were asked to select their three primary challenges to learning science at the college level. The top three challenges identified by participants were (1) "textbook is too hard or difficult to understand" (52%); (2) "the content was difficult to remember or understand" (50%); and (3) the "content does not create real-world connections" (45%). Additionally, 33% of students stated lectures make it difficult to be engaged.

There appears to be no relationship between the challenges faced by learners and their declared major, X^2 (147, n=48) = 149.331, p=.431 or to learning disability, X^2 (126, n=48) = 133.799, p=.301. However, the challenges faced by students to learn science appear to be different between male and female students. When the two groups were compared, there was a significant difference in the challenges selected by each group, X^2 (63, n=48) = 90.771, p=.013.

The biggest challenge described by male students centered on the material connecting to their life, whereas female students reported having difficulty in reading or interpreting course text. Closely following challenges associated with reading, female students noted the content being difficult to understand or remember as well as the traditional lecture not being engaging. Conversely, male students indicated having difficulty in reading and interpreting text as well as remembering or understanding. However, the feeling of learning not connecting to life was a greater challenge to learning according to the male participants in the study (see Table 2).

There were three themes related to challenges when learning science content. They include text, anxiety, and collaborative learning (see Table 3). These findings were captured through the open-ended questions and focus group prompts.

Research Question 2: Instructional Strategies Preference

Research Question 2 was: "Which science-specific instructional strategies are preferred by students?" Participants were asked to order eleven different instructional methods from favorite (#1) to least favorite (#11). These methods were chosen based on instructional strategies utilized in science and STEM education. The most popular choice for favorite method was no exams (n=11) followed by learning outdoors (n=7). The instructional method most commonly identified as the least preferred was writing a final paper in stages or in chunks throughout the semester (n=19) and the standard lecture (n=13). Focus group participants repeatedly disclosed a dislike for the traditional lecture. One focus group participant stated, "in lectures I space out and I can't grasp [the material], I have trouble grasping what you're saying."

When participants were asked to describe why they ordered the instructional methods in the manner they did, 11 participants provided a detailed response explaining these teaching strategies aided in the reduction of stress and anxiety created by learning science. Sources of stress and anxiety included (a) difficulty reading/interpreting text (n=4); (b) working with others (n=2); and exams (n=3). There is no relationship between gender and preferred instructional method, X^2 (33, n=48) = 29.481, p=.643.

None of the participants placed hands-on activities or lessons as their least preferred instructional method. When participants were asked to describe their ideal science course, a total of 18 participants stated the course would be hands-on. All focus group participants (n=8) stated the utilization of hands-on activities or experiential learning guided by the instructor is the preferred manner to learn science in a college level course. In total, hands-on learning was mentioned 32 times as it related to a beneficial or helpful instructional process during the focus group sessions. During the focus group, nearly all of the participants were able to effectively recall a memory from their science course involving a hands-on or experiential learning lesson. Information provided included specific details about the lesson or the procedure and more importantly what the participant learned from the specific activity.

Research Question 3: Preferred Instructional Strategies by Major

Research Question 3 was: "Are there differences in preferred instructional strategies in students who have declared a science/STEM major versus those who have not?" When asked to rearrange a list of instructional methods commonly used by the science faculty, participants in the same major did not select similar preferred instructional methods. The declared major appeared to have no relationship to the preferred instructional method, $X2$ (77, n=48) = 82.881, p=.303. Participants provided further explanations of their rationale for ordering the instructional methods. Nearly half of the groupings included a statement describing hands-on learning as the preferred way to learn. In multiple open-response opportunities in the electronic survey, participants who have declared a major in computer information systems did indicate a preference to learn indoors rather than outdoors.

Research Question 4: Preferred Instructional Method

Research Question 4 was: "Are there differences in preferred instructional strategies based upon diagnosed learning disability?" When asked to rearrange a list of instructional methods commonly used by the science faculty, participants with a similar learning disability did not select similar preferred instructional methods. The instructional method preferred by students did not demonstrate a relationship between the instructional method and the participant's learning disability, *X2* (66, n=48) = 69.544, p=.359. Similarly, the least preferred instructional method did not demonstrate a relationship with learning disability, *X2* (63, n=48) = 75.963, p=.188.

When participants were asked how their ideal science course would be instructed, hands-on and experiential instruction were mentioned by each learning disability. Hands on instruction was mentioned by five out of six participants with dyslexia, by all participants with dyscalculia (n=3) as well as language processing disorder (n=2), and by four out of nine participants with auditory processing disorder.

Discussion

Participants in this study self-reported their top three challenges to learning science at the college level as (1) text is too hard or difficult to understand, (2) content is difficult to remember or understand, and (3) content instruction does not create real-world connections. While these challenges faced by students do not appear to have a relationship with their learning disability or declared major, there were noticeable differences between male and female participants. Keri (2002) suggested that gender differences may relate to male students' preference for an applied and experiential learning approach in contrast to female students' preference for a conceptual approach to learning. These differences in cognitive processing of information by gender may influence performance in college STEM courses. To enhance gender inclusivity, practitioners could consider these findings when designing STEM activities.

While both genders described the difficulty of reading and interpreting text, it was reportedly a bigger challenge for female students. The utilization of complex texts is often the curricular foundation for science and STEM courses. Since both genders reported this as a challenge as well as having difficulty in remembering course content, the difficulty in reading (which could potentially be disability related) may serve as a barrier for rehearsal and encoding of information. These findings echo the findings of Schneps, et al. (2010), which have identified the ability to interpret, rehearse, and properly store the information conveyed in complex texts as a barrier for the successful completion of college courses by students in higher education.

Student in this study preferred to learn science through hands-on activities and lessons. The findings of the present study are similar to findings by Black, Weinberg, and Brodwin (2015). Students with a learning disability self-report a preference of visual and hands-on learning more frequently than the students without a learning disability. Kirschner, Sweller, and Clark (2006) argued that this form of instruction is vital to ensure student success in college level science courses, even though this method of instruction it is underemployed by faculty. Additionally, the findings from Black, et al. (2015) indicated that students with a learning disability described group discussions and alternative textbooks as a preferred instructional method.

The preference for a hands-on learning approach included discussions about individually realized direct benefits to the learner. Each of the focus group participants (n=8) were able to recall a specific lesson and the information presented when direct instruction was associated with hands-on, experiential learning activities. Instructional designers and educators should consider placing a greater emphasis on the purposeful inclusion of opportunities for students to engage in hands-on active learning through movement, utilization of artifacts, creation of models, manipulatives, and investigations involving props and/or equipment. Etkina and Mestre (2004) noted that when direct instructional strategies are employed, it allowed for the learner to engage with novel skills and experiences. The rehearsal period provided by these experiences is critical to the cognitive process. Once the learner has demonstrated mastery of the skill or concept, assessment practices could mirror instruction so the learner may demonstrate the rehearsed skill or concept in an applied manner. Instructors in higher education need to consider ways to provide more practice opportunities to learners identified with disabilities prior to assessments.

While collaborative or cooperative learning appears to be an unfavorable experience for students, it is an important instructional method for this student population. Evidence from the literature supported collaborative and/or cooperative learning as an approach to increasing academic performance among students with diagnosed learning disabilities (McMaster & Fuchs, 2002). Cognitive processing of information is aided through multiple rehearsals created by conversing with peers. The process of explaining information to someone else aids in the ability to retrieve and store information beyond the working memory (Slavin, Hurley, & Chamberlain, 2003). Additionally, collaborative and cooperative learning approaches appeared to have a positive impact on the student's resilience and the ability to work with peers (Jenkins, Antil, Wayne, & Vadasy, 2003). Therefore, it may be important to scaffold collaborative learning experiences to make them more meaningful and productive when working with learners who have an identified learning disability.

While the survey did not document a relationship between learning disability and higher education students' instructional preferences to learn, the focus group participants preferred visual learning tools and strategies like watching a video to reinforce a lecture. Heiman (2006) demonstrated there is a significant difference between the preferred method of learning between students with a learning disability and their neurotypical peers. Students with a learning disability often incorporate more visual and oral learning strategies compared to their neurotypical peers (Heiman & Precel, 2003). Therefore, a concerted effort should be made to include more visuals when instructing students identified with a learning disability.

A limitation of the current study pertains to the selective sample and accordingly the study's generalizability. The student population was from a higher education institution dedicated to solely serving students diagnosed with a learning disability. The student population in the study was not reflective of most higher education classrooms. Future research could include replicating the study in other types of institutions. The participants in the study had a variety of learning disabilities that further restricts the generalizability of the study to specific learning disabilities. Another limitation of the study included the types of science courses that the participants had taken prior to the study. The participants had only taken environmental and life sciences higher education classes. If their prior course experiences included physics, chemistry, engineering, or math the findings may have been different. A final limitation of the study included researcher bias. Many of the participants were familiar and may have had an attachment with one the researchers/authors. However, due to the size of the faculty and student population, familiarity with the students could not be avoided. Participants were cautioned to respond authentically.

Conclusion

Vaughn and Linan-Thompson (2003) contended that students with a learning disability should be provided the same curriculum as their neurotypical counterparts; however, the instruction should be altered. The findings in this study confirmed that participants in this study preferred altered and varied instructional methods and approaches to learning STEM content. The need for direct instruction augmented by hands-on learning opportunities, modeling of strategies, and teaching in small, collaborative groups were described to yield best results in student performance. Grumbine and Alden (2006) echoed this conclusion by stating science instruction for students with a learning disability must be centered on methods inclusive of direct instruction. For instructors, combining multiple instructional approaches benefits students identified with a learning disability.

Ultimately, for information to be stored properly in the long-term memory, faculty and instructional designers could design instruction so the learner can depict information in multiple forms, solve complex problems, and repeat operations multiple times (Sarasin, 2006). According to Grumbine and Alden (2006), strategies involving rehearsal of complex vocabulary and phrases allowed students with a learning disability to properly store and retrieve information. Implications from the difficulty to read and comprehend text findings include incorporating modeling skills and strategies necessary to successfully interpret the text so it may be properly rehearsed.

Participants in this study ranked their inability to connect course material to their own life as a major challenge to learning science content. When designing instructions for students with learning disabilities, consideration to providing concrete examples may aid students with a learning disability. Lattuca and Stark (2009) argued an observed disconnect between faculty knowledge of instruction and selected methods for instruction.

Instructors' andragogical knowledge may have a direct impact on the student. There is an observed inability for faculty to select the appropriate instructional method for a given learning task or outcome. The participants in this study, consistently heralded the benefits of hands-on instruction for retention of knowledge; however, the participants noted that their STEM instructors relied on "extensive lecturing" as their primary instructional method. While purposeful design of active learning has been demonstrated to be successful in increasing academic performance in students, with and without learning disabilities, there have been documented barriers to including these strategies in the college classroom. Primary barriers include: (a) available time to design instruction; (b) faculty's willingness to be inclusive of all learners; and (c) the lack of knowledge of curriculum and instruction design principles (Moriarty, 2007). The gap in andragogy and instruction of how to teach students with identified learning disabilities may be attributed to the lack of training available for STEM faculty in the areas of instructional design and andragogy.

Finally, the students in this study indicated their preference for active over passive approaches to learning STEM content. Challenges and barriers to learning and course completion in STEM courses included: (a) heavy emphasis on reading dense texts without instructor scaffolds and supports; (b) limited real-world connections to the content; and (c) trouble remembering content. Educators and disability service providers may want to consider multiple approaches to teaching STEM content to overcome the challenges and barriesr to learning for students identified with a learning disability. Educators need more opportunities to learn how to provide a learning environment that can foster the success of students identified with a learning disability.

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Table 1

Breakdown of Participant's Primary Learning Disability

Primary Learning Disability	**Percentage of Students Self-Reporting**	**Male (n=11)**	**Female (n=22)**	**Did Not Disclose Gender (n=5)**
Dyslexia	24	6	3	0
Dysgraphia	3	1	0	0
Dyscalculia	18	1	5	1
Auditory Processing Disorder	34	2	7	4
Language Processing Disorder	10	1	3	0
Visual Processing Disorder	10	0	4	5

Table 2

Challenges to Learning STEM/Science Content Reported by Gender

Which of the following have been the biggest challenges for you to do well in a science course? (Select up to three)	**Male**	**Female**	**I Do Not Wish to Disclose**	**Total**
Textbook is too hard to read or understand	6	14	0	20
What we learn does not relate to my life	11	7	0	18
Lectures make it hard to be engaged	3	10	0	13
Lectures do not teach me how I prefer to be taught	2	2	2	6
What we do in lab is not connected to what we learn in lecture	1	1	1	3
What we learn is difficult to understand or remember	6	13	1	20

Table 3

Thematic Categories of Challenges to Learning Science from Open-Ended Responses

Theme	Key Term	Characteristic Response
Text	Textbook or Readings	"how [textbook] was written...makes it hard for me to read." "can't focus with a book"
Anxiety	Overwhelming or Anxiety or Stress	"I find the lab part of the class overwhelming." "knowing there are no tests takes a lot of stress of me." "I get very anxious with exams and quizzes, although I know the material I blank out when it comes to exam time."
Collaborative Learning	Group or Team	"team based learning is the worst"