

Journal of Postsecondary Education and Disability

JOURNAL OF POSTSECONDARY EDUCATION AND DISABILITY • VOLUME 24(4) • Winter 2011 • Pages 263 - 370

Volume 24(4), Winter 2011

SPECIAL ISSUE:
STEM Education

Journal of Postsecondary Education and Disability

Executive Editor

David R. Parker, *CRG (Children's Resource Group)*

Special Issue Editor

Sheryl Burgstahler, *University of Washington*

Managing Editor

Richard Allegra, *AHEAD*

Editorial Review Board

Manju Banerjee - *University of Connecticut*
Loring Brinckerhoff - *Educational Testing Service*
Stephanie Cawthon - *University of Texas at Austin*
Connie Chiba - *University of California, Berkeley*
Justin Cooper - *Eastern Kentucky University*
Lyman Dukes III - *University of South Florida at St. Petersburg*
Sharon Field Hoffman - *Wayne State University*
Joanie Friend - *St. Louis Community College*
Elizabeth Evans Getzel - *Virginia Commonwealth University*
Christie L. Gilson - *Moravian College*
Sam Goodin - *University of Michigan*
Wendy S. Harbour - *Syracuse University*
Cheri Hoy - *University of Georgia*
Charles A. Hughes - *The Pennsylvania State University*
Michael John Humphrey - *Boise State University*
Tori Kearns - *East Georgia College*
Kristina Krampe - *Eastern Kentucky University*
Sue Kroeger - *University of Arizona*
Tracy Knight Lackey - *Jackson State University*
Ruth C. Loew - *Educational Testing Service*
Pamela Luft - *Kent State University*
Joseph W. Madaus - *University of Connecticut*
Elaine Manglitz - *Clayton College & State University*
Matthew Marino - *Washington State University*

Joan McGuire - *University of Connecticut*
Janet Medina - *McDaniel College*
Deborah Merchant - *Keene State College*
Ward Newmeyer - *Dartmouth College*
Christine O'Dell - *University of California, Davis*
Nicole Ofiesh - *Notre Dame de Namur University*
Betty Preus - *College of St. Scholastica*
Kelly Drew Roberts - *University of Hawaii at Manoa*
Frank R. Rusch - *The Pennsylvania State University*
Daniel Ryan - *SUNY at Buffalo*
Mary Catherine Scheeler - *Pennsylvania State Univ. Green Valley*
Sally Scott - *University of Mary Washington*
Stuart S. Segal - *University of Michigan*
Stan Shaw - *University of Connecticut*
Sharon K. Suritsky - *Upper St. Clair School District*
Tomone Takahashi - *Shinshu University, Japan*
Colleen A. Thoma - *Virginia Commonwealth University*
Audrey Trainor - *University of Wisconsin - Madison*
Mary Lee Vance - *University of Montana*
Ruth Warick - *University of British Columbia*
Kristine Webb - *University of North Florida*
Marc Wilchesky - *York University*
Lee Woods - *Boise State University*

Practice Brief Review Board

Doris A. Bitler - *George Mason University*
Melinda S. Burchard - *Messiah College*
Trey J. Duffy - *Cal Poly San Luis Obispo*
Martha Jacques Engstrom - *Indiana University*
Alberto Guzman - *University of Arizona*
Andrea Henry - *Massasoit Community College*
Andrew Jason Kaiser - *St. Ambrose University*
Colleen Lewis - *Columbia University*
Larry Markle - *Ball State University*
Lori R. Muskat - *Georgia School of Professional Psychology, Argosy - Atlanta*
Linda Nissembaum - *St. Louis Community College*
Jack Trammell - *Randolph-Macon College*
Susan A. Vogel - *Northern Illinois University*
Margaret P. Weiss - *University of North Carolina, Chapel Hill*

AHEAD Board of Directors

Jean Ashmore, President; *Emeritus, Rice University*
L. Scott Lissner, President-Elect; *The Ohio State University*
Terra Beethe, Secretary; *Bellevue University*
Michael Johnson, Treasurer; *Monroe Community College - Damon City Campus*
Jamie Axelrod, Director; *Northern Arizona University*
Scott Bay, Director; *Emeritus, Anoka Ramsey Community College*
Gaeir Dietrich, Director; *High Tech Center Training Unit, California Community Colleges*
Alberto Guzman, Director; *University of Arizona*
Katheryne Staeger-Wilson, Director; *Missouri State University*
Tom Thompson, Director; *Emeritus, Harper College*
Mary Lee Vance, Director; *University of Montana*
Ron Stewart, Lead Standing Committee Chair; *High Tech Center Training Unit, California Community Colleges*
Stephan J. Hamlin-Smith, (ex-officio) Executive Director; *AHEAD*

The *Journal of Postsecondary Education and Disability* is published in accessible formats. Please contact AHEAD to discuss hard copy subscription requests. All members of the Association on Higher Education And Disability receive the *Journal*.

© 2011, The Association on Higher Education And Disability, 107 Commerce Centre Drive #204, Huntersville, NC 28078 USA

Table of Contents

Journal of Postsecondary Education and Disability

Volume 24(4)

From the STEM Special Issue Editor	265 - 267
<i>Sheryl Burgstahler</i>	
Perceptions of Self-Efficacy Among STEM Students with Disabilities	269 - 283
<i>Ronda J. Jenson</i>	
<i>Alexis N. Petri</i>	
<i>Arden D. Day</i>	
<i>Kevin Z. Truman</i>	
<i>Kate Duffy</i>	
Recruitment of Students with Disabilities: Exploration of Science, Technology, Engineering, and Mathematics	285 - 299
<i>Jay K. Martin</i>	
<i>Norma J. Stumbo</i>	
<i>Liam G. Martin,</i>	
<i>Kimberly D. Collins</i>	
<i>Bradley N. Hedrick</i>	
<i>Dan Nordstrom</i>	
<i>Michelle Peterson</i>	
Using Student Learning Communities to Recruit STEM Students with Disabilities	301 - 316
<i>Margaretha Vreeburg Izzo</i>	
<i>Alexa Murray</i>	
<i>Sarah Priest</i>	
<i>Bianca McArrell</i>	
Asynchronous Online Access as an Accommodation on Students with LD and/or ADHD in Postsecondary STEM Courses	317 - 330
<i>Laura Graves</i>	
<i>Paul A. Asunda</i>	
<i>Stacey J. Plant</i>	
<i>Chester Goad</i>	
Evaluation of Programmatic Interventions to Improve Postsecondary STEM Education for Students with Disabilities: Findings from SciTrain University	331 - 349
<i>Nathan W. Moon</i>	
<i>Tristan T. Utschig</i>	
<i>Robert L. Todd</i>	
<i>Ariyana Bozzorg</i>	
The Impact of a Working Conference Focused on Supporting Students with Disabilities in STEM	351 - 367
<i>Audrey C. Rule</i>	
<i>Greg P. Stefanich</i>	
<i>Robert M. Boody</i>	
Book Review	369 - 370
<i>Greg P. Stefanich</i>	
Author Guidelines	Inside Back Cover

FROM THE STEM SPECIAL ISSUE EDITOR SHERYL BURGSTAHLER

Not only is there a shortage of talented science, technology, engineering, and mathematics (STEM) professionals in general, but people with disabilities are also underrepresented in their attainment of STEM degrees and careers. The authors of this special issue of the *Journal of Special Education and Disability (JPED)* report interventions for students with disabilities and for faculty and resources that might, ultimately, help to bridge the gap between participation of individuals with and without disabilities in STEM.

The first article serves to increase our understanding of the problem. Jenson, Petri, Duffy, Day, and Truman report several cross-cutting themes that emerged from the responses of students with disabilities within a focus group. Findings reported include that instructors set the tone for learning and consequently highly influence students' confidence, motivation, anxiety and stress, self-efficacy and, ultimately, success in demanding STEM courses.

Interventions for Students with Disabilities

In the second article, Martin, Stumbo, Hedrick, Collins, Nordstrom, Peterson, and Martin report promising recruiting practices for increasing the participation of individuals with disabilities in STEM. Their reflections may help others develop strategies to encourage students with disabilities to pursue STEM. In the third article, Izzo, Murray, Priest, and McArrell report evidence that student learning communities for high school and college students with disabilities interested in pursuing STEM degrees show promise for enhancing self-advocacy and career development skills. In the fourth article, Graves, Asunda, Plant, and Goad share findings from their study that suggest offering asynchronous access to instructional content may enhance the learning experiences of students enrolled in STEM courses.

Professional Development Interventions and Materials for STEM Educators

The fifth and sixth articles explore the effectiveness of professional development offerings for STEM faculty. Moon, Utschig, Todd, and Bozzorg share a case study of a combination of in-person and web-

based training for STEM faculty. Their multi-faceted evaluation suggests the efficacy of these practices in enhancing the abilities of STEM faculty to make instruction more accessible to students with disabilities. Next, Rule, Stefanich, and Boody report outcomes of a two-day working conference. Evidence presented suggests that a short-term working conference can significantly impact educators' preparedness, responsiveness to make accommodations, and attitudes toward the inclusion of students with disabilities in STEM and other courses.

Finally, Stefanich reviews a comprehensive set of materials developed through a collaborative effort of STEM and special educators hosted by the DO-IT Center at the University of Washington. Acknowledging that few practicing STEM educators have had access to adequate preparation or to resources for addressing the diversity of students in their classes, he concludes that the comprehensive content and multimedia presentation materials in *Making Math, Science, and Technology Instruction Accessible to Students with Disabilities* can help pre-service and in-service educators more effectively deliver STEM instruction.

Implications for Future Research and Practice

Americans with disabilities are underrepresented with respect to STEM degree attainment and careers. Although the authors of the articles in this issue present promising interventions and resources, additional rigorous research studies are needed to move this young field of study forward. Such studies would engage large samples of participants, compare outcomes with those of well-matched comparison groups, test interventions in a variety of settings (e.g., online, on-site, at different types of schools), use multiple evaluation techniques, gather perceptions from multiple stakeholder groups, and conduct longitudinal investigations to determine long-term effects. Such studies are expensive and therefore are likely to require external funding from government or other agencies. With large sample sizes of students, analysis could explore the relationship between type of disability and the effectiveness of support activities. It is also important to explore why participants and nonparticipant peers who have apti-

tude and interest in STEM do not pursue these fields. Specifically for professional development of faculty, more outcomes research is needed regarding teaching practices and performance of students in classes of trained and untrained faculty and of students in a specific course taught before and after an instructor receives training.

Originally applied to the development of physical spaces, technology, and consumer products, universal design (UD) has more recently emerged as a paradigm for the development of instruction, curriculum, and assessment that addresses the needs of students with a wide variety of characteristics. Although UD holds promise for reducing the need for disability-related accommodations and benefiting all students, further research is required to identify and test the efficacy of specific UD practices when applied to STEM instruction. In addition, all researchers and practitioners who explore interventions to increase participation and/or success in STEM should be encouraged to address disability-related issues within the design of the interventions and reporting of the results for individuals with disabilities. For example, a research study that tests the efficacy of a teaching practice on the success of women in STEM could compare the success of women with and without disabilities in both intervention and comparison groups. Similarly, a study testing the impact of using a technology-based teaching tool should include students with a variety of disabilities.

STEM instructors should also consider how their courses might increase in quality by infusing the UD philosophy within their curricula. For example, if the creation of software is part of an assignment in an IT course, the instructor could require that students apply UD principles as they develop their software interfaces so that they are usable by potential users with disabilities.

Besides evaluating individual programs for students and instructors, significant efforts are needed to identify best practices for campus-wide systemic changes in policy and practice. These efforts should consider implications of new technologies; respective roles of campus units such as disability services, teaching and learning centers, computing centers; and proliferation of modern approaches that include the social model of disability and UD.

A major challenge in evaluating institutional change is accurately measuring alterations in the number of students with disabilities on campus and those specifically pursuing STEM over the course of an intervention period. Without these data, it is difficult to know if progress is being made on an individual campus and nationwide. Often, changes in the number of registered users of a postsecondary institution's disability services office is used to measure changes in enrollment of students with disabilities, including those in STEM, on that campus. However, the number of students with disabilities who choose to disclose their disabilities to these service units is often estimated at less than 50% (Smith, 2009). Further, we cannot assume that this group is a representative sample of students with disabilities on that campus.

Changes in disability services registrations is also an unreliable measure of success in increasing STEM enrollment of students with disabilities, because some project interventions are likely to increase disclosure numbers (e.g., recruitment of students with disabilities to an institution and to STEM degree programs) and some are likely to decrease disclosure numbers (e.g., implementation of UD strategies that make STEM labs and instruction more accessible, offering assistive technology ubiquitously rather than as an accommodation only for registered students with disabilities). These numbers also do not account for how the availability of personal devices impacts whether a student with a disability registers for accommodations. For example, receiving a cochlear implant, personal communication device, or power wheelchair may result in a STEM student no longer needing an accommodation that was once required; comparison data would reflect one fewer STEM student with a disability on campus if disability service figures were used to measure change in STEM enrollment of students with disabilities.

To correct this problem, postsecondary institutions nationwide should be encouraged to collect and report data on disability status that does not require self-disclosure to the disability services office and is collected after a student has been accepted to the institution. Although still subject to the limitations of self-report and different understandings of what constitutes a "disability," such data would include students with disabilities who do not require accommodations as well as those who do not wish to disclose during the

application process because of concerns with respect to discrimination.

STEM participation of students with disabilities is an important and timely topic for this issue of JPED. Interventions and results reported in these articles can teach practitioners how to choose strategies and evaluate them, and help researchers identify research questions for further investigation. It is important to keep an eye on what a level playing field for all students interested in STEM would look like from multiple angles. For example, consider what might be the first response of a professor when a student who is quadriplegic enrolls in his science class. Would he be preoccupied with how much of his time might be required to implement accommodations? Or, would he value the unique perspective this student brings to his field of study, viewing differences in physical abilities as simply a normal part of the human experience? Not all important outcomes are easy to measure!

About the Guest Editor

Dr. Sheryl Burgstahler is an Affiliate Professor in the College of Education and the founder and director of the DO-IT (Disabilities, Opportunities, Internetworking, and Technology) and the Access Technology Centers at the University of Washington in Seattle. Her projects and research focus on the successful transition of students with disabilities to college and careers and on the application of UD to technology, learning activities, physical spaces, and student services. She has directed many NSF-funded projects to increase the participation of students with disabilities in STEM fields. Current projects include *AccessSTEM* and the *RDE Collaborative Dissemination Project*. Dr. Burgstahler is lead author and editor of the book *Universal Design in Higher Education: From Principles to Practice*. She publishes extensively and has taught precollege and postsecondary mathematics and computer programming to students and technology, UD, and teaching methods to pre-service and in-service educators. Dr. Burgstahler can be reached at sherylb@uw.edu.

Author Notes

This material is based upon work supported by the National Science Foundation under Award #CNS-1042260, #HRD-0833504 and # HRD-0929006. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

Perceptions of Self-Efficacy Among STEM Students with Disabilities

Ronda J. Jenson

Alexis N. Petri

Arden D. Day

Kevin Z. Truman

University of Missouri-Kansas City

Kate Duffy

Metropolitan Community College – Penn Valley

Abstract

Numerous studies examine the relationship between self-efficacy and positive outcomes for postsecondary students. Collectively they echo that self-efficacy is an essential component to positive outcomes. Relatively few studies focused on students with disabilities majoring in STEM fields. Twenty postsecondary students with disabilities participated in focus groups organized around Bandura's key factors leading to self-efficacy: mastery experiences, vicarious experiences, social persuasion, and physiological reaction. By pairing participant-response devices, commonly known as "clickers," with traditional qualitative methods, students provided their individual perspectives as well as reacted to collective responses. Several cross-cutting themes emerged from the study. Instructors set the tone for learning and consequently highly influence confidence, motivation, anxiety and stress, and ultimately success. Applied learning is important, especially in team settings. A student's sense of self influences his or her perceptions of self-efficacy. The results offer insight into designing support services and measuring self-efficacy with this population.

Keywords: Disability, higher education, STEM, self-efficacy

Individuals with disabilities, including military veterans, have talents to offer and want to have careers in science, technology, engineering, or mathematics (STEM), but often lack necessary education for employment in those fields. Because gaps in support services often create barriers for this population, a variety of new, focused programs are being made available to students with disabilities, such as peer mentoring, assistance navigating college programs and systems, career exploration, and college and career preparation workshops. As a needs assessment for a Midwest program focused on postsecondary students with disabilities, focus groups of college students with disabilities were conducted on the topic of self-efficacy. Data gained from these focus groups are being used by project staff to enhance supports provided to college students with disabilities, including veterans with service-connected disabilities.

Undeniably there is a gap between the number of STEM jobs the U.S. economy requires and the number of students who are attaining their college education in these fields (National Science Board, 2004). The persistence and retention of all students in STEM fields is of critical importance. A recent analysis of postsecondary STEM enrollment for students with and without disabilities suggests 1 in 5 students with disabilities choose a STEM major (Lee, 2011). Additionally, this same study using data from the National Longitudinal Transition Study-2 Wave 4 (Lee, 2011) reported a lower rate of students with disabilities in STEM majors accessing accommodations compared to students with disabilities in other degree programs. Yet, the range of access and attitudinal barriers that postsecondary students face has been well-documented (Dowrick, Anderson, Heyer, & Acosta, 2005; Stodden & Conway, 2003; Webb, Patterson, Syverud, & Seabrooks-

Blackmore, 2008). These studies pose further questions regarding retention of people with disabilities in STEM majors and the nature of essential supports and strategies to support their persistence. This study focuses on the student perspectives of confidence in their ability to persist in postsecondary STEM studies and the factors that promote or hinder their confidence.

Perceived self-efficacy has been linked in the literature to numerous personal factors that in turn lead to desired outcomes. Successful college students are more motivated to work toward goals (Bandura, 1994; Kim, Newton, Downey, & Benton, 2010; van Dinther, Dochy, & Segers, *in press*), more resilient when faced with challenges (Kitsantas & Zimmerman, 2009; Reynolds & Weigand, 2010), more likely to continue in their studies (Kitsantas & Zimmerman, 2009; van Dinther *et al.*, *in press*), and show greater self-determination (Getzel & Thoma, 2008). As part of an ongoing evaluation of student needs, the purpose of this study was to explore and describe how postsecondary students with disabilities studying in STEM fields perceive themselves as efficacious. The results of this study describe supports and strategies reported by the students to promote their self-efficacy. Additionally, the results provide insight into the roles of college disability support (DS) services, peer mentors, course instructors, and general academic support services in promoting and supporting self-efficacy.

According to Bandura (1997), perceived self-efficacy is defined as “belief in one’s capabilities to organize and execute the courses of action required to produce given attainment” (p. 2). In the literature studying college persistence, this personal sense of confidence in abilities has been linked to goal setting and success in college (Bandura, 1997; DeWitz, Woolsey, & Walsh, 2009; Hsieh, Sullivan, & Guerra, 2007). Additionally, the literature suggests self-efficacy is a mediating variable between cognition and performance (Rugutt, Ellett, & Culcross, 2003). In other words, while skills and knowledge are important factors leading to success, students need a sense of efficacy to use their skills, access support, and engage in learning (Bandura, 1994).

Self-efficacy theory identifies four contributing factors to students’ sense of self-efficacy: mastery experiences, vicarious experiences, social persuasion, and self-management of physiological reactions (Bandura, 1994). Prior experiences resulting in positive outcomes can boost confidence and willingness

to persist when faced with challenges (Bandura, 1997; Schunk & Pajares, 2009). Mastery experiences – feelings of accomplishment and success when faced with challenges – are linked to resilience, perseverance, and reduced stress imposed by daunting tasks. Vicarious experiences refer to observing others succeed and consequently feeling an increased sense in one’s own ability to similarly succeed (Bandura, 1997; Schunk & Pajares, 2009). When a person sees someone like him/herself succeed, he/she in turn can feel capable of mastering comparable tasks. Conversely, seeing a peer fail can reduce a person’s sense of self-efficacy. The third way that self-efficacy can be changed is social persuasion: Influences of others who either uplift or decrease a person’s feelings of confidence and judgment of personal capabilities. Encouragement from parents, teachers, and peers whom students trust can boost confidence. When one is persuaded that he/she is capable, then one is more likely to put forth and sustain greater effort. Lastly, emotional reactions can heighten or diminish confidence. Feelings of stress, tension, and depressed mood have physical and psychological effects that negatively impact performance (Bandura, 1994; Schunk & Pajares, 2009).

Fortunately, self-efficacy beliefs are malleable and, thus, can change over time (Cervone & Peake, 1986). Because self-efficacy is not a static personal state and is linked to positive personal outcomes, it is an important focus and worthy of observation and study. For the general population of college students majoring in the STEM fields, self-efficacy arises frequently in studies of persistence and retention. What STEM students believe about their own self-efficacy and responsibility for learning are linked to their academic persistence as well as their achievement (Eccles & Wigfield, 2002; Hackett, Betz, Casas, & Rocha-Singh, 1992; Lent *et al.*, 2003; Zeldin & Pajares, 2000). Interestingly, the role of instructors can become enmeshed with self-efficacy. There is an increase in the literature describing effective strategies for teaching postsecondary learners with disabilities at both 2-year and 4-year colleges (Moriarty, 2007; Schelly, Davies, & Spooner, 2011). The act of learning at the college level is much more than a reaction to effective teaching; the goal of learning in college is helping students transform abilities into skills and operates as a training ground for life-long learning (Zimmerman, 2002). When college students attribute their achievements to the influence of an instructor rather than their increasing ability to regulate

their learning processes, research shows postsecondary institutions interpret that information as students' avoiding taking responsibility for their learning at levels appropriate for college (Zimmerman, 2002; Zimmerman & Kitsantas, 1999). Through the process of gaining self-regulation of learning, self-efficacy becomes entwined with learning at the college level (Zimmerman, 2002).

How STEM students interpret their experiences in course-related assignments shapes their self-efficacy. Students increase their enjoyment of their learning experiences as they increase content mastery and often attribute good grades to content mastery (Hutchison, Follman, Sumpter, & Bodner, 2006). The quality of challenging assignments is shown to influence the development of college students as learners, particularly in the domain of self-efficacy (Kitsantas & Zimmerman, 2009). When students feel satisfaction from completing quality work, they are positively influencing their own self-efficacy, especially in STEM courses (Hutchison et al., 2006). In the area of social persuasion, STEM students may interpret their grades to be an indication of how their instructors gauge their personal abilities. The verbal exchange between students and those whom they seek for academic help similarly shapes self-efficacy because students may perceive those exchanges as judgments, whether positive or negative. In the realm of physiological constructs of self-efficacy, students associate how they feel during certain academic tasks with what they believe about themselves (Hutchison et al., 2006).

For college students with disabilities, issues of persistence and retention are additionally tied to accommodations and supports matching their disability-specified needs as provided by the campus DS office. A known concern with relying on DS offices is low rates of self-identification of disabilities (Getzel & Thoma, 2008; Klassen, 2002). Not all college students with disabilities want support from the DS office, or they wait until they experience significant academic challenges before requesting accommodations. This reality poses questions for how mentors, advisors, and instructors influence beliefs of self-efficacy among college students with disabilities. Similarly, there are questions as to how general academic support centers such as writing labs, tutoring programs, and supplemental instruction influence student self-efficacy. Questions center on perceptions of roles and responsibilities. How do mentors, advisors, instructors, and staff in

general academic support centers perceive their roles in promoting self-efficacy of all students and, in particular, students with disabilities when the interaction with the DS office is minimal or absent? What is their responsibility in supporting students with disabilities in their learning and in boosting their perceptions of self-efficacy?

Research pertaining to college students without disabilities presents recommended practices for promoting student academic success and persistence. Examples of recommended practices include student participation in a learning community of students with common goals (Pandya, Henderson, Anthes, & Johnson, 2007; Wenger, 1998), developing a student-instructor working relationship that increases the instructor's understanding of student learning styles and provides encouragement to persevere (Getzel & Thoma, 2008), and accessing the array of campus opportunities and learning centers designed to support and enhance learning (Kim et al., 2010; Zhao & Kuh, 2004). The present study builds on this research by looking at how postsecondary students with disabilities focused on achievement in STEM personally describe their sense of self-efficacy and the factors that have uplifted or deflated confidence in their ability to be successful in their studies and finish their degree. Existing research comparing the dimensions of self-efficacy between students with and without disabilities in secondary learning settings suggests there is a difference in self-concept, confidence, and level of self-determination (Klassen, 2002; Lackaye, Margalit, Ziv, & Ziman, 2006; Tabassam & Grainger, 2002), thus worthy of further exploration in postsecondary settings.

Evaluation Questions

The two evaluation questions for this study are as follows: (1) From the perspective of postsecondary students with disabilities involved in STEM programs, how do the constructs of self-efficacy relate to their feelings of confidence? (2) How can postsecondary support services and programs be enhanced to better promote the self-efficacy of students with disabilities studying in STEM fields?

Method

For both evaluation and research, involving people with disabilities as active, fully contributing partners is a priority. Evaluation emphasizes utilization-focused processes that create a continuous loop of linking evaluation results to programmatic design (Patton, 2008). Similarly, researchers use participatory action research (Garcia-Iriarte, Kramer, Karmer, & Hammel, 2009), thus creating opportunities for participants with disabilities to be involved in the “identification of problems, collection of data, and analysis of their own situation to improve it” (Selener, 1997, p.11). Out of a commitment to involving postsecondary students with disabilities in all aspects of evaluation, this Midwestern program sought input from college students with disabilities. Through focus groups structured for dialogue as well as real-time data from participant-response devices, or “clickers,” students discussed self-efficacy and the college experience. By employing “clickers” with traditional qualitative methods, students provided their perspectives as well as reacted to collective responses. While multiple focus groups were held, each student participated in only one focus group.

Participants

In total, 20 college students with disabilities participated in the focus groups. Participants self-reported their disabilities. Disabilities reported included one speech impairment, one visual impairment, three attention deficit/hyperactivity disorders (ADHD), three physical impairments, four learning disabilities, four Autism, and four psychiatric disorders. Students ranged in age from 19 to 51, with an average age of 28 and 75% of students between 19 and 29 years of age. Students came from two urban community colleges (n=10) and one urban university (n=10), of which one student was in a graduate program. Of the participants, four students were veterans with service-connected disabilities. All students majored in the STEM fields as defined by the National Science Foundation, which includes social, behavior, and economic sciences as STEM fields. Participant majored in computer science (n=7), social science transfer degree (n=4), stationary engineering (n=2); and one participant from each of the following: biology, electrical engineering, forensic archaeology, information technology, political science, precision manufacturing, and psychology.

Procedures

Four constructs describing the key factors leading to increased self-efficacy were used as a framework for addressing the evaluation questions. These four validated constructs were mastery experiences, vicarious experiences, social persuasion, and physiological reaction (Bandura, 1997; Schunk & Pajares, 2009). The focus-group and participant-response-device questions corresponded to the four constructs (see Figure 1). Two staff members facilitated each focus group with one serving as the group moderator and the other as the scribe. The moderator used the focus group script to pose questions and prompt discussion and verified responses with the participants during the focus group by summarizing conversation points and asking the group to confirm accuracy, offer clarifications, or correct the summary. The scribe provided a written transcript of the discussions. While a written transcript was obtained, no audio recording was used during these focus groups.

Participant-response devices. The questions posed using the participant-response devices used a Likert-type response scale. A Likert scale has been determined an acceptable method of measuring self-efficacy (Maurer & Pierce, 1998). Participant-response devices are similar to remote control pads and commonly called “clickers.” Using a computer, projector, CPS Plus and CPS Power Point, questions are projected onto a screen. The computer has a receiver and as participants indicate their responses on their “clickers,” their answers are received via wireless electronic delivery. At the beginning of the focus group, the “clickers” were handed out to all participants. Mock questions were used in the beginning as a way of teaching the participants how to use the devices. Once the group was clear on the instructions, the following questions were posed with a Likert scale of (1) certain cannot do, (2) somewhat certain cannot do, (3) somewhat can do, (4) certain can do, and (5) highly certain can do.

- How confident are you that you can get good grades in your STEM courses this semester?
- How confident are you that you can get help with assignments or studying if needed?
- How confident are you that you can get needed accommodations necessary for full participation in courses?
- How confident are you that you can do as well in your STEM classes as other students?

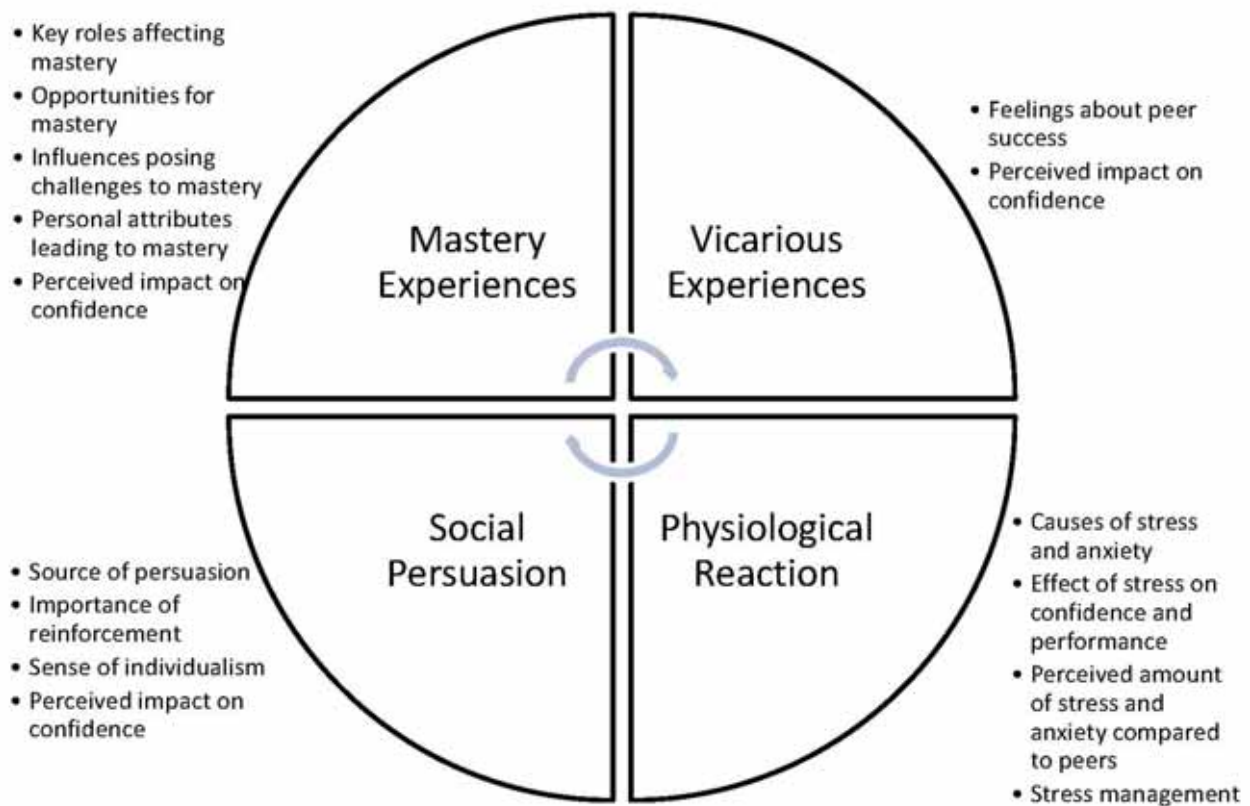


Figure 1. Self-efficacy coding schematic

- How confident are you that you can persist in your STEM courses even when faced with criticism?
- How confident are you that you can remain calm and relaxed during tests?
- How confident are you that you can remain calm and relaxed when expected to complete a challenging assignment?

After all participants responded, the focus group facilitator used the computer to display the collective responses. The participants then viewed the responses and had the opportunity to react and discuss prior to addressing the focus group questions. Reactions and comments to the collective “clicker” responses were included in the focus group transcripts for analysis.

Focus groups. Aligning with the four constructs, the following focus group questions were posed:

- Describe a situation in college when you were proud to have met a challenge and succeeded. Was there someone or something that helped you succeed? How has this success affected your confidence?

- When you see classmates succeed, how does that make you feel? How does it affect your confidence?
- When you see people with disabilities succeed in STEM careers, how does that make you feel? How does it affect your confidence?
- Thinking about your college work, how important is positive feedback from instructors? From classmates? From family and friends? Whose encouragement do you believe more strongly affects your confidence to succeed in college?
- How does stress and anxiety affect your ability to do your best work? Thinking about a stressful course or assignment, do you feel your stress level is more, less, or the same as your classmates?

Data analysis. The responses to the Likert-scale questions administered by the participant response devices are displayed in Table 1. While a Likert-scale presents a rank order, it cannot be assumed that the intervals between ranks are constant (Jamieson, 2004).

Table 1

Participant-response system self-efficacy questions and results (N = 22)

Item	Median	Mode	Range
1. How confident are you that you can... Get good grades in your STEM courses this semester?	3	4	2 - 5
2. How confident are you that you can... Get help with assignments or studying if needed?	4	4	2 - 5
3. How confident are you that you can... Get needed accommodations necessary for full participation in courses?	4	4	1 - 5
4. How confident are you that you can... Do as well in your STEM classes as other students?	3	4	2 - 5
5. How confident are you that you can... Persist in your STEM courses even when faced with criticism?	4	4	2 - 5
6. How confident are you that you can... Remain calm and relaxed during tests?	2	2	1 - 5
7. How confident are you that you can... Remain calm and relaxed when expected to complete a challenging assignment?	3	4	2 - 5

Therefore, calculations of mode, median, and range are most appropriate and displayed in Table 1.

Transcripts from the focus groups were reviewed by a research team of four people. Based on initial review, the team identified meaningful ways of sorting the data and developed a coding tree. A coding tree is defined as the outline structure developed by the users and intended for sorting meaningful chunks of data (Patton, 2002). In order to permit the natural unfolding of key themes, the levels are broad. After developing the coding structure, all data were coded by three members of the team to determine areas of consensus and discrepancy in interpretation. Areas of discrepancy were discussed until the full team arrived at consensus. As the team went through the process of coding and discussion, additional themes emerged and the coding tree was transformed into the coding schematic displayed in Figure 1. The figure shows that the four constructs are integrated and compensatory; that is if a particular construct is strongly present it may compensate for a weaker construct. Informing understanding of

the constructs as they apply to postsecondary students with disabilities in STEM fields are the lists of coded items as they apply to each construct.

Credibility. Credibility is established through a number of methods traditionally associated with qualitative research (Denzin & Lincoln, 1994). For this study, a standardized protocol was used with respondents and triangulation through consensus coding was used. The value of coding data in a collaborative fashion using a consensus approach is the reduction in bias in interpretations and judgments made about the data. During the coding process, the research team discusses the qualitative data and arrives at a common understanding of the emergent themes (Hill et al., 2005). An audit was also conducted by a person with expertise in the field of disability studies and postsecondary education. The auditor thoroughly read the findings, traced suppositions to the original raw documents, and reported that *“data files were consistent with the results reported in the findings of the study. Furthermore, no contradictions of information were*

found nor was there any evidence to suggest contrary findings were not included." Thus, all propositions have been verified as credible.

Results

To address the evaluation questions, the results of the focus group conversations and the participant response device questions are organized by each of Bandura's (1994) four constructs and within each construct is a discussion of the roles of support services and programs in promoting self-efficacy. It is important to recognize that themes overlapped and cross-cutting themes emerged. The themes that emerged from the focus groups were organized by Bandura's constructs, as listed below:

- Mastery experiences: key roles affecting mastery, opportunities for mastery, influences posing challenges to mastery, personal attributes leading to mastery, and perceived impact on confidence.
- Vicarious experiences: feelings about peer success and perceived impact on confidence.
- Physiological reaction: causes of stress and anxiety, effect of stress on confidence and performance, perceived amount of stress and anxiety compared to peers, and stress management.
- Social persuasion: source of persuasion, importance of reinforcement, sense of individualism, and perceived impact on confidence.

Each of Bandura's constructs and the findings from the focus groups are discussed below.

Mastery Experiences

Participants in the study reported that success in their STEM classes added to their overall sense of accomplishment and self-confidence as they made their way through college. Representative statements include, "Success has made me more confident," and, "I didn't think I could, but I got through it." The most frequent response to "clicker" questions about academic confidence (i.e. earning good grades in STEM courses, getting help with class work, and working with faculty on accommodations) was, "I am certain I can do."

Students reported that several factors contributed to their mastery experiences in college, ranging from the role of instructors, family, friends, and classmates

to the assistance of the college's academic and disability support offices. Having opportunities to apply learning was also reported as valuable. As one student noted, "When I work with other people and accomplish a goal, that teamwork makes me feel successful." Students also reported that personal attributes such as perseverance, self-confidence, and an unwillingness to fail contributed to these mastery experiences. One student discussed the connection between a course and confidence: "I took speech class, worked on becoming more comfortable talking in front of people and am now more confident." Students recognized self-responsibility in content mastery. When they struggle, they generally did not consider it to be the fault of the instructor and, if they have success, they attribute it to studying and to going to class.

Of the people in their lives, the participants credited instructors as having the most impact on their ability to experience success in their classes. Several students told of instructors who went out of their way to provide extra support: "We had class two days a week, but we convinced the teacher to host extra study sessions once a week." Another student associated attention from a teacher with an increased ability to be engaged in class: "When I was going through [personal] ... drama in 2007, I was in a math class. The teacher stayed after class and talked to me. [This] helped me not to hesitate to ask questions." Instructors created a valuable culture for learning in a class that students appreciated and that promoted mastery experiences.

Vicarious Experiences

When focus group participants were asked if they were confident they could do as well in their STEM courses as other students, the most frequent response was "I am certain I can" (see Table 1). Predominantly, students reported positive feelings when they saw their classmates succeed and this boosted their confidence. In particular, students reported positive value in seeing their peers with disabilities experience success. According to one student, "If they can do it, I can do it too." Another student echoed this conclusion by saying, "What helps more is hearing success stories of people with disabilities who succeed beyond you." In contrast, a small group of students reported feeling happy for the success of peers, but that peer success did not affect their confidence. Some participants stressed that it is important to keep focused on one's own work and studies and to avoid allowing the success or struggles

of peers affect one's performance. One student summarized this sentiment by saying, "I can't judge myself based on them, just based on how hard I work." None of the students reported that seeing their peers succeed lowered their confidence.

Although all of the participants agreed they were happy to see others with disabilities succeed, two participants expressed concern about the way others viewed them. These students described how, in college, they felt many viewed them from a needs-based perspective and not a strengths-based perspective. One student noted that, while she needed accommodations in classes, there were areas in her life where she did not need accommodations. "I've got a comprehension disability, but I've been a manager at my job for five years. And I worked up to that position. Not everyone can do that!" Another participant, though happy when someone with disabilities succeeded, worried about being lumped together with other people with disabilities. "There are 100 million factors at play, and, though it does help my confidence, it does get weird, kind of like *Beautiful Minds*." The students shared concerns that others viewed them all in one category, disability, instead of seeing them as individuals.

For the students, teamwork and collaboration was part of seeing peers succeed and the effect of that success on self-confidence. Numerous students, from two-year and four-year colleges, reported positive experiences when completing team projects. Being part of a team gave students the opportunity to see peers succeed, to observe the steps leading to success, and to join the collective positive feeling of completing the project. In addition, teamwork seemed to reinforce the learning and understanding of new concepts being addressed. Peers had a role in boosting confidence in the short term – such as asking a peer to look over an assignment, studying together for a test, or doing a more formalized peer critique in the classroom setting. "Doing peer critiques on work increased my confidence because then I knew my peers liked my work." Students felt increased confidence when their colleagues succeeded in class. The four participants who had military backgrounds spoke most often about teamwork – they valued connecting with their peers and noted that it bolstered their confidence. The community college students spoke of an additional importance between the instructor and feedback in a class. Many community college students viewed instructors as gatekeepers to a STEM career path. Students noted that instructors'

encouragement to pursue a particular career path held more value than encouragement from family or friends. One student described how he turns to his instructors first, before family or friends, for feedback: "Instructors know what they are talking about when it comes to my future careers. My family and friends don't always know why something matters or is important."

Participants reported that self-efficacy increased through the vicarious experiences of their peers as well as their instructors. They felt a special connection to others with disabilities and their success— whether these were fellow students or someone famous in the STEM fields whom the students admired. One student observed, "Stephen Hawking is the most brilliant person in science. I have high hopes for me to be the best I can be from seeing him do what he does. It gives me motivation."

Social Persuasion

From the comments of participants in the focus groups, it is evident that social persuasion is a vital construct in positive academic experiences. There are four distinct players when it comes to social persuasion for the students with disabilities studying in the STEM fields: instructor, classmates/peers, self, and family and friends. Participants discussed the role of family and friends as related to their self-efficacy. All students expressed having someone in their life, whether a family member or a friend, who has provided general support and encouragement: "My mom always has encouraging things to say." Students expressed that their support systems outside of college often knew little about what it like to be a student majoring in the STEM fields. For example, most family members had not been in a laboratory and did not know what transpires in lab settings. Students noted that the support of family members tended to be more general in nature. One student echoed, "my uncle always encourages me."

Students in the focus groups described a difference between peers and classmates— peers were others with disabilities majoring in the STEM fields or enrolled in college. They defined classmates as students who were in classes but who did not necessarily have a disability. Students talked about how their classmates were sometimes uncomfortable being honest with them because of their disabilities. This further complicated the challenges of peer-feedback in the classroom:

Criticism from teachers is helpful so you can tell what you're doing wrong and right. We've done peer reviews and they weren't as helpful, because the students aren't always as honest [as teachers] because they don't want to hurt your feelings.

Many participants noted that it could be discouraging when classmates without disabilities did not have to put forth the same amount of effort as they did but achieved higher grades. Students expressed that this sometimes formed barriers between themselves and their classmates.

Students described an important connection between positive feedback and motivation: "Positive reinforcement works the best with me.... It is an ego boost. I am motivated by a good job or a great job and good grades. Negative reinforcement bogs me down. I feel in a swamp." Of the respondents, 17 noted that positive reinforcement from the instructor was very important, 11 respondents noted that positive reinforcement from family and friends was very important, and 7 out of the 11 noted that both were equally important but for different reasons. Students commonly identified the following reasons for why instructors are important factors in social persuasion: they have content mastery, they often have specialized knowledge in one area of STEM, and they may offer potential connections to employment due to their role as an expert in a particular field.

While many participants noted their peers were helpful, rapport with instructors was considered to be "most important." Rapport building is something that happens between instructors and students; the energy the instructor gives to building relationships with the students and setting a tone for the class matters. Students could tell if instructors wanted them to succeed and push beyond their present academic difficulties to meet their goals. "If you get a bad grade, but you still have a rapport or a good relationship with the teacher, there is still hope. Otherwise you're trying to do it all alone." Students identified the value of constructive criticism in addition to positive feedback. The value of positive feedback spoke to evidence of success; success feels good; things that feel good are motivators. Success also increased students' confidence. A few students noted the importance of constructive criticism as a motivator because it helped them increase their content mastery, which then led to increased confidence and/or positive feedback. "Since they [teachers] are

experienced and have mastery [of the content] it is good to hear what you need to improve on and what you have done wrong." "There is still that little devil in my head going 'probably you should overcome this before [you] move on, otherwise you will miss some critical principle to help you move forward.'" Participants viewed negative feedback or criticism that was not constructive as unhelpful. Students identified examples of negative feedback, including a bad grade without explanation or dismissive remarks such as, "This is not college level writing."

Interestingly, and somewhat unexpectedly, many students discussed the importance of their role in social persuasion. With all of the players in their lives, both collegiate and personal, students believed that their motivation ultimately involved their own belief in themselves. "Instructors, very important; family and friends, not as important. [Peers], yes, definitely [important]. We are like a cohesive element. [But] it's really up to the individual. You have to believe in yourself, have focus, initiative, and drive." As one student who had struggled in some courses said, "If I need the course, I can persist.... It has to be you that encourages yourself. You have to believe in yourself." The role of the self became important to understanding how social persuasion affects confidence in the academic setting. The students who participated in this study have persisted against the odds. They have had to find and utilize an inner reserve of motivation to persist at their goals. This intrinsic motivation was an important resource to students. "I don't know whether it's confidence or bravery that keeps me going sometimes." This student added that, after positive feedback from STEM instructors, his "own feedback is more important to me."

As shown in Table 1, the majority of participants responded positively to the "clicker" question related to the social persuasion construct (item 5) and were at least "certain" they could persist in STEM courses when faced with criticism (16 out of 19 or 84%). This important result speaks to rapport with instructors and peers as well as support from family and friends. Perhaps most importantly, it shows how central self-determination is to persistence. When facing criticism, the majority of students had rapport with instructors and peers, social supports for encouragement, or self-determination. One student described that "I adamantly deny my mind from [the thought] 'I want to quit' because I have quit at things before and I have regretted it. I never think of [the thought] 'I quit.' I keep going forward."

Physiological Reaction

The last lens of analysis is the physiological reaction to the college environment students experienced. Participants in the focus groups reported struggling with physiological reactions to stress and anxiety. As shown in Table 1, responses to the “clicker” question related to the physiological reaction construct (item 6) vary more than the other constructs, with more participants responding that they were unsure if they could remain calm during tests. More participants responded they were at least somewhat certain they could remain calm when completing an assignment.

The main situations reported to produce stress or anxiety were tests and courses that are based on abstract concepts that form the basis for advanced understanding or application, such as algebra or chemistry. Students noted that applied courses did not produce as much stress, unless there is a time when they need to perform certain tasks in a timed setting. For abstract courses students were concerned about their ability to grasp the information. They studied and did their assignments and still struggled. “Whatever pressure I feel, 90% of it comes from me. This Math 120 [college algebra] is no joke. I don’t skip class, so I figure the light bulb will come on and go ‘bling’ and I’ll get it. If I keep doing these math problems, something will click.”

A few of the older students, especially those with military experience, noted that they had largely “outgrown stress.” They referred to a combination of maturity and finding ways to cope with situational stress and/or anxiety in explaining this development. These same students also saw a connection between stress and positive outcomes. They noted that sometimes stress could boost adrenaline and lead to improved performance. These students were in the minority. Across age and disability, tests and challenging assignments caused stress and anxiety for most participants. A few students reported that they tried to find motivation in their stress. “I try to know the materials... It’s just that, a challenge, but you go into it because you like the challenge. Challenges are the rewards.” Other students described how they coped with stress and anxiety. As one student noted, “When I started I wasn’t [very confident that I could relax during tests]. But now, I sit outside in the hallway and practice deep breathing exercises.”

Overwhelmingly the students reported that they want to do well in their classes. Many of the students echoed the sentiment, “I put a lot of pressure on myself to do really well.” Sometimes this internal pressure led

to procrastination when students wanted to perform perfectly and then had difficulty getting started. “I make too many changes if I do it too far in advance and feel like it has to be perfect, so I do it last minute and then I just have to get it done.” Other students felt their stress was higher because classes were more difficult for them. “For me it’s like if I don’t pass this class then I’m just going to quit, because I’m not taking it a fourth time... So there’s a lot of pressure.” There was also a connection between wanting to do well as a person with a disability and [...]. “[Instructors] know I have a disability and I wonder if they’re wondering if I can do this. And the anxiety comes from wanting to do well as a person with a disability.”

Students had different reactions to their physiological reactions. Some students described how stress had a detrimental physiological effect on them. “It hampers me.” “My mind goes blank.” They also reported that stress causes them not to remember what they had studied or learned. Students felt that the information was in their brains but stress interfered with their ability to retrieve it. “With tests, I want to place my brain on the table and say, ‘Here it all is.’” Other physiological symptoms caused by tests included feeling shaky and sick to the stomach. Several students mentioned “trying to stay relaxed” but also expressed not having control over what they were experiencing with their test anxiety and academic stress. A few students presented strategies for trying to overcome their physiological reaction to the stress and pace of being a student with a disability and majoring in STEM. These students talked about the importance of getting enough sleep and studying hard and frequently. One student described the following strategy for reducing test anxiety: “Before the class, I sit outside in the hallway and practice deep breathing exercises to help me relax during tests.”

Discussion

Two central concepts emerged from the mastery experiences construct. Participants reported a positive relationship between success in their STEM classes and their overall sense of self-efficacy in college. From the participants’ perspective, many people and roles affected their self-efficacy about content mastery— instructors, student support offices, family, friends, classmates, and peers. In addition, having opportunities to apply learning reinforced their self-efficacy. Most commonly, students echoed the critical role of

instructors in helping them master a challenging concept, validating their effort, and designing learning opportunities that gave them opportunities to apply learning and experience success.

Participants also noted that vicarious experiences could increase their feelings of self-efficacy. For example, seeing other students with disabilities succeed boosted their self-confidence. Additionally, learning in the context of a team project provided opportunities for students to observe peer success and the steps taken to achieve mastery. Thus, students with a disability reported that team activities could increase their sense of self-efficacy. Vicarious experiences that decreased participants' self-efficacy involved situations when they felt they were being judged based on their disabilities, especially when connected to classroom performance situations such as lab work.

The construct of social persuasion builds off of that of vicarious experiences and mastery experiences. While peers and teamwork have a unique role in boosting confidence, students with disabilities overwhelmingly noted the importance of positive feedback from instructors to enhanced motivation to persist in their academic studies. Participants also noted the importance of their own roles in social persuasion. Despite all of their collegiate relationships, students indicated that believing in themselves had the greatest impact on their motivation. After all, the students themselves are the ones in class, working toward a degree. Perhaps most importantly, this finding shows how important self-determination is to persistence. Regarding the physiological reaction construct of self-efficacy, students reported struggling with stress and anxiety. Situations most likely to produce stress or anxiety were tests and abstract or theoretical courses. Older participants identified successful strategies for coping with stress and anxiety, but most of the participants reported that high-stress situations made it difficult to recall information, even when they felt well prepared. Many of the students noted that they put pressure on themselves to perform well.

Several cross-cutting themes emerged from the qualitative data. First, instructors set the tone for learning and consequently highly influenced students' confidence, motivation, anxiety and stress, and – ultimately – success. Student rapport with instructors was important because it reinforced learning and encouraged students to ask questions and seek assistance. Additionally, by building rapport with students, the

instructor could be more aware of factors that created stress and when students were feeling a great deal of stress. All of these instructor behaviors, as well as providing positive feedback and constructive criticism, were valued by the STEM students with disabilities as ways to boost their self-efficacy.

Second, when discussing self-confidence as learners, many STEM students with disabilities noted the importance of applied learning, especially in team-oriented settings. The students described how team projects gave them opportunities to learn from each other, exchange peer-to-peer feedback, and share positive feelings of accomplishment. Participants reported that accomplishing a goal with a team was personally rewarding and boosted their self-efficacy.

The last cross-cutting theme to emerge from analysis of the focus group data was a sense of self and how that influenced perceptions of self-efficacy. Many STEM students with disabilities believed that they often needed to work harder than their peers without disabilities but did not mind doing so because they valued hard work. Rather than lowering their self-confidence, participants found that hard work strengthened their resilience and perseverance. Students spoke of keeping focused on their personal goals and purposefully avoiding distracters such as comparing themselves with peers as a way to keep motivated and maintain self-confidence. Stress and anxiety triggered other insights about a sense of self. While many of the students reported numerous academic situations that caused them to feel stress and anxiety, they described strategies to minimize those negative emotions. The students believed that their ability to successfully manage their stress and anxiety strengthened their self-efficacy.

These cross-cutting themes add a unique perspective to the current literature. College students believe their instructors influence their achievements (Getzel & Thoma, 2008), but some publications report that institutions view this as a sign of students shirking expected levels of responsibility for their college learning (Zimmerman 2002; Zimmerman and Kitsantas, 1999). The focus group participants described a strong sense of personal responsibility for their learning. Perceived self-efficacy can change (Cervone & Peake, 1986) due to an array of influences including feelings of stress (Bandura, 1994; Kim, Newton, Downey, & Benton, 2010), disconnected relationship with instructors (Getzel & Thoma, 2008), and lack of access to needed accommodations and supports (Getzel & Thoma, 2008).

The focus group students confirmed that these factors did influence their self-efficacy. However, they reported that this influence did not have a negative impact on their personal levels of responsibility for carrying out their own responsibilities as learners. Indeed, as Bandura's model predicts, students were able to enhance their self-efficacy as learners with the influence of instructor support, vicarious learning experiences with peers, and positive reactions to high levels of stress while taking STEM and other rigorous courses.

Implications

Several recommendations emerged from this study that could improve access to STEM careers for individuals with disabilities. First, on an institutional level, students could benefit from colleges and universities strengthening the connections between their full range of support centers and labs to build natural bridges to DS offices. Students in the focus groups expressed gravitating to classes or labs with opportunities for hands-on or applied learning. Many students also expressed struggling with abstract theory courses, such as mathematics. While it is a challenge, and two students shared it may be a barrier to degree attainment for them, all students need to pass college algebra. Student retention may be improved by finding "hands-on" or applied ways to teach traditionally abstract theory classes such as college algebra.

Participants in the study referred regularly to instructors who helped them succeed by taking extra time to explain concepts in class or making time to work with them after class. Clearly, having a rapport with students is a powerful instructional and retention tool and perhaps the simplest recommendation to incorporate into working with students with disabilities. To increase retention of students with disabilities, campuses may wish to offer faculty workshops on universal design for learning or teaching circles to explore techniques for building meaningful relationships with students. When students feel they have a positive relationship with their instructors, they often feel greater motivation to work diligently in their classes. When instructors provided regular and timely feedback, participants reported feeling encouraged and able to persevere even when the class grew more difficult. Another recommendation for faculty would be to incorporate more team projects in their course design, even though many students find these projects more

difficult. For students with disabilities, in particular, these projects allow more opportunities to build rapport with others, learn necessary workplace skills, and master class subject matter in different ways.

Institutions of higher education can play an important role in supporting students with disabilities, specifically those in STEM majors. The focus groups clearly highlighted how important instructor beliefs and behaviors are to student success. Institutions of higher education may want to address this importance systemically by providing resources that enhance instructors' capacity to make classroom learning accessible to the widest variety of learners. Paying attention to how the DS offices are promoted or marketed may also help more students with disabilities seek accommodations they need. Lastly, for institutions struggling with retention, finding ways for students to obtain effective support in difficult classes may reduce some of the barriers they face in degree attainment.

Limitations

Caution should be exercised in interpreting the results of this evaluation project. First, due to the small number of participants, inferences to a larger population are limited. Second, the student perspectives are a snapshot of their experiences at the current stage of their education. Their perspectives may change as their experiences unfold. Third, student perspectives are limited to experiences in a small geographic area with regard to a few higher education institutions. Finally, there is the possibility of bias due to employing self-report strategies and the likelihood of participants being influenced by peer responses in the focus group setting.

Conclusion

The relationship between faculty and student is extremely important in postsecondary settings. Faculty not only grade students' work, they can influence career decision-making and provide compelling forms of motivation. In conclusion, students with disabilities at three colleges were informative. The focus groups helped the authors identify ways to bolster the self-efficacy of postsecondary students with disabilities taking STEM and other courses.

References

- Bandura, A. (1994). Self-efficacy. In V. S. Ramachandran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71-81). New York: Academic Press. (Reprinted in H. Friedman [Ed.], *Encyclopedia of mental health*. San Diego: Academic Press, 1998).
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.
- Cervone, D., & Peake, P. K. (1986). Anchoring, efficacy, and action: The influence of judgmental heuristics on self-efficacy judgments and behavior. *Journal of Personality and Social Psychology*, 50, 492-501.
- Denzin, N. K., & Lincoln, Y. S. (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage.
- DeWitz, S.J., Woolsey, M.L., & Walsh, W.B. (2009). College student retention: An exploration of the relationship between self-efficacy beliefs and purpose in life among college students. *Journal of College Student Development*, 50(1), 19-34.
- Dowrick, P. W., Anderson J., Heyer, K., & Acosta, J. (2005). Postsecondary education across the USA: Experiences of adults with disabilities. *Journal of Vocational Rehabilitation*, 22(1), 41-47.
- Eccles, J.S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, 53, 109-132.
- Garcia-Iriarte, E., Kramer, J. C., Kramer, J. M., & Hammel, J. (2009). Who did what: A participatory action research project to increase group capacity for advocacy. *Journal of Applied Research in Intellectual Disabilities*, 22(1), 10-22.
- Getzel, E. E., & Thoma, C. A. (2008). Experiences of college students with disabilities and the importance of self-determination in higher education settings. *Career Development for Exceptional Individuals*, 31(2), 77-84.
- Hackett, G., Betz, N. E., Casas, J. M., and Rocha-Singh, I. A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology*, 39(4), 527-538.
- Hill, C. E., Knox, S., Thompson, B. J., Williams, E. N., Hess, S. A., & Ladany, N. (2005). Consensual qualitative research: An update. *Journal of Counseling Psychology*, 52, 196-205.
- Hsieh, P., Sullivan, J. R., Guerra, N. S. (2007). A closer look at college students: Self-efficacy and goal orientation. *Journal of Advanced Academics*, 18(3), 454-476.
- Hutchison, M. A., Follman, D. K., Sumpter, M., and Bodner, G. M. (2006). Factors influencing the self-efficacy beliefs of first-year engineering students. *Journal of Engineering Education*, 95(1), 39-47.
- Jamieson, S. (2004). Likert scales: How to (ab)use them. *Medical Education*, 38, 1212-1218.
- Kim, E., Newton, F. B., Downey, R. G., & Benton, S. L. (2010). Personal factors impacting college student success: Constructing College Learning Effectiveness Inventory (CLEI). *College Student Journal*, 44(1), 112-125.
- Kitsantas, A., & Zimmerman, B. J. (2009). College students' homework and academic achievement: The mediating role of self-regulatory beliefs. *Metacognition and Learning*, 4(2), 1556-1623.
- Klassen, R. (2002). A question of calibration: A review of the self-efficacy beliefs of students with learning disabilities. *Learning Disability Quarterly*, 25(2), 88-102.
- Lackaye, T., Margalit, M., Ziv, O. and Ziman, T. (2006). Comparisons of Self-Efficacy, Mood, Effort, and Hope Between Students with Learning Disabilities and Their Non-LD-Matched Peers. *Learning Disabilities Research & Practice*, 21: 111-121.
- Lee, A. (2011). A comparison of postsecondary science, technology, engineering, and mathematics (STEM) enrollment for students with and without disabilities. *Career Development for Exceptional Individuals*, 34(2), 72-82.
- Lent, R.W., Brown, S. D., Schmidt, J., Brenner, B., Lyons, H., and Treistman, D. (2003). Relation of contextual supports and barriers to choice behavior in engineering majors: Tests of alternative social cognitive models. *Journal of Counseling Psychology*, 50(4), 458-465.
- Maurer, T. J., & Pierce, H. R. (1998). A comparison of Likert scale and traditional measures of self-efficacy. *Journal of Applied Psychology*, 83(2), 324-329.
- Moriarty, M.A. (2007). Inclusive pedagogy: Teaching methodologies to reach diverse learners in science instruction. *Equity and Excellence in Education*, 40, 252-265.

- National Science Board. (2004). *An emerging and critical problem of the science and engineering labor force*. Retrieved from <http://www.nsf.gov/statistics/nsb0407/nsb0407.pdf>
- Pandya, R. E., Henderson, S., Anthes, R. A., & Johnson, R. M. (2007). BEST practices for broadening participation in the geosciences: Strategies from the UCAR Significant Opportunities in Atmospheric Research and Science (SOARS) program. *Journal of Geoscience Education*, 55(6), 500-506.
- Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thousand Oaks, CA: Sage.
- Patton M. Q. (2008). *Utilization-focused evaluation*. (4th ed.). Thousand Oaks, CA: Sage Publication.
- Reynolds, A. L., & Weigand, M. J. (2010). The relationships among academic attitudes, psychological attitudes, and the first-semester academic achievement of first-year college students. *Journal of Student Affairs Research and Practice*, 47(2), 175-195.
- Rugutt, J. K., Ellett, C. D., & Culross, R. R. (2003). Discriminating student learning and efficacy levels in higher education: Contributions of classroom environment and teaching and learning effectiveness. *Planning and Changing*, 34, 229-249.
- Selener, D. (1997) *Participatory action research and social change*. Ithaca, NY: Cornell University.
- Schelly, C. L., Davies, P. L., Spooner, C. L. (2011). Student perceptions of faculty implementation of universal design for learning. *Journal of Postsecondary Education and Disability*, 24(1), 17-30.
- Schunk, D. H., & Pajares, F. (2009). Self-efficacy theory. In K. R. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 35-53). New York: Routledge.
- Stodden, R., & Conway, M. (2003). Supporting individuals with disabilities in postsecondary education. *American Rehabilitation*, 27, 24-33.
- Tabassam, W., & Grainger, J. (2002). Self-concept, attributional style, and self-efficacy beliefs of students with learning disabilities with and without attention deficit hyperactivity disorder. *Learning Disability Quarterly*, 25(2), 141-151.
- van Dinther, M., Dochy, F., & Segers, M. (in press). *Factors affecting students' self efficacy in higher education*. Educational Research Review.
- Webb, K.W., Patterson, K.B., Syverud, S.M., & Seabrooks-Blackmore, J.J. (2008). Evidence based practices that promote transition to postsecondary education: Listening to a decade of expert voices. *Exceptionality*, 16(4), 192-206.
- Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.
- Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal* 37, 215-246.
- Zhao, C. M., & Kuh, G. D. (2004). Adding value: learning communities and student engagement. *Research in Higher Education*, 45, 115-138.
- Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, 41(2), 64-71. Doi: 10.1207/s15430421tip4102_2
- Zimmerman, B. J., & Kitsantas, A. (1999). Acquiring writing revision skill: shifting from process to outcome self-regulatory goals. *Journal of Educational Psychology*, 9(2), 241-250. Doi:10.1037/00220663.91.2.241

About the Authors

Ronda Jenson received her MS and Ph.D. in special education from the University of Kansas. Her experience includes working in the public school system as a special education teacher, chairing a college interdisciplinary training program in disability studies, and leading research focused on improving access to general curriculum, universal design for learning, and school improvement. She is currently the Director of Research at the University of Missouri-Kansas City Institute for Human Development. She can be reached by email at: jensonr@umkc.edu.

Alexis Petri received her MA degree in English with an emphasis in composition and rhetoric from University of Missouri-Kansas City and is A.B.D. in her doctoral work at the School of Education, University of Missouri-Kansas City. Her experience includes working as director of the Center for Service Learning for Rockhurst University and serving as program director at the Center for the City at University of Missouri-Kansas City. She is currently research associate at the Institute for Human Development. Her research interests include campus-community partnerships, reciprocity, self-efficacy in higher education students, and high impact learning environments. She can be reached by email at: petria@umkc.edu.

Kate Duffy received her M.A. in journalism from the University of Kansas. Her experience includes writing about employment for individuals with disabilities, mentoring new adjunct faculty and teaching writing and entrepreneurship classes at Metropolitan Community College – Penn Valley. Her last book, *Developing Talents: Careers for Individuals with Asperger Syndrome and High Functioning Autism* was coauthored with Dr. Temple Grandin and focuses on removing employment barriers for those on the autism spectrum. Her research interests include employment and small business ownership for individuals with disabilities. She can be reached by email at: Kate.Duffy@mccckc.edu.

Arden Day received her BS degree in psychology from Drake University and is pursuing a MA in psychology from University of Missouri-Kansas City. Her experience includes working as a research assistant for UMKC Institute for Human Development. Her research interests include adolescent learning in urban environments. She can be reached by email at: dayad@umkc.edu

Kevin Z. Truman received his BA degree in math and physics from Monmouth College, his BS and MS degrees in civil engineering from Washington University in St. Louis and Ph.D. from Missouri University of Science & Technology. His experience includes working as a faculty member and chair of civil engineering at Washington University from 1985-2008. He is currently the Dean of the School of Computing & Engineering at the University of Missouri-Kansas City. As an administrator in engineering educational institutions, he has secured several federal and foundation grants related to K-12 STEM education and outreach. He can be reached by email at: trumank@umkc.edu.

Authors' Note

This research was supported in full by the National Science Foundation under NSF Award 0929212. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect those of the National Science Foundation.

Recruitment of Students with Disabilities: Exploration of Science, Technology, Engineering, and Mathematics

Jay K. Martin

Norma J. Stumbo

Liam G. Martin

Kimberly D. Collins

University of Wisconsin - Madison

Bradley N. Hedrick

Dan Nordstrom

Michelle Peterson

University of Illinois

Abstract

Individuals with disabilities are underrepresented in postsecondary education; in science, technology, engineering, and mathematics (STEM) majors; in graduate and post-doctoral work; and in faculty positions, particularly in STEM. Despite these lags behind their non-disabled counterparts, few organizations recruit persons with disabilities into postsecondary education and/or STEM careers and, thus, scant literature exists on targeted recruitment efforts. The intent of this article is to examine data concerning these lags, to review what literature does exist on recruitment of students with disabilities, and to report on promising practices developed by the Midwest Alliance, an NSF-funded endeavor to increase the number of individuals with disabilities in STEM. It is believed that these efforts and descriptions may help other organizations recruit individuals with disabilities into their postsecondary programs.

Keywords:

“Persons with disabilities are a national asset whose productive potential cannot be ignored.”
(Tororei, 2009, p. 2)

The National Science Foundation (NSF), the premier government agency advancing science, technology, engineering, and mathematics (STEM) in America, has noted that persons with disabilities, along with women and members of ethnic and racial minority groups, are underrepresented in science and engineering in postsecondary education and the workforce (Burrelli & Falkenheim, 2011; National Science Board [NSB], 2003; NSF, 2009). People with disabilities are underrepresented in higher education of any kind, traditional STEM undergraduate majors, graduate schools and post-doctoral work, and faculty positions, especially in STEM (NSB, 2003; NSF, 2009). In order for these deficits to be overcome, special attention must be given to issues related to the recruitment of students

with disabilities to STEM education and subsequent STEM careers.

Since few recruitment programs specifically for students with disabilities have been developed and reported in the literature (Fichten et al., 2003), the purposes of this article are to (a) examine the importance of recruiting activities to improving participation by students with disabilities in STEM educational activities, (b) introduce a number of issues related to recruitment of students with disabilities in STEM, and (c) describe several promising practices related to such recruitment. To meet the first purpose, data about people with disabilities in STEM education and careers are presented to illustrate that concerted efforts are needed to bolster the number and success of students with disabilities. Second, three issues prominent in recruitment of students with disabilities to postsecondary education and STEM are discussed. Third, a number of promising practices or strategies related to

the recruitment of students with disabilities in STEM are highlighted. While *best practices* are validated by stringent large-scale research and replicable across multiple settings, *promising practices* are those that suggest effectiveness in addressing a common problem, have shown potential in at least one context, are likely to be replicable, and have initial data supporting positive outcomes (Administration for Children and Families, 2010).

The authors represent the Midwest Alliance in Science, Technology, Engineering, and Mathematics, an NSF-funded, five-year project based at the University of Wisconsin-Madison, with subcontracts to the University of Illinois at Urbana-Champaign and the University of Northern Iowa. The specific aim of the Midwest Alliance is increasing the number of students with disabilities exploring, entering, and succeeding in STEM education and careers. Recruitment and retention of students with disabilities into STEM education and careers is a large part of the Midwest Alliance's activities.

Generically, recruitment and retention activities for many types of students are often referred to as the *STEM pipeline*, representing pathways students may take toward achieving career success in STEM (The Forum for Youth Development, 2010). In general, the idea is to identify and move talented students efficiently and effectively through the educational system. If a student moves through the STEM education pipeline efficiently, graduates, and obtains a job position in STEM, the pipeline is seen as being successful.

The Midwest Alliance staff, however, recognized that the idea of a pipeline is too simplistic for some groups of students, such as those with disabilities. The Midwest Alliance staff believe that students with disabilities are in one of three groups at any time in their educational careers: (1) in the STEM pipeline, (2) not in the STEM pipeline, or (3) undecided about STEM. Given this range of possibilities and the staff's desire to cast the widest possible recruitment net, Midwest's activities had three objectives. First, for students with disabilities already in the STEM pipeline, make sure they stay in the pipeline for the right reasons and not leave for the wrong reasons (such as difficulty with accommodations, participation, or the culture). If they do leave, make sure it is for the right reasons (e.g., they change majors based on passions or desires). Second, if students are unsure or uninformed about STEM goals, attempt to assist them in making informed decisions about opting in or out of STEM majors or careers. Third,

if students have already departed the STEM pipeline, attempt to give them a chance to experience STEM in a different way if possible so that they can reevaluate their participation from a new perspective. Instead of singularly focusing on students who were identified to have a disability early in their education, may have STEM talent, and who had already entered the STEM pipeline, this broader, systems-based approach views each student with a disability as having STEM potential throughout the full course of his or her education until he or she made an informed choice otherwise.

This model can be of assistance to similar organizations as well as to postsecondary disability service providers, administrators, and recruiters. We acknowledge that not all campuses, academic departments, or disability support offices wish to actively recruit students with disabilities. This may be due to current staff/student ratios, lack of facilities, and/or lack of support from faculty and/or administration. We also acknowledge that our approach often targeted students who had been identified early in their school career as having a disability. For some students, whose disabilities are not identified until they reach postsecondary education, this approach may not be practical.

Importance of Postsecondary Education and Recruiting Programs for Students with Disabilities

The Forum for Youth Investment (TFYI, 2010) recently reported critical data regarding the importance of postsecondary education to all individuals, including those with disabilities. Labor market projections suggest that by 2018 nearly 66% of all jobs will require at least some postsecondary education (TFYI, 2010). Over a lifetime, completing a postsecondary education can mean additional earning power (Fichten et al., 2003; NSF, 2009). Individuals with a high school diploma or equivalent are expected to earn approximately \$30,000 annually; those with an associate's degree, \$36,000; those with a bachelor's degree, \$46,000. In addition, the latter two categories of workers are also more likely to receive health insurance and retirement benefits (TYFI). Similar data were reported by Stodden, Whelley, Chang, and Harding (2001) and Yuen and Shaughnessy (2001).

Participation by people with disabilities in postsecondary education has traditionally been low when compared to their representation in the American population (Bureau of Labor Statistics, 2011; Burrelli & Falkenheim, 2011; Fairweather & Shaver, 1990;

NSF, 2009; Stodden & Conway, 2003). In addition, data on employment rates as of March 2011 show that persons with disabilities, at 21.0%, are far below their non-disabled counterparts, at 69.7% (Bureau of Labor Statistics, 2011). National data also show that students with disabilities are underrepresented in STEM (NSB, 2003; NSF, 2009; Rendon, 1985), especially in graduate degrees and careers and in some degree areas such as engineering. While some progress for students with disabilities has been made in computer and mathematical science, lower proportions of students with disabilities are entering engineering (Burrelli & Falkenheim, 2011). See Table 1 for example statistics.

Munro and Elsom (2000) noted that the economy will continue to need a constant supply of highly educated scientific and technological people in the workforce, with skills such as data handling, analysis, problem solving, and information technology. These skills are foundational to STEM. However, students in general are often discouraged from pursuing STEM for a number of reasons. First, knowledge of science and mathematics builds up gradually and, once dropped, subject matter is much harder to grasp. Second, many young people are cut off from entry into STEM as they find out too late the requirements for entry. Third, science is seen by many as a “specialty” rather than as an area of core knowledge. Especially low proportions of students with disabilities in STEM may also be due to additional factors such as perceptions by postsecondary recruiters and faculty, inattention to fully accessible postsecondary education and STEM environments, and lack of targeted recruitment strategies (Dunn, Hanes, Hardie, Leslie, & MacDonald, 2008; Fairweather & Shaver, 1990; Test, Fowler, White, Richter, & Walker, 2009). Therefore, issues such as recruitment of students with disabilities into postsecondary education and STEM need to be examined and promising practices need to be shared in order to work toward equal opportunity for students with disabilities (Fichten et al., 2003). The next section discusses three issues critical to the recruitment of students with disabilities in STEM.

Issues in the Recruitment of Students with Disabilities in STEM

At least three major issues contribute to the need for recruitment programs for students with disabilities in STEM. The first is the dearth of published program descriptions, program evaluations, and research data

about recruitment of students with disabilities to postsecondary education. This is especially true for recruitment into STEM. The second is the need for institutional commitment to the recruitment, retention, and graduation of students with disabilities, again, especially in STEM fields. The third issue is the influence that high school teachers, special education teachers, guidance counselors, and postsecondary education faculty have on whether students with disabilities envision STEM as a future career possibility.

Lack of data on recruitment of students with disabilities. Lewis and Farris (1999) reported that research on best practices in the recruitment of students with disabilities in STEM is nearly non-existent, as recruitment programs are either scarce or not well documented. These authors noted that approximately 20-27% of all postsecondary institutions have developed outreach and recruitment activities aimed at students with disabilities. They found that larger institutions were more likely than smaller institutions to develop recruitment materials. Most of their sample institutions provided recruitment materials to high school counselors, transition specialists, and vocational rehabilitation counselors. About half provided them to other vocational rehabilitation agencies, civic and business organizations, and other postsecondary institutions, and less than a quarter shared information with businesses and employers (Lewis & Farris). In more recent years, a few articles have provided recruitment program descriptions for specific educational programs such as social work (Dunn et al., 2008).

Need for systemic and institutional support. A second issue is the need for systemic and institutional support for the recruitment of students with disabilities and their continued success on campus. Higher education institutions need a strong recruitment message in order to attract students with disabilities, and these messages must come from the highest echelons of the academy such as the president's, provost's, and deans' offices (Ellis, 2010; Hartman, 1993; Mayhew, Grunwald, & Dey, 2005; Palombi, 2000; Ralph & Boxall, 2005). Mayhew et al. (2005) cited Hurtado, Milem, Clayton-Pederson, and Allen (1998) as defining a positive campus climate for diversity by four precepts: (a) the campus' historical legacy of exclusion or inclusion of various underrepresented groups, (b) its structural diversity or representation of various groups on campus, (c) its psychological climate (perceptions, beliefs, and attitudes about diversity), and (d) its behavioral

Table 1

Statistics Involving Students with Disabilities in STEM (NSF, 2009)

-
- Students with disabilities are more likely to enter two-year programs than their non-disabled counterparts.
 - Students with disabilities are more likely to be part-time students than their non-disabled counterparts.
 - Students with disabilities made up roughly 11% of undergraduate students in most fields.
 - Students with disabilities made up roughly 7% of graduate students in most fields; 3% of computer science and engineering graduate students; 10% of social and behavioral science graduate students.
 - Graduate students with disabilities are more likely to be women (57%) than men (43%).
 - Students with disabilities earned roughly 1% of the STEM doctorates awarded to U.S. citizens and permanent residents.
 - Doctoral students with disabilities were more likely to use personal/family funds (31.3% vs. 18.2%) and less likely to be awarded research assistantships (16.4% vs. 24.4%) than their non-disabled counterparts.
 - Persons with disabilities made up 7% of all U.S. scientists and engineers; 2% of those younger than 35, 15% of those ages 65 to 75.
 - Scientists and engineers with disabilities throughout their lifetimes earn from \$4,000 to \$13,000 less per year than their non-disabled counterparts.
-

Note: Data from: National Science Foundation. (2009). Women, minorities, and persons with disabilities in science and engineering. Washington, D.C.: National Science Foundation (NSF 09-305).

climate (how different groups interact on campus). The degree to which these four elements contribute to students from diverse groups feeling comfortable and confident is the extent to which the campus has a positive climate for diversity. Of course the campus climate may be different for different groups of students.

Examples of systemic and institutional support can run the gamut from:

- Inclusive university mission statements (Belch, 1995; Howard-Hamilton, Phelps, & Torres, 1998; Oseguera & Rhee, 2009);
- Recruitment materials that go beyond photographs of students with disabilities in brochures (Belch, 1995; Haller, 2006);
- Accessibility in orientation and new student programs (Hartman, 1993; Smith, English, & Vasek, 2002);
- Informational and application materials in alternative formats for all students (Belch, 1995);
- Faculty training regarding types of accommodations, teaching styles, confidentiality, legal issues, and responsibilities (Belch, 1995; Dunn et al., 2008); and
- Data collection on the types of strategies and

supports that affect the enrollment, persistence, and graduation rates of various student groups (Howard-Hamilton et al., 1998).

In her research of university recruitment materials directed at students with disabilities, Haller (2006) noted that although some materials depicted students with disabilities, little effort was expended by the institutions to actively recruit these students. As such, "Universities may be missing out on many excellent students with disabilities who might enroll there" (Haller, Discussion and Recommendations section, para. 2). It is clear that successful strategies for recruiting students with disabilities will require multilevel approaches and significant efforts (Haller, 2006).

Influence of guidance counselors, secondary teachers, and postsecondary faculty. A third issue in recruitment is the effect guidance counselors and secondary teachers have on the self-perceptions of students with disabilities regarding their ability to take part in STEM endeavors and pursue STEM careers. For example, Munro and Elsom (2000) studied career advisors (guidance counselors) and secondary education science teachers in the UK and found that these professionals had a strong influence on students' entry into STEM education and careers. The science

teachers had a negative influence on student motivation and enjoyment of science, in and out of the classroom. While high school science teachers were sources of information to both students and their parents about STEM careers, they infrequently talked to students with disabilities about taking high school science courses past the sophomore level to keep their career options open to STEM. The research found, therefore, that students often did not link science topics in class to possible STEM careers. If they were not aware of STEM career possibilities, students saw little use in continuing science beyond their sophomore year. Guidance counselors also had little to no contact with science teachers and the overwhelming majority had humanities backgrounds themselves. The researchers recommended that teachers and guidance counselors work together more closely, students and their parents be informed about the connections between high school science and future STEM careers, and students be exposed to STEM professionals such as alumni and community members.

Additional literature, albeit from dated sources, has addressed the influence of postsecondary faculty on the perceptions of students with disabilities, both in general and in STEM specifically. West et al. (1993) found that poor faculty attitudes and lack of instructional accommodations for students with disabilities were problematic within Virginia postsecondary institutions. Likewise, Hill (1996) found that faculty members' unwillingness to make accommodations and lack of accessibility were primary reasons for the withdrawal from postsecondary education by students with disabilities. In fact, this sample of students with disabilities reported that "laboratory instructors" were the most unaccommodating of all faculty and students with disabilities believed they were seen as an "inconvenience" in laboratory settings. A study of 16 students with disabilities at a mid-Atlantic university found that similar negative experiences with professors were one of five major barriers reported (Marshak, Van Wieren, Ferrell, Swiss, & Dugan, 2010). For example, students with disabilities experienced faculty who did not believe they had a disability or that their disability affected class participation, although whether these faculty members were in STEM curricula was not reported. The other four reported barrier categories in this study included (a) self-identification/disclosure of disability issues, (b) desire to avoid stigma and not be singled out, (c) insufficient student knowledge of

their disability and appropriate accommodations, and (d) perceived lack of quality and usefulness of services from the disability support office.

Brockelman (2011) studied 107 full-time faculty at a large Midwestern university by comparing STEM and non-STEM faculty in providing accommodations to students with psychiatric disabilities and rating the effectiveness of those strategies. Engineering faculty (representing over half of the STEM faculty sample), on average, were more likely to provide accommodations to students with psychiatric disabilities. They were most likely to provide these accommodations: extended test time, private testing rooms, alternative formats for test answers, consultation with disability professionals, and discussions with the student. The engineering faculty members were much more likely than non-STEM faculty to rate extended test time as an effective accommodation strategy. Brockelman suggested that additional research with larger samples and more detailed demographics be conducted.

A more comprehensive study used a broad sample of American institutions ($n=56$) and students with and without disabilities in STEM and non-STEM majors ($n=16,995$) while reviewing data from the National Survey of Student Engagement (NSSE) (Hedrick, Dizen, Collins, Evans, & Grayson, 2010). The purpose of this study was to examine if and how college students with disabilities differed from their peers without disabilities, and how STEM majors differed from non-STEM majors, on five benchmarks. The five benchmarks included: (a) academic challenge; (b) an atmosphere of active and collaborative learning; (c) student-faculty interactions; (d) enriching educational experiences; and (e) supportive campus environments that allow students to succeed academically and socially, and promote supportive relationships across campus. The authors found: (a) students with disabilities, compared with students without disabilities, reported less supportive campuses (e.g., in social, extra-curricular, and non-academic arenas); (b) no differences among any of the five benchmarks between students with disabilities and students without disabilities based on STEM or non-STEM majors; and (c) regardless of disability status, STEM majors felt their institutions provided greater academic challenges and opportunities, their faculty were more supportive, and the campus environment was less supportive than non-STEM majors. This study noted minimal differences between students with disabilities and other students,

and few effects of STEM vs. non-STEM majors. These results may be encouraging for those involved in the recruitment of students with disabilities to STEM educational programs and careers.

Strategies for Success in Recruiting Students with Disabilities to Explore Opportunities in STEM

Midwest Alliance staff experienced some surprises and learned many lessons prior to their current success at recruiting students with disabilities into STEM. These lessons can provide important information for others who are interested in developing similar recruitment programs. The first lesson concerns the message being sent to students with disabilities. The second lesson concerns the ability to quickly locate students with disabilities to participate in programs.

Students receive different messages regarding educational and career choices. Students with disabilities receive an additional set of messages, including those related to their potential to be successful in STEM. By talking with student participants, Midwest Alliance staff found that STEM stereotypes and/or the stigma associated with self-reporting a disability (Marshak et al., 2010; Trammell, 2009) significantly limited students with disabilities' participation in STEM. The first concern is that participation in STEM requires specific special abilities such as math excellence, which may or may not be true. Unfortunately, this misperception is continuously reinforced via many sources students encounter when thinking about what they might study and what career they might choose. The second concern is the stigma associated with self-reporting their disability (Fichten et al., 2003; Marshak et al., 2010). Unless students choose to disclose their disability and register for support services, they often are not afforded services and accommodations that are essential for participation and their continued success in STEM.

Limited Numbers Lead to Programmatic Changes

When Midwest Alliance staff began the recruiting process, for example through mass mailings to school districts and disability organizations, the number of students recruited for our programs was less than anticipated. To improve our recruiting numbers, we employed two marketing consultants. They asked, "What is the message you want potential recruits to hear?" As staff reviewed the Midwest Alliance message via printed materials and website, we realized the message being communicated was not the one we

intended. What Midwest Alliance materials told a student with disabilities was, "*If you are sufficiently talented and accomplished, then these activities are appropriate for you.*" This is a message with which students with disabilities are very familiar, as they have heard it repeatedly from various sources. As Midwest staff considered this, two premises became apparent. First, the Midwest Alliance wanted to promote a message about participation in STEM that most students with disabilities had not heard, that is, that they *were* capable and had talent. Second, the Midwest Alliance wanted students with disabilities to determine whether STEM was an appropriate choice for them, independent from and in some cases despite what others had told them. This meant that students with disabilities were encouraged to *explore* participation in STEM in order to make their own informed choices about pursuing majors and careers in these disciplines.

Second, we found that we lacked the ability to easily and quickly locate and attract students with disabilities into programs. For organizations new to recruiting students with disabilities to opportunities in postsecondary education, it is perhaps surprising that it can be difficult to find students with disabilities to participate in the organization's programs. We had operated with the implicit assumption that students with disabilities were interested, eager, and actively seeking opportunities to explore possible educational and career paths. Unfortunately, our experience suggests that this belief is not true for most students with disabilities. Instead, recruiting potential participants requires significant resources and effort.

Our initial recruitment efforts produced extremely low rates of return from contact with school districts. The first attempt included bulk emails to every school district throughout the three-state region. The return rate was less than 5%. It quickly became clear that merely offering programs to help students with disabilities explore STEM education and career paths would not be sufficient. In fact, the recruitment program needed to be planned and multidimensional if it was going to be effective (Haller, 2006; Roessler & Brown, 2000).

To overcome these obstacles with a comprehensive recruitment plan, a system design process was used. This process began with an examination of the needs of the stakeholders, including students with disabilities, their parents, their teachers (including special education teachers), and school administrators. After the

needs were determined, a multilevel recruitment plan was established to maximize the penetration and efficiency of staff efforts. We redesigned our recruitment model to include three sequential components. The first part is termed "Finding Students with Disabilities," the second "Reaching Students with Disabilities," and the third "Assisting Students with Disabilities." This multilevel approach is outlined in Table 2.

Finding Students with Disabilities

Each component of the systems-designed plan consists of several sub-components. Logically, identifying students with disabilities for participation in postsecondary STEM begins with contact with personnel in the middle and secondary school system (Fairweather & Shaver, 1990), key stakeholders, and persons involved in disability-related networks. Each of these focal points can be a significant source for finding students with disabilities.

Through secondary schools. An initial portal to potential participants is through the school districts (Fairweather & Shaver, 1990). This early student-identification process can be helpful, since the continuance from high school to postsecondary education is considerably lower for students with disabilities than their non-disabled counterparts (Fairweather & Shaver, 1990). Garrison-Wade and Lehmann (2009) noted that high school students with disabilities are rarely encouraged to identify possible postsecondary education institutions and programs of study in which they might be interested. Changing this pattern takes concerted effort (Palombi, 2000).

Our experience suggests that the difficulty in reaching students with disabilities through interactions with school districts arises from the need to pass several gatekeepers before communication with the student can occur. Recruitment efforts should address this barrier by employing two approaches. First, staff needs to take steps to ensure that school districts are familiar with the organization attempting to recruit its students. Second, staff needs to cultivate "word of mouth" support from students with disabilities who have participated in activities provided by the organization. The development of relationships and establishment of a quality reputation require time and patience, a difficult proposition when continued funding for recruitment efforts depends on the ability to recruit sufficient numbers of students relatively quickly.

Through key stakeholders and gatekeepers.

Key stakeholders and potential gatekeepers span a wide range of individuals and groups, including general education teachers, special education teachers, local boards of education, and educational administrators (Fichten et al., 2003; Roach & Salisbury, 2006; Roessler & Brown, 2000; Tororei, 2009). Midwest Alliance staff initially targeted our message directly to special education teachers because of their familiarity with students with disabilities. However, we have experienced instances where special education teachers have not passed invitations on to students because they felt our programs were not appropriate for their students. In order to counteract this pattern, we directly contacted many stakeholders and attended their functions to explain the purpose and activities of the Midwest Alliance and invited them to Alliance events. Taking a more proactive approach to recruitment, such as through parents' groups and at professional and transition conferences, paid greater dividends and helped spread the word more effectively than widespread mailings and indirect contact.

Parent groups. Many groups exist for parents of children with disabilities, such as Easter Seals, United Cerebral Palsy, The Arc, and related groups. In addition, the Internet hosts many online parent groups, as shown in Table 3. Both face-to-face and online parent groups can be powerful means of recruitment. Similar to school districts, recruitment through parents requires developing familiarity and reputation before successful recruitment can occur. One method used successfully by Midwest Alliance staff has been to include parent groups in a variety of programs (e.g., discussion panels during college preparation workshops and campus tours). In addition, parents are an integral part of many Midwest Alliance activities, such as the immersion camps discussed below. While students were engaged in exploratory activities in the immersion camps, parents simultaneously attended informational sessions about postsecondary disability services, academic skills needed in postsecondary education and in STEM, and postsecondary accommodations. At the conclusion of the immersion camp, students and parents worked together to plan a higher education path in which the student could utilize information gained during the camp.

Professional conferences and workshops. Another means of establishing relationships with key stakeholders is through participation at targeted conferences and workshops. The Midwest Alliance routinely

Table 2

Midwest Alliance Strategies for Recruiting Students with Disabilities to Explore STEM

-
- Finding Students with Disabilities
 - o Through secondary schools
 - o Through key stakeholders and gatekeepers
 - Parent groups
 - Professional conferences and workshops
 - Transition conferences
 - Targeted recruiting through special programs
 - o Building recruitment networks
 - Reaching Students with Disabilities
 - Assisting Students with Disabilities
 - o Creating a community and answering questions
 - o Offering career guidance
 - o Opportunities for exploration
 - o Providing guidance and/or direct financial support
-

Note: Information extracted from: www.stemmidwest.org

Table 3

List of Online Groups for Parent of Students with Disabilities

www.childrensdisabilities.info
www.disaboom.com/children-with-disabilities
www2.ed.gov/parents/needs/speced/edpicks.jhtml
www.our-kids.org
www.lookinglgass.org
www.disabledparents.net
www.parentcenternetwork.org
www.lookingglass.org
www.pacer.org
www.supportforfamilies.org
www.LDonline.org

participates in a wide variety of conferences, including making presentations and hosting booths at national and regional conferences for special educators and secondary science and math teachers. Examples have included the National Science Teachers Association, Association on Higher Education And Disability, the Wisconsin Department of Public Instruction, and the Science Education for Students with Disabilities Association.

Transition conferences. We have also found that conferences designed for professionals and teachers involved in students' transition from high school to postsecondary education are an effective way to engage another group involved with students with disabilities. Midwest Alliance staff sponsored informational booths and presented numerous sessions at annual transition conferences in Illinois, Wisconsin, and Iowa. In addition, the staff hosted public webinars on transition planning and employment to organizations and associations involved in transition services.

Targeted recruiting through special programs. Science Olympiad (SO) is a national science competition for middle and high school students. Student teams conceptualize and create hands-on activities and projects based on categories such as earth science, chemistry, or astronomy. Each team competes against all other teams in their category. The SO has been operating since 1982, has grown in both prestige and coverage, and currently registers more than 6,200 teams and representation in all 50 states (SO, 2011). Students who participate in SO often are already viewed as being skilled at STEM. Recruiting these students, who have been identified by their teachers as talented, often produces a high rate of return.

Students with disabilities participate in SO activities, which produces two recruiting opportunities. First, like their non-disabled peers, students with disabilities participating in SO are likely to have an existing interest in STEM, so recruiting these students to further explore opportunities in STEM is natural. Second, because students with disabilities and their teams' coaches may be seeking resources to enable participation by everyone in SO activities, providing assistance in accommodations can serve as an additional recruitment means. We believe that our help in providing accommodations to facilitate full inclusion in SO creates a compelling interest in students, coaches, and others for Midwest Alliance programs.

Building recruitment networks. Ultimately, the objective of many of these activities is the development

of recruiting networks. The message provided in the recruitment materials needs to be consistent with what the recruitment networks value, such as specific information on how the program will benefit the student. Recruitment networks can be established with other programs such as NSF funded projects (e.g., Research in Undergraduate Education [REUs]); with disability support services offices at technical and vocational schools, community colleges, and universities; and with disability advocacy organizations.

Reaching Students with Disabilities

Once students with disabilities have been identified, strategies for reaching the students need to be developed. There are two main features essential to this stage. First, multiple means of dissemination is necessary, and second, the message sent to key stakeholders including students is essential.

We have used five different approaches to reaching students with dissemination methods. The first four are examples of social media that align with how students routinely interact with one another: email, the Midwest Alliance website, listservs, and social networking. We have used all of these approaches extensively, including a Facebook page. We also have published a quarterly newsletter as our fifth dissemination method. All the online material is provided in multiple formats and is routinely checked for accessibility.

Assisting Students with Disabilities

In addition to finding and reaching students with disabilities, programs such as the Midwest Alliance need to assist them in achieving academic success and persisting to graduation. For most students, this means creating a positive peer climate, exercising choices, self-advocating, and being engaged in both academic and extracurricular activities (Mayhew et al., 2005; Oseguera & Rhee, 2009; Roessler & Brown, 2000). Adams and Proctor (2010) noted the importance of attitudes and skill sets in addition to traditional skills that may be required by STEM majors. For example, they recommended personal and counseling services, advocacy services, social-networking activities, and services that oriented students to college life. These opportunities and skill sets are the target of many Midwest Alliance programs.

Creating a community and answering questions. Individualized and group programs such as mentoring (Brown, Takahashi, & Roberts, 2010; Stumbo, Lindahl-

Lewis, & Blegen, 2008; Stumbo et al., 2010/2011) and tutoring are important recruitment tools. Mentoring, especially in cases where the mentors are upperclassmen or STEM employees in the workforce, can help high school and beginning postsecondary education students with disabilities learn about campus and community services for students with disabilities (Hill, 1996), for example, the disability services office.

In the case of the Midwest Alliance, mentorships are conducted either face-to-face or electronically. The best possible matches are created based on major or career interests, location, and disability. Mentorships focus on self-advocacy, transitioning from high school to postsecondary education, academic accommodations, and study skills such as time management. The primary benefit for the mentees is the ability to ask questions about the postsecondary education environment, about STEM majors, and about disability issues without fear of stigma, ridicule, or embarrassment. The primary benefit to the mentors is the satisfaction of guiding an individual toward his or her path of success (Stumbo et al., 2008; Stumbo et al., 2010/2011). Many of the individual success stories are published in the Midwest Alliance newsletter (cf. Midwest Alliance, 2010) in order to encourage additional students to apply for the program and to continue to build the mentoring community.

Offering career guidance. Mowbray et al. (2005) noted that transitioning is focused on a “choose-get-keep” premise that helps individuals make choices about their own paths for education and training, get an appropriate education or training, and keep on track until their goals are achieved. According to these authors, services that help individuals choose-get-keep include career planning, academic survival skills, and outreach services and resources. Career planning may include self-assessments, career exploration, and goal setting. Academic survival skills might include stress and time management, developing social support networks, tutoring and mentoring, and social skill development. Outreach services include financial aid offices, disability service providers, vocational rehabilitation agencies, and on-campus centers such as those for computing and writing skills.

The Midwest Alliance staff provides a number of activities that help students explore career opportunities and develop career-related skills. Campus tours of university laboratories and departments are offered to students with disabilities and their parents. These tours allow high school students with disabilities to learn

about potential career options; visualize themselves in these settings; and familiarize themselves with the facilities, equipment, and language of STEM-related careers. Students with disabilities and their parents are also invited several times a year to workshops and panel presentations that include students and scientists with disabilities, personnel from university disability offices, transition specialists, and other parents. The focus of these information-sharing activities is to acquaint students with disabilities and their parents with various options available within the wide spectrum of STEM, in an effort to allow students with disabilities to determine if a STEM-related career suits their own abilities and preferences. In addition, the Midwest Alliance staff aids students with disabilities in developing interviewing and job application skills, resume writing, and disclosing disability information as they progress further into their education and career.

Opportunities for exploration. It is essential that students with disabilities have opportunities to actually participate in STEM activities and visualize themselves engaged in a STEM profession. The Midwest Alliance refers to these experiences as immersion and enrichment experiences and offers them to all students regardless of prior interest and/or ability in STEM. According to Melber and Brown (2008), these “authentic, inquiry-based experiences” (p. 36) that occur outside of a classroom are important for student exploration and discovery, empowerment, and creating a self-portrait of being successful in STEM.

Midwest Alliance has developed and hosted two-, three-, and five-day immersion camps on design in 2009, 2010, and 2011. These camps, with titles such as “Exploration by Design: How Stuff Works,” allow high school students with disabilities to explore design and engineering activities in non-traditional ways. Approximately 15 students with disabilities and 25 parents participate in each of these immersion experiences. For the most part, the students and the parents participate in separate activities. Students experience a wide range of physical, visual, hearing, psychological, and learning disabilities.

A variety of activities were part of the immersion camps. The camp typically begins by introducing the students and parents to one another with activities such as, “What Do You Know? Competition,” and tower and boat building. The students learn about the design process and how things work. One design problem was to develop a game. The game may involve physical

activity or be a table-type game. Examples activities include study of the Wii controller and bridge building, including simulation of the bridge designs the students put together. At the conclusion of the camps, students present and demonstrate their designs. Concurrent with these activities, parents are gaining information on postsecondary education disability access and supports, and skills that the students would need to be successful at the postsecondary level. The camps are held on college campuses and include tours of campus and the disability service offices with question/answer sessions on two-year and four-year colleges.

Providing guidance and/or direct financial support. Financial aid is designed to help students and their families meet the gap between postsecondary education expenses and their own personal resources. Typically, four types of aid are available: grants, which generally do not have to be repaid; loans that typically need to be repaid with interest in the future; work-study, or university-based employment during or between periods of enrollment; and scholarships, which are gifts and awards based on academic achievement, background, or other criteria. In addition, many students with disabilities, especially undergraduates, may qualify for assistance through their state vocational rehabilitation agency (Gardner & Ward, 2007). Most financial aid options are based on need, although many scholarships are merit-based, that is, based on the student's exceptional abilities or achievement in certain areas, such as mathematics, drama, or overall grade point average.

St. John (2000) stated, "While for a brief period in the 1960s and 1970s there was sufficient aid to promote equal opportunity, federal student aid is no longer adequate for this purpose" (p. 72). Additionally, students with disabilities may have above average costs due to disability-related equipment and its maintenance; personal help such as interpreters or personal care assistants; transportation when accessible means are unavailable; and disability-related medical expenses not paid by insurance. To cover these expenses, scholarships and/or other forms of financial assistance are needed for students with disabilities (Lau, 2003; Mobility International, 2011).

In the second year of operation, the Midwest Alliance provided scholarships to selected students with severe physical disabilities who were majoring in STEM. However, one student withdrew for medical reasons and another had his vocational rehabilitation

aid lowered by the amount of the scholarship. Since that seemed unproductive for both the students and Midwest Alliance, no additional scholarships have been awarded. However, the Midwest Alliance does provide stipends to students who are mentees, mentors, and interns. While these stipends do not offset the expenses mentioned above, they do provide an income for students and encourage continuance of their commitment to their education and career.

Table 4 represents data on the number of students involved in various programs during the six years of Midwest Alliance. The numbers show continued growth in each program. The first years show modest progress, while later years shown increasingly robust numbers of students. While this continued growth cannot be attributed to particular recruitment efforts, it is felt that the increases reflect the success of the systems-designed, multilevel approach used by the Midwest Alliance. Hopefully, other programs recruiting students with disabilities into STEM can learn from this approach.

Conclusion

"Persons with disability must be equipped with the necessary skills required in the performance of tasks before them if they are to compete favorably with non-disabled workers in an already saturated labor market" (Tororei, 2009, p. 4). This statement resonates deeply with individuals and organizations tasked with providing educational and support services to students with disabilities. In order to be afforded equal opportunity, especially in STEM fields, people with disabilities must be able to work their way through multiple barriers. A systems-designed, multilevel approach aimed at reducing or eliminating these barriers is required. The comprehensive approach taken by the Midwest Alliance, an NSF-funded program that recruits students with disabilities and helps them succeed in postsecondary education/STEM majors, is described. As promising practices, the ideas presented here are intended to help other individuals and organizations determine if recruitment is desired and, if so, to conceptualize and create multi-level systems-designed recruitment plans. Understanding what has and has not worked for the Midwest Alliance may help others to more efficiently and effectively meet the challenges of recruiting students with disabilities.

Table 4

Numbers of Participants in Midwest Alliance Activities 2005-2011

Year/ Program	2005- 2006	2006- 2007	2007- 2008	2008- 2009	2009- 2010	2010- 2011	TOTAL
Internships	6	10	18	32	29	17	112
Mentoring	-	15	21	40	41	42	159
Immersion Experiences	-	-	-	13	38	27	78
Webinars	-	-	-	-	-	160	160
TOTAL	6	25	39	85	108	246	509

References

- Adams, K. S., & Proctor, B. E. (2010). Adaptation to college for students with and without disabilities: Group differences and predictors. *Journal of Postsecondary Education and Disability*, 22(3), 166-184.
- Administration for Children and Families, U. S. Department of Health and Welfare. (2010). Identifying and promoting best practices. Retrieved from: http://www.acf.hhs.gov/programs/ocs/ccf/about_ccf/gbk_bp/bp_gbk_ov.html
- Belch, H. A. (1995). Admitting graduate students with disabilities. *New Directions for Student Services*, 72, 101-110.
- Brockelman, K. F. (2011). Faculty members' ratings of the effectiveness of academic strategies for university students with psychiatric disabilities. *Journal of Postsecondary Education*, 24(1), 52-65.
- Brown, S. E., Takahashi, K., & Roberts, K. (2010). Mentoring individuals with disabilities in postsecondary education: A review of the literature. *Journal of Postsecondary Education and Disability*, 23(2), 98-111.
- Bureau of Labor Statistics. (2011). Economic news release. Retrieved from <http://www.bls.gov/news.release/empst.t06.htm>
- Burrelli, J. S., & Falkenheim, J. C. (2011). *Diversity in the federal science and engineering workforce*. Washington, DC: National Science Foundation, Directorate for the Social, Behavioral, and Economic Sciences (NSF 11-303).
- Dunn, P., Hanes, R., Hardie, S., Leslie, D., & MacDonald, J. (2008). Best practices in promoting inclusion within Canadian schools of social work. *Disability Studies Quarterly*, 28(1). Retrieved from: <http://www.dsqsds.org>
- Ellis, S. E. (2010). But does it really work? A vision for student services, 2002-2007. *New Directions for Student Services*, 132, 87-100.
- Fairweather, J. S., & Shaver, D. M. (1990). A troubled future? Participation in postsecondary education by youths with disabilities. *Journal of Higher Education*, 61(3), 332-348.
- Fichten, C. S., Asuncion, J. V., Barile, M., Robillard, C., Fossey, M. E., & Lamb, D. (2003). Canadian postsecondary students with disabilities: Where are they? *The Canadian Journal of Higher Education*, 33(3), 71-114.
- The Forum for Youth Development. (2010, September). *Ready by 21, credentialed by 26 Issue Brief #1: Insulating the education pipeline to increase postsecondary success*. Washington, D.C.: The Forum for Youth Investment.

- Gardner, D., & Ward, M. (2007). *Creating options: 2007, financial aid for individuals with disabilities*. Washington, D.C.: HEATH Resource Center, The George Washington University.
- Garrison-Wade, D. F., & Lehmann, J. P. (2009). A conceptual framework for understanding students' with disabilities transition to community college. *Community College Journal of Research and Practice*, 33, 415-443.
- Haller, B. A. (2006). Promoting disability-friendly campuses to prospective students: An analysis of university recruitment materials. *Disability Studies Quarterly*, 26(2). Retrieved from www.dsqsds.org/article/view/673/850
- Hartman, R. C. (1993). Transition to higher education. *New Directions for Student Services*, 64, 31-43.
- Hedrick, B., Dizen, M., Collins, K., Evans, J., & Grayson, T. (2010). Perceptions of college students with and without disabilities and effects of STEM and non-STEM enrollment on student engagement and institutional involvement. *Journal of Postsecondary Education and Disability*, 23(2), 129-136.
- Hill, J. L. (1996). Speaking out: Perceptions of students with disabilities regarding adequacy of services and willingness of faculty to make accommodations. *Journal of Postsecondary Education and Disability*, 11(1), 1-13.
- Howard-Hamilton, M. F., Phelps, R. E., & Torres, V. (1998). Meeting the needs of all students and staff members: The challenge of diversity. *New Directions for Student Services*, 82, 49-64.
- Hurtado, S., Milem, J., Clayton-Pedersen, A., & Allen, W. (1998). *Enacting diverse learning environments: Improving the climate for racial/ethnic diversity in higher education*. ASHE-ERIC Higher Education Report, Volume 16, No. 8. Washington, DC: Graduate School of Education and Human Development, The George Washington University.
- Lau, L. K. (2003). Institutional factors affecting student retention. *Education*, 124, 126-136.
- Lewis, L., & Farris, E. (1999). An institutional perspective on students with disabilities in postsecondary education. Washington, DC: National Center on Educational Statistics. Retrieved from: <http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=1999046>
- Marshak, L., Van Wieren, T., Ferrell, D. R., Swiss, L., & Dugan, C. (2010). Exploring barriers to college student use of disability services and accommodations. *Journal of Postsecondary Education and Disability*, 22(3), 151-165.
- Mayhew, M. J., Grunwald, H. E., & Dey, E. L. (2005). Curriculum matters: Creating a positive climate for diversity from the student perspective. *Research in Higher Education*, 46(4), 389-412.
- Melber, L. M., & Brown, K. D. (2008). "Not like a regular science class:" Informal science education for students with disabilities. *The Clearing House*, 82(1), 35-39.
- Midwest Alliance. (2010). Midwest Alliance newsletter. Retrieved from: <http://stemmidwest.org/default.asp?contentID=521>
- Mobility International USA. (2011). A recruitment guide on outreach to Americans with disabilities for international exchanges. Retrieved from www.miusa.org/ncde/tools/recruiting
- Mowbray, C. T., Collins, M. E., Bellamy, C. D., Megivern, D. A., Bybee, D., & Szilvagy, S. (2005). Supported education for adults with psychiatric disabilities: An innovation for social work and psychosocial rehabilitation practice. *Social Work*, 50(1), 7-20.
- Munro, M., & Elson, D. (2000). *Choosing science at 16: The influence of science teachers and career advisers on students' decisions about science subjects and science and technology careers*. London, England: Department for Education and Employment. ERIC 448 334.
- National Science Board. (2003). *Broadening participation in science and engineering faculty*. Washington, DC: National Science Foundation (NSB 04-41).
- National Science Foundation. (2009). *Women, minorities, and persons with disabilities in science and engineering*. Washington, D.C.: National Science Foundation (NSF 09-305).
- Oseguera, L., & Rhee, B. S. (2009). The influence of institutional retention climates on student persistence to degree completion: A multilevel approach. *Research in Higher Education*, 50, 546-569.
- Palombi, B. J. (2000). Recruitment and admission of students with disabilities. *New Directions for Student Services*, 91, 31-39.

- Ralph, S., & Boxall, K. (2005). Visible images of disabled students: An analysis of UK university publicity materials. *Teaching in Higher Education*, 10(3), 371-385.
- Rendon, L. I. (1985). *Elements of successful math and science models for Mexican American students*. Paper presented at the Border College Consortium Southwest Region Education Conference, May 3, 1985, San Antonio, TX. ERIC 258 777.
- Roach, V., & Salisbury, C. (2006). Promoting systemic, statewide inclusion from the bottom up. *Theory into Practice*, 45(3), 279-286.
- Roessler, R. T., & Brown, P. L. (2000). Transition and the community college: A career keys model for students with disabilities. *Work*, 14, 23-29.
- St. John, E. P. (2000). The impact of student aid on recruitment and retention: What the research indicates. *New Directions for Student Services*, 89, 61-75.
- Science Olympiad. (2011). About Science Olympiad. Retrieved from: <http://www.soinc.org/about>
- Smith, S. G., English, R., & Vasek, D. (2002). Student and parent involvement in the transition process for college freshmen with learning disabilities. *College Student Journal*, 36(4), 491-503.
- Stodden, R. A., & Conway, M. A. (2003). Supporting individuals with disabilities in postsecondary education. *American Rehabilitation*, 27(1), 24-33.
- Stodden, R. A., Whelley, T., Chang, C., & Harding, T. (2001). Current status of education support provision to students with disabilities in postsecondary education. *Journal of Vocational Rehabilitation*, 16, 189-198.
- Stumbo, N. J., Lindahl-Lewis, P., & Blegen, A. R. (2008). Two mentorship case studies of high school and university students with disabilities: Milestones and lessons. *Journal of Rehabilitation*, 74(3), 45-51.
- Stumbo, N. J., Martin, J. K., Nordstrom, D., Rolfe, T., Burgstahler, S. Whitney, J., . . . Misquez, E. (2010/2011). Evidence-based practices in mentoring students with disabilities: Four case studies. *Journal of Science Education for Students with Disabilities*, 14(1), 33-54.
- Test, D. W., Fowler, C. H., White, J., Richter, S., & Walker, A. (2009). Evidence-based secondary transition practices for enhancing school completion. *Exceptionality*, 17, 16-29.
- Tororei, S. K. (2009). The right to work: A strategy for addressing the invisibility of persons with disabilities. *Disability Studies Quarterly*, 29(4), Retrieved from www.dsqsds.org/article/view/73/1174
- Trammell, J. (2009). Postsecondary students and disability stigma: Development of the postsecondary student survey of disability-related stigma (PSSDS). *Journal of Postsecondary Education and Disability*, 22(2), 106 - 116.
- West, M., Kregel, J., Getzel, E. E., Ming, Z., Ipsen, S. M., & Martin, D. (1993). Beyond section 504: Satisfaction and empowerment of students with disabilities in higher education. *Exceptional Children*, 59(5), 456-465.
- Yuen, J. W. L., & Shaughnessy, B. (2001). Cultural empowerment: Tools to engage and retain postsecondary students with disabilities. *Journal of Vocational Rehabilitation*, 16, 199-207.

About the Authors

Jay Martin is a professor of Mechanical Engineering and affiliate of Biomedical Engineering at the University of Wisconsin-Madison. He is the director of the UW Center for Rehabilitation Engineering and Assistive Technology (UW-CREAtE) and the principal investigator for the NSF-sponsored Midwest Alliance in Science, Technology, Engineering, and Mathematics.

Norma J. Stumbo is the Research Director for the Midwest Alliance.

Brad Hedrick is the Director of the Division of Disability Resources and Education Services (DRES) at the University of Illinois and the Severe Disabilities Coordinator for the Midwest Alliance.

Kim Collins is the Assistant Director of Academic Services at DRES and the Psychological Disabilities Coordinator for the Midwest Alliance.

Dan Nordstrom is the Project Manager and the Outreach Coordinator for Wisconsin for the Midwest Alliance.

Michelle Peterson is the Outreach Coordinator for Illinois for the Midwest Alliance.

Liam Martin is the Assistant Outreach Coordinator for the Midwest Alliance.

Authors' Note

The Midwest Alliance is an NSF-funded five-year project aimed at increasing the number of students with disabilities entering and succeeding in STEM education and careers. It is based at the University of Wisconsin-Madison, with subcontracts to the University of Illinois at Urbana Champaign and the University of Northern Iowa.

The information contained in this publication is based upon work supported by the National Science Foundation under Grant No. 0533197. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. In addition, we wish to acknowledge that NSF Grant No. HRD-0929006 facilitated the publication of this article.

Using Student Learning Communities to Recruit STEM Students with Disabilities

Margaretha Vreeburg Izzo

Alexa Murray

Sarah Priest

Bianca McArrell

The Ohio State University Nisonger Center

Abstract

Student Learning Communities (SLCs) for high school and college students with disabilities interested in pursuing science, technology, engineering, and mathematics (STEM) degrees were piloted at a major Midwestern university from 2009 to 2011. Students participated in a series of weekly sessions and/or a residential campus experience as part of a multifaceted intervention that included instruction on transition, self-determination, and self-advocacy skills. These activities culminated in the development of customized Self-Advocacy Plans and Transition Portfolios that students presented as their final project for the SLCs. Survey results from a formative evaluation process reveal that students gave high ratings to the development of Self-Advocacy Plans and Transition Portfolios as well as networking with other students with disabilities who are interested in STEM. The majority of students who participated in the STEM-focused SLCs were admitted to STEM degree programs at the undergraduate or graduate levels. These findings suggest the value of providing SLCs to teach self-determination, self-advocacy, and career development skills to students with disabilities, especially for students interested in STEM careers.

Keywords: Transition, STEM, learning communities, self-advocacy, twenty-first century workforce

As the nation wrestles with the need to train more STEM professionals, persons with disabilities are undereducated and underrepresented in STEM disciplines. National statistics on the science and engineering workforce show that only about 7% of graduate students in science and engineering were persons with disabilities (as of 2004, the latest year available) (Sevo, 2011). The most commonly cited reason for the disparity between STEM graduates with and without disabilities is inadequate education and training for available positions (Bruyere, 2000). Numerous researchers have cited the gap in enrollment and persistence in postsecondary education between students with and without disabilities (Kochhar-Bryant, Bassett, & Webb, 2009; Newman, Wagner, Cameto, Knokey & Shaver, 2010). While 63% of students without disabilities enroll in postsecondary education, only 46% of students with disabilities enroll (Newman et al., 2010). In regards to degree attainment, according to a 2003 Government Accountability Office report, only 16% of students with disabilities complete a bachelor's degree program

as opposed to 52% of their non-disabled peers (U.S. Government Accountability Office, 2003).

Moreover, when examining 2005 cohort data from the National Longitudinal Transition Study 2 (NLTS2), 18% of students with disabilities who left their postsecondary program actually left because they graduated. This number has remained relatively stable over time, as it was 17% in 1990 when the first NLTS was conducted. An implication of this statistic is that when students leave college, few are leaving because they are completing their programs and earning degrees (Newman et al., 2010). When students with disabilities do complete their degree programs, they tend to take longer than the general student population and frequently report feeling alienated from mainstream campus life (Brinckerhoff, McGuire, & Shaw, 2002; Rumrill, 2001).

Students with disabilities in two-year colleges also face challenges as they transition to four-year schools. Some are similar to those faced by their non-disabled peers, such as changes in academic requirements, poor

study skills, and inadequate financial support. Some challenges, however, are related to disability or a lack of self-advocacy skills. Another challenge is the difficulty in adjusting to the differences in the offices for disability services between the two types of schools (Burgstahler, Crawford, & Acosta, 2001). Clearly, obtaining two-year or four-year college degrees continues to be a significant challenge for many students with disabilities.

Considering the gap for students with disabilities pursuing higher education degrees, the gap for training and employment for persons with disabilities is even wider in STEM fields where increased participation is critical to American competitiveness (Golshani, 2005). The unique challenges faced by students with disabilities in STEM are complex. In postsecondary education, students face barriers to access. In order to receive accommodations, students must disclose having a disability and request accommodations—a process often laden with social stigma. Sevo (2011) observes that higher education institutions are willing to make physical accommodations for students with disabilities, but creating a welcoming climate, as evidenced by faculty who maintain high performance expectations while encouraging students with disabilities to use accommodations, has yet to follow suit. Often students with disabilities resist requesting accommodations due to poor societal perceptions of people with disabilities (May & Stone, 2010). Students are often met with negative attitudes from faculty and peers or are altogether discouraged from pursuing STEM degrees. In a study on the perceptions of parents and teachers on students with learning disabilities entering science and engineering fields, both parents and teachers had the perception that counselors, teachers, and parents do not encourage students with learning disabilities to take courses in science and engineering (Alston, Bell, & Hampton, 2002).

To face these challenges, numerous researchers have identified evidence-based practices to improve postsecondary outcomes of students with disabilities, such as providing transition programs to increase self-advocacy and self-determination skills (Baer et al., 2003; Benitez, Lattimore, & Wehmeyer, 2005; Halpern, Yovanoff, Doren & Benz, 1995; Repetto, Webb, Garvan, & Washington, 2002; Wehmeyer & Palmer, 2003; Wehmeyer & Schwarz, 1997). Self-determination is a combination of skills, knowledge, and beliefs that enable a person to engage in goal-

directed, self-regulated, and autonomous behaviors (Field, Martin, Miller, Ward, & Wehmeyer, 1998). Embedded in the self-directed planning and execution processes are essential skills related to choice making, problem solving, decision-making, self-regulation, and self-advocacy or leadership (Wehmeyer, 2003).

Many students with disabilities are poorly equipped to request and negotiate accommodations at the postsecondary level due to a lack of opportunity to practice these self-advocacy skills in high school (Grigal & Hart, 2010). Therefore, students who wish to pursue postsecondary education need training and support in the area of self-determination and self-advocacy skills (Thoma & Wehmeyer, 2005). Research suggests that practicing these skills can help students with disabilities succeed in and out of school (Field et al., 1998). Benitez et al. (2005) reported that teaching self-determination skills in high school was positively correlated with improved post-school outcomes.

Wehmeyer and Schwartz (1997) found that students with disabilities who measured higher on measures of self-determination were nearly twice as likely to be employed and have a higher hourly wage one year after high school. In a later study conducted by Wehmeyer and Palmer (2003), self-determination skills in high school were found to be significant predictors of post-school education and independent living success. Without self-determination skills, many students with disabilities do not effectively advocate for the accommodations they need (Izzo & Lamb, 2002). Emphases on helping students with disabilities develop self-determination and self-advocacy skills are in concert with the demands of gaining STEM degrees and careers. We assert that self-advocacy will increase students' ability to navigate the challenges they face in rigorous STEM programs.

Student Learning Communities

Student Learning Communities (SLCs) are one strategy to help STEM students with disabilities develop self-advocacy skills while planning their transition to STEM degrees and careers. The SLCs provide opportunities for skilled professionals to teach these self-determination skills directly to high school and college students with disabilities. These communities can vary depending on the context in which they are implemented but, generally speaking, SLCs are defined as a collection of activities organized by common goals that a group of students complete together (Swaner & Brownell,

2008). An important feature of an SLC is that a cohort of participants is created, which serves as an ongoing social support network. Student Learning Communities are more prominent on college and university campuses in recent years because they can afford concentrated and creative learning through a cost-effective model (Swaner & Brownell, 2008).

Student Learning Communities can lead to a range of positive outcomes—including academic, personal, and civic—for the general population of college students as well as underserved students (Swaner & Brownell, 2008). In a study of 80,479 randomly selected first-year and senior college students across 365 four-year universities implementing SLCs, the results indicated that participation in an SLC was uniformly and positively linked with student academic performance, engagement in educational activities, gains associated with college attendance, and overall satisfaction with the college experience (Zhao & Kuh, 2004). The DO-IT Scholars program at the University of Washington has developed a residential SLC model where high school students with disabilities interested in STEM come to campus in the summer to learn how to navigate a large university, request disability accommodations, get along with roommates, and succeed in college. When students were surveyed on the long-range impact of the program, which included career preparation, peer support, and internship experiences, they reported growth in their level of preparation for college, employment, and self-advocacy skills (Burgstahler, 2003).

Our SLC model builds upon the success of other models and includes an online transition-focused curriculum resulting in a comprehensive Self-Advocacy Plan and Transition Portfolio. Prior to being modified for SLC purposes, our online curriculum was piloted statewide across various high schools and school districts using a pretest-posttest control group design. Through two consecutive U.S. Department of Education grants, a transition-focused curriculum called EnvisionIT was piloted by 600 students with and without disabilities in special education and inclusive classrooms at 15 Ohio high schools during a six-year period. Findings revealed that, when compared to the control group, students in the experimental group made statistically significant gains in several key transition skill areas, including goal setting and knowledge of how to find information about college and jobs (Izzo, Yurick, Nagaraja, & Novak, 2010). Based on these

findings, EnvisionIT was used as a valid archetype for our SLC curriculum. Our current SLC curriculum consists of 8-10 units with activities and assessments and is delivered through Ning.com, an accessible and secure social networking website.

Method

Our SLC Model

Currently two STEM-focused SLC models for students with disabilities are being piloted at a major postsecondary Midwestern institution. These models were developed from the review of the literature and serve as key transition scaffolds to success in STEM. These two models are similar in design, but each has a slightly different focus, target population, and desired outcome (see Table 1). One model, called the Beginner SLC, introduces key study and self-advocacy skills and prepares high school and community college students for the transition to college life and STEM majors. The other model, called the Advanced SLC, strengthens self-advocacy skills and prepares undergraduate and graduate students at a four-year institution for the transition to STEM internships and employment. Despite slightly different areas of emphasis, both models provide students with the supports, information, and resources to successfully transition into STEM degree programs and ultimately the STEM workforce.

Curriculum content and delivery is tailored to the instructional needs of SLC participants, but generally both Beginner and Advanced SLC curricula focus on the following core transition areas, which are defined more specifically as follows (see Table 1):

- Self-Awareness: researching interests, learning styles, personality traits, strengths, and challenges
- Self-Determination/Self-Advocacy: understanding disability, disclosure, and how to negotiate for accommodations
- Assistive Technology (AT): learning about AT assessment, identification, and use
- Career Exploration: matching strengths and interests to potential majors and careers
- Networking: creating a support network
- Study Skills: learning time management and organization strategies
- Setting Goals: developing short and long-range goals

Table 1

Comparison of SLC Models and Curricula

	Beginner SLCs	Advanced SCLs
SLC Model & Target Population	Residential or weekly SLC for high school and community college students with disabilities	Weekly SLC for college and graduate students with disabilities
Focus	Students with disabilities transition to college, STEM majors, and internships	Students with disabilities complete STEM degree programs and internships, resulting in transition to STEM workforce
Desired Outcome	Students matriculate to two-year or four-year college programs and access needed accommodations as identified in their Self-Advocacy Plans developed through the SLC	Students persist in and graduate from STEM majors and transition to STEM careers and access needed accommodations as identified in their Transition Portfolios developed through the SLC
Curricular Content		
Self-Awareness	<p>Students take self-assessments:</p> <ul style="list-style-type: none"> • VARK (Learning Styles) www.vark-learn.com/english/page.asp?p=questionnaire • Myers-Briggs (Personality) www.personalitypathways.com/type_inventory.html • Princeton Review (Career Interests) www.princetonreview.com 	<p>Students take self-assessments:</p> <ul style="list-style-type: none"> • VARK (Learning Styles) www.vark-learn.com/english/page.asp?p=questionnaire • Myers-Briggs (Personality) www.personalitypathways.com/type_inventory.html • Princeton Review (Career Interests) www.princetonreview.com
Choice-Making	Students research colleges, compare and contrast colleges and STEM majors, identify college to apply to, and begin application process	Students research and compare and contrast graduate schools and STEM careers, identify graduate schools and employment opportunities to apply to, and begin application process
Assistive Technology	Program staff assess students' AT needs, match appropriate AT to students, pilot selected AT with students, and train students on AT	Program staff assess students' AT needs, match appropriate AT to students, pilot selected AT with students, and train students on AT

(Table 1 continued on next page)

Career Exploration	Students research STEM careers and internships in-depth, match abilities and strengths with careers and internships, and pursue internships	Students research STEM careers and internships in-depth, match abilities and strengths with careers and internships, and pursue internships
Networking	Students build professional relationships with peer group, program staff, support services, and potential internship sites	Students build professional relationships with peer group, faculty, support services, program staff, and potential employers
Study Skills	Students learn essential organization, time management, and learning strategies	Students learn essential organization, time management, and learning strategies
Setting Goals	Students develop long and short term goals related to increasing GPA, applying for college and self-advocating	Students develop long and short term goals related to self-advocating, gaining internships and employment
Internships & Employment	Students learn job-searching techniques, find internships, build resumes, create cover letters, and practice interviewing for jobs	Students enhance job-searching techniques, find internships, build or refine resumes, create cover letters, and practice interviewing for jobs
Disability Issues	Students learn impact of disability on learning as well as student responsibilities with disclosure and requesting accommodations in the college environment	Students learn impact of disability on learning and employment as well as employee responsibilities with disclosure and requesting accommodations in the workplace

- Internships and Employment: searching, applying, writing resumes, and interviewing

Setting

The Beginner SLC is often delivered in a residential format where students stay in a university dorm for four to five days. It allows students to experience college, identify needed accommodations and/or AT supports, network with people with similar interests, and learn essential skills for independence. The Beginner SLC can also be implemented as a weekly class on a college campus in which transition-based instruction, supports, and services are delivered in a class seminar format for a specified academic period (usually about 10 weeks or more with 90-120 minutes of instruction per week). Career development specialists, disability services counselors, assistive technology specialists, and college staff from admissions, student life, and financial aid offices present on a variety of topics ranging from getting into college to selecting a STEM major.

Students have opportunities to gain knowledge about their personal characteristics, strengths, limitations, interests, and skills through personality, interest, and learning style assessments. They learn strategies for selecting colleges and STEM majors, taking essential coursework in STEM, completing college and financial aid applications, and developing resumes and letters of application. Students also can take STEM modules, which are mini-courses in specific STEM concentrations, in order to learn about STEM disciplines in a fun and interactive way. For example, STEM modules in the area of applied cognitive science include (a) artificial intelligence and game playing in which students create strategy games with computer software, (b) brain anatomy and physiology in which students build a brain model and test neuromuscular plasticity, and (c) mental heuristics in which students design interfaces that enhance human problem solving. At the conclusion of the SLC, students present a comprehensive Self-Advocacy Plan and Transition Portfolio, which summarizes their personality and learning style assessments, postsecondary goals for college and employment, and a self-advocacy component that includes a description of how their disability impacts learning and what accommodations are available to enhance learning college material, especially challenging STEM content.

Targeting undergraduate and graduate students majoring in STEM, the Advanced SLC model is

implemented as a weekly class on a college campus in which transition-based instruction, supports, and services are delivered in a class seminar format for a specified academic period (usually about 10 weeks or more with 90-120 minutes of instruction per week). The structured format of this SLC engages students in weekly sessions that cover similar topics to those in the Beginner SLC, with more in-depth exploration of self-advocacy, time management and goal setting, resume development, interviewing skills, and leveraging internships. At the conclusion of the Advanced SLC, students develop and present a Self-Advocacy Plan and Transition Portfolio similar in content to the Beginner SLC but with greater emphasis on building resume, internship, and job readiness skills.

When the Advanced SLC ends, students are expected to remain involved in the SLC community by serving as role models and supports for Beginner SLC students. Advanced students participate in the residential summer SLCs for Beginner students and are matched as mentors to Beginner Students. Advanced students also receive mentoring from working professionals in STEM fields. The SLC alumni also support new SLC students through campus tours, field trips to engineering and science labs, panel discussions about selecting STEM majors and classes, and discussions about self-advocacy, including recommendations about when to disclose and when not to disclose one's disability. These activities contribute to establishing and broadening a network among STEM students with disabilities.

Recruitment

Project staff have participated in over 25 recruitment activities to date, including presentations at state conferences, participation in Regional Transition Council meetings, and local transition fairs. High school students recruited for the Beginner SLCs were recruited from 10 different high schools, with no more than three students from any one high school. Participants for the weekly Beginner SLCs were recruited from local high schools and community colleges, whereas participants for the residential Beginner SLCs were recruited from high schools statewide including the Ohio State School for the Blind and Metro High School, a STEM-focused charter school. Letters and emails with SLC applications were posted to websites and sent to principals, teachers, special education directors, rehabilitation counselors, and transition coordinators.

Community college participants were recruited via recruitment fairs, back to school campus events, and referrals from the Department of Disability Services at a local community college. Notably, at this same institution, Beginner participants were also recruited from a unique transition support program for students with Autistic Spectrum Disorders matriculating from high school to college. This program helps students with Autistic Spectrum Disorders with the numerous social and academic adjustments that accompany going to college. Many of these students are interested in pursuing STEM majors and careers, thus creating a natural pipeline for recruitment into our SLC program.

Participants for the Advanced SLCs were undergraduate and graduate students from local four-year postsecondary institutions. These students were often referred by the college campus' office for disability services or equivalent as well as STEM faculty at four-year institutions. Additionally, letters and emails with SLC applications were disseminated to faculty members and administrators across STEM departments, and project staff recruited via back to school campus and mentoring events. State rehabilitation counselors also provided referrals.

Candidates for all SLCs went through a formal application and interview process. Students submitted applications including current career goals and interest in STEM disciplines. Once admitted, qualified students completed an intake process that included face-to-face interviews in order to ascertain functional limitations and learning needs, accommodations and supports used, prior experiences with STEM and transition planning, technological literacy, current coursework and progress in school, and goals. Letters of recommendation were solicited to verify student interest in STEM careers. This intake process helped to create a comprehensive profile of each student so that SLC content and delivery was tailored to the individual needs of those participating. It should be noted that not all high school students who applied to participate in the SLCs were selected. Some were not selected because of not meeting the grade level requirement (must be high school juniors or seniors) and some were not selected because there were no more slots available (for the residential SLC), whereas all candidates who applied to the Advanced SLC were admitted as participants.

Measures

Our measures were iterative because the SLC implementation process itself was iterative and not an outcropping of pre-planned research. Therefore, though we have Cronbach alpha coefficients for our instruments, these measures were developed mainly for the purpose of formative rather than summative assessment so that we could improve the SLC process in the early phases of the project. We revised our measures based on need to match recommended changes in SLC content and delivery, resulting in non-comparable instruments.

The High School SLC Evaluation Survey: Non-Residential. This self-report instrument was administered on the last day of the SLC. It consisted of 24 Likert Scale items (1 to 5 scale with 5 being the highest) that asked students to assess their perceptions of knowledge and benefits gained from the SLC in the areas of STEM, career interest, self-advocacy plans, and social networking. It also was comprised of six open-ended items that asked students to describe the SLC experience to other students not familiar with it, particularly key learning points they would emphasize and recommendations for improvement. Items for this survey were selected based on the learning objectives and content map for the Beginner SLC. Due to the small sample size, the Cronbach alpha coefficient of this instrument was only 0.429.

The High School SLC Evaluation Survey: Residential. This self-report instrument was administered on the last day of the SLC. It consisted of 35 Likert Scale items (1 to 5 scale with 5 being the highest) that asked students to assess their perceptions of knowledge and benefits gained from the SLC in the content areas of STEM, career interest, self-advocacy plans, and social networking. This instrument was patterned after its non-residential counterpart in regards to inclusion of these content areas. The items differed in wording so the instruments were not comparable, especially since coordination and organization questions were added that only pertained to the residential experience. It also was comprised of eight open-ended items that asked students to describe the SLC experience to other students not familiar with it, particularly key learning points they would emphasize and recommendations for improvement. Items for this survey were selected based on the learning objectives and content map for the Beginner SLC. The Cronbach alpha coefficient of this instrument was 0.842.

Diverse Ability University SLC Evaluation Survey: Residential. To enhance our methodology, we developed a new instrument that examines common core constructs across all our SLCs. This instrument was piloted in summer 2011 at a residential Beginner SLC called Diverse Ability University hosted in collaboration with a partnering regional university. This self-report instrument was administered on the last day of the SLC. It consisted of 74 Likert Scale items on a 1 to 4 scale (with 1=not at all, 4=very much) with one open-ended item for a total of 75 items on the survey. The Likert Scale items asked students to evaluate each activity on each day of the residential SLC experience in regards to three perceptual ratings: how informative, useful, and engaging was the activity. Students were also asked to provide global ratings of how much they think they learned because of the SLC in regards to eight common core constructs that will be used as benchmark measures for all our SLCs for the sake of yielding comparison data. These constructs include the following: (1) awareness of learning opportunities and strategies, (2) personal responsibility, (3) time and stress management, (4) engagement, (5) identity as scientists, (6) self-advocacy, (7) self-determination; and (8) intention to persist in STEM. A Cronbach alpha coefficient of these constructs is not available due to the fact there is only item per construct. However, there were also four SLC specific constructs—confidence with hands-on science, relationship building, description of personality types and learning styles, and confidence with transition to college—on which Cronbach alpha coefficients were able to be calculated and are as follows: 0.740, 0.527, 0.730, and 0.546, respectively. Again, small sample size and low number of items per construct yielded modest coefficients.

The Advanced SLC Evaluation Survey. This self-report instrument was administered on the last day of the SLC. It consisted of 35 Likert Scale self-report items (1 to 5 scale with 5 being the highest) that asked students to assess their perceptions of knowledge and benefits gained from the SLC in the areas of STEM, transition planning, self-advocacy, social networking, college survival skills, and available campus resources and supports. It also was comprised of nine open-ended items that asked students to describe key learning points of the SLC that stand out, positive and negative factors, and recommendations for improvement. Items for this survey were selected based on the learning objectives and course syllabi for the Advanced SLC. The Cronbach alpha coefficient of this instrument was 0.733.

Results

Participants

Table 2 provides sample sizes, grade level, gender, and primary disability status of all the SLC participants. Data for the four Beginner SLCs has been aggregated for comparison purposes (N=67). Likewise, data for the two Advanced SLCs has also been aggregated for comparison (N=16). As Table 2 indicates, most of the students were male. The SLC participants identified themselves as having various disabilities, including attention deficit/hyperactivity disorder (ADHD), specific learning disability, sensory impairments, and autistic spectrum disorder. In the Beginner SLC, Autism Spectrum Disorder was the most common disability category (27% of participants), whereas for the Advanced SLC, ADHD was the most common disability category (38%). Regarding race and ethnicity, for the Beginner SLCs, 61% of participants were Caucasian, 32% were African-American, and 7% were Hispanic/Latino. For the Advanced SLCs, 55% of participants were Caucasian, 19% were Hispanic/Latino, 13% were African-American, and 13% were Asian. In regards to GPA, the average GPA for the Beginner SLC participants in 2009-10 was 2.95 and in 2010-11 was 3.01, an increase of .06. For Advanced SLC participants, their 2009-10 average GPA was 2.97 and in 2010-11, their average GPA was 3.12, an increase of .15.

SLC Ratings

Likert Scale Responses. In Table 3, the most highly rated items on a 1 to 5 Likert Scale with 5 being the highest are presented for the three 2009-2010 Beginner and two Advanced SLCs. For the Beginner SLCs, results reveal that knowledge of self-advocacy, disability, academic supports, and campus resources were the most highly rated. Social networking in which students with disabilities interested in STEM are able to have discussions with their own peer group was also highly rated. Participants in the Beginner SLCs rated learning about college highly, whereas participants in the Advanced SLCs rated resume content highly, which is logical given their different points in the transition process. The global satisfaction survey item “would recommend the SLC only with changes” received a mean of 1.70 on a scale where 1 equals strongly disagree and 5 equals strongly agree.

In Table 4, the most highly rated items for the 2011 residential SLC include the constructs of personal re-

Table 2

Characteristics of SLC Student Participants

	Beginner SLCs (N=67)	Advanced SLCs (N=16)
Dates	April – May, 2009 (weekly) July, 2010 (residential) August, 2010 (residential) July, 2011 (residential)	December, 2009 – March, 2010 (weekly) March, 2010 – June, 2010 (weekly)
Grade Level		
High School	93% (n=62)	n/a
Community College	7% (n=5)	n/a
Undergraduate	n/a	75% (n=12)
College Graduates*	n/a	25% (n=4)
Gender		
Male	78% (n=52)	87% (n=14)
Female	22% (n=15)	13% (n=2)
Primary Disability		
ASD	27% (n=18)	6% (n=1)
Blind/VI	19% (n=13)	6% (n=1)
ADD/ADHD	16% (n=11)	38% (n=6)
SDD/LD	11% (n=7)	19% (n=3)
Deaf/HoH	12% (n=8)	6% (n=1)
Multiple	4% (n=3)	0% (n=0)
Health	11% (n=7)	19% (n=3)
Grade Point Average		
2009 - 2010	2.95	2.96778
2010 - 2011	3.006211	3.1225

* Includes two graduate students

Table 3

*Highest Rated Results from 2009 - 2010 SLCs**

Beginner SLCs (N=41)	Advanced SLCs (N=16)
1. Learning about academic assistance available on campus (4.73)	1. Enjoyed participating in the SLC (4.60)
2. Discussing with other students with disabilities interested in STEM (4.67)	2. Met others who share interests/concerns (4.50)
3. Understanding accessing Disability Services as support (4.64)	3. Self-Advocacy Plans and accommodations (4.42)
4. Understanding accessing OSAA as support (4.64)	4. Time management content (4.36)
5. Discussing with other OSAA students (4.55)	5. Mentoring content (4.33)
6. Learning about specific services related to fields of study (4.55)	6. As a result of the SLC, considering taking more STEM courses (4.30)
7. Gaining college survival skills (4.47)	7. OSAA Ning site and tutorial (4.30)
8. Learning about college life (4.47)	8. Learned about people to contact with problems and issues (4.20)
9. Felt the learning community was a good experience (4.40)	9. Want to continue contacts made from the SLC (4.20)
10. Producing a meaningful Self-Advocacy Plan (4.30)	10. Resume, cover letter, and personal statement content (3.92)
11. Learning key factors for academic success (4.29)	11. SLC improved my ability to handle stress (3.90)
12. Learning about one's self (4.10)	12. Disability disclosure (3.83)

*Mean results reported. Likert Scale 1 to 5 rating was used with 5 being the highest (1 equals strongly disagree and 5 equals strongly agree).

sponsibility and self-advocacy. Students also reported a high level of confidence with transition to college because of the SLC experience. Once again, self-advocacy seems to be a key skill area in which students reported they obtained knowledge through the SLC process, thus supporting the 2009-2010 survey findings. The global satisfaction item “how satisfied are you with Diverse Ability University?” received a mean of 4.20 on a scale where 1 equals very dissatisfied and 5 equals very satisfied. Most participants (84%) reported that they would recommend this SLC experience to a friend.

Open-Ended Responses. The qualitative data seem to support the quantitative findings. One Beginner SLC student commented, “Under the right environment, you can begin to feel comfortable talking about your disability, and that is what the SLC did.” Several Beginner participants commented that the “assignments made them think,” and “people were comfortable with discussing disability.” Other comments such as “persuade people to sign up,” “important to anyone with a disability,” and “mature environment aids in character development” provide evidence that Beginner students valued their SLC experience.

Likewise, Advanced SLC participants reported finding the SLC experience meaningful. Several Advanced participants indicated that the SLC process taught them to be more comfortable discussing and disclosing their disability. When asked, “What is the first thing about the Learning Community that stands out?” one Advanced respondent said, “How to let others know about your disability.” Another student commented that it is important to learn when not to disclose your disability as well. Additionally, several Advanced students commented positively about the resume content emphasis, with one student saying they appreciated “the focus on improving resumes.” Other participants in the Advanced SLC commented more generally on the experience, with one student simply saying, “It was what I was looking for and was helpful.”

Themes. When examining the quantitative and qualitative SLC data, certain themes emerged. High student ratings on survey items (see Tables 3 and 4) as well as grouping student responses into categories based on shared topics and perceptions revealed similarities in what students reported that they learned. Generally speaking, across SLCs, students reported that they found developing a customized Self-Advocacy Plan and/or Transition Portfolio to be most help-

ful in their career development. They also reported valuing the opportunity to socially network with other students with disabilities interested in STEM careers. Students also indicated that the training they received in disability self-awareness, the disability disclosure and accommodations process, and adaptive technologies increased their self-advocacy skills and ability to function independently.

Some of the constructive criticism Beginner SLC participants offered includes feedback on the length of sessions, stating that they were too long (or in some cases, not long enough). Students also offered recommendations for more group activities and interactions. They also recommended a greater emphasis on assistive technology. Several participants in the Advanced SLCs stated that they wanted more assistance with resume building. Additionally, one student recommended a class session on “making academic schedules for ourselves and a daily study plan that includes what my ideal work environment is and how I study best. Also follow up with us on our goals we made.” In sum, students collectively recommended session length and content emphasis changes. These changes are currently being applied in order to enhance the SLC experience for all participants.

Discussion

The evaluation results suggest that facilitating SLCs is a promising practice to support the recruitment and retention of qualified students with disabilities into STEM degree programs. High school and community college participants consistently rated the Beginner SLC as a good experience where they produced meaningful self-advocacy plans, became more self-aware of their learning and personality styles, and gained insights into STEM fields of interest. College and graduate students with disabilities who are majoring in STEM reported that, during the Advanced SLC, they produced meaningful self-advocacy plans, learned time management skills, and learned about the importance of internships. They also reported that learning about disclosure of disability and the accommodations process through the SLCs was extremely helpful. Other comments included that learning more about their personality was useful in school and work. The majority of students in the first Advanced SLC commented that developing resumes and interview skills and learning about internships was essential.

Table 4

*Highest Rated Results from 2011 Residential SLC****Learning Community Common Core Construct (N=26)**

1. Personal responsibility (3.79)
2. Self-advocacy (3.67)
3. Time management ability (3.63)
4. Engagement (3.63)
5. Persistence in STEM (3.61)
6. Self-determination (3.54)
7. Awareness of learning opportunities and strategies (3.47)

Diverse Ability University Specific Construct (N=26)

1. Confidence with transition to college (3.68)
2. Description of personality types and learning styles (3.64)
3. Relationship building with counselor and other participants (3.61)
4. Confidence with hands-on science (3.37)

*Mean results reported. Likert Scale 1 to 4 rating was used with 1 being not at all and 4 being a lot. Participants were asked to what extent they increased in the above mentioned areas as a result of participating in Diverse Ability University.

Time spent on this portion of the Advanced SLC was increased with a mock job interview activity added to the SLC syllabus. Additionally, students in both the Beginner and Advanced SLCs reported that discussions with other students who are enrolled in STEM programs were most helpful.

Self-Advocacy

As discussed earlier, both high school and college students reported that one of the most valuable activities completed as part of the SLC process was developing a Self-Advocacy Plan. The Self-Advocacy Plan that SLC participants developed includes numerous activities that support a larger framework of student self-determination. Given that self-advocacy

is repeatedly cited as a critical college survival skill (Grigal & Hart, 2010; Kochhar-Bryant, Bassett, & Webb, 2009), the process used to assist students with increasing their self-advocacy knowledge and comfort level is discussed in detail here. Students begin their self-advocacy plan by completing a minimum of three learning style and personality assessments (see Table 1). Students described their learning and personality styles and discussed the relationship between learning and teaching methods. Students become more aware of how they learned and how they could create study strategies to help them learn challenging content. For example, creating small group study sessions, working with a tutor, or outlining texts and readings using software applications may assist students with learning

challenging STEM content. Then students compared and contrasted three careers they were interested in pursuing. They developed a career narrative describing their first career choice, using information gained from career research and assessments. Students described their talents, strengths, and abilities and summarized their long-term goals for entering STEM majors and careers. Finally, they broke their long-term goals down into smaller goals that could be accomplished within a few weeks.

The next section of their Self-Advocacy Plan included a description of their disability and how the disability affected their ability to complete assignments, tests, and papers. This section provided an opportunity for students to describe specific accommodations and study strategies that they needed to be successful in classes. Meetings with disability counselors and academic advisors were facilitated to provide opportunities for students to learn how accommodations are negotiated at a particular postsecondary institution. These meetings allowed students to practice how to negotiate accommodations with faculty or employers.

The final section of the Self-Advocacy Plan asked students to identify their responsibilities as self-advocates. Students identified how often they would meet with their disability counselor and instructors and what actions they would take to manage their own learning. For example, will they ask questions in class, audiotape lectures, use a note-taker or study buddy, request extended time for tests, or meet with instructors?

Both high school and college students reported that the development of their Self-Advocacy Plans was an important feature of our SLC model. Since nearly 56% of college students with disabilities do not disclose that they have a disability and go without formal accommodations (Newman et al., 2010), the need to assist students with their ability to advocate for themselves is evident. It seems that more students with disabilities could be successful in college if they had the self-advocacy skills needed to master rigorous STEM content. Once students have the skills to explain their disabilities, identify accommodations that are likely to mitigate their functional limitations, negotiate their accommodations assertively, and assist in the coordination of those accommodations, they are more likely to gain the quality education and training they deserve (Izzo, Hertzfeld, Simmons-Reed, & Aaron, 2001).

Recruiting and Retaining STEM Students with Disabilities

Recruitment. Initial recruitment of Beginner SLC students has been challenging because each high school has a small population of students with disabilities interested in STEM. So far, the recruitment strategies we have found helpful include a broad sweep of formal and informal education and rehabilitation networks. Successful recruitment strategies include the following: mailing or emailing SLC fliers with application packets to special educators, transition specialists, and science and math teachers; targeted meetings with special educators, transition coordinators and rehabilitation networks; presenting at transition fairs at area high schools or colleges; and presenting at conferences and local, regional, or state transition council meetings. At the college level, based on our experience, recruitment of students for Advanced SLCs has been somewhat less challenging because of existing collaborations among campus units. Successful recruitment strategies for Advanced SLCs include expanding cooperative efforts with disability services and student affairs offices as well as STEM faculty across two- and four-year institutions. However, recruitment at the college level can prove difficult if collaborative working relationships among units are not established. Also, accessing the campus population of students with documented disabilities who do not register with or use disability services is an ongoing challenge because these students are difficult to identify.

In short, getting the word out early through multiple, strategic venues is instrumental to project success. We anticipate that, as our programs continue to deliver the SLC model, the challenging recruitment efforts will become somewhat easier. Schools will begin to recognize the benefits of referring students to the SLC because they see the benefits to the student, such as increased self-advocacy and transition skills as well as an established, expanding network of peers. Once this kind of program notoriety is obtained, we assert that schools will participate in an ongoing basis as well as spread the word to other schools.

Retention. Based on our SLC population, students with disabilities frequently have high academic abilities but need individualized intervention services in other key content or social areas—services that can be difficult to provide in inclusive classrooms. For example, our Beginner SLC students had an average GPA of 2.95 in 2009-10, the first year we began to

track GPA of our participants. In 2010-11, the average GPA increased to 3.01. Advanced students increased their GPA from 2.97 in 2009-10 to 3.1 in 2010-11. These academically successful students can ultimately benefit from the SLC experience by gaining a social and professional network that reinforces interest and achievement in STEM pursuits. This kind of network is critical for student engagement in STEM and can lead to increased numbers of students with disabilities entering and completing STEM degrees and joining the STEM workforce. Of the 21 high school students who participated in the first two Beginner SLCs in 2009 and 2010, 76% were actively involved in our STEM program interventions such as mentoring and SLC alumni participation. Of the 10 high school students who have graduated, six have gone on to enrollment in STEM majors as of Spring 2011. Furthermore, of the 21 undergraduate students who participated in the two Advanced SLCs in 2009-10, 100% have remained actively involved in STEM program interventions. Of the four college graduates who were Advanced SLC participants, two went on to competitive employment while the other two were applying to STEM graduate programs as of Spring 2011.

Study Limitations

These SLC programs and their corresponding measures were iterative. They have emerged as part of an ongoing cycle of program development. We were not able to conduct a rigorous research study because of resource and personnel limitations in the first few years of the project. That is, we were focusing our resources on program development and formative assessments, rather than formal evaluations that use rigorous research methodologies. Students provided input on the SLC process through non-equivalent self-report measures, partly due to the unique format of each SLC requiring different types of questions. Other than conducting content validity reviews and calculating Cronbach's alpha coefficients, psychometric steps to validate the instruments were not applied, again due to personnel limitations. It is recommended that future studies employ more rigorous research methodologies to determine the effects of SLCs on academic performance, persistence in STEM, and successful transition to STEM careers. Also, a greater sample size is needed to validate our measures and conclusions. In spite of our current study limitations, the primary purpose of our SLC model was to deliver an intervention that

would enhance the recruitment and retention of students with disabilities interested in STEM. Through the interventions and supports they provide, our findings suggest that our SLC model is, at the very least, a promising practice in this area.

References

- Alston, R. J. Bell, T. J., and Hampton, J. L. (2002). Learning disability and career entry into the sciences: A critical analysis of attitudinal factors. *Journal of Career Development*, 28(4) 263-275.
- Baer, R. M., Flexer, R. W., Beck, S., Amstutz, N., Hoffman, L., Brothers, J.,....Zechman, C. (2003). A collaborative follow-up study on transition service utilization and post-school outcomes, *Career Development for Exceptional Individuals*, 26, 7-25.
- Benitez, D. T., Lattimore, J., & Wehmeyer, M. L. (2005). Promoting the involvement of students with emotional and behavioral disorders in career and vocational planning and decision-making: The self-determined career development model. *Behavioral Disorders*, 30, 431-447.
- Brinckerhoff, L., McGuire, J., & Shaw, S. (2002). *Postsecondary education and transition for students with learning disabilities* (2nd ed.). Austin, TX: Pro-Ed.
- Bruyere, S. M. (2000) Civil Rights and Employment Issues of Disability Policy. *Journal of Disability Policy Studies*, 11(1) 18-28.
- Burgstahler, S. (2003). Do-IT: Helping students with disabilities transition to college and careers. *National Center on Secondary Education and Transition*, 2(3).
- Burgstahler, S., Crawford, L., & Acosta, J. (2001). Transition from two-year to four-year institutions for students with disabilities. *Disability Studies Quarterly*, 21(1).
- Field, S., Martin, J., Miller, R., Ward, M., & Wehmeyer, M. (1998). *A practical guide for teaching self-determination*. Reston, VA: Council for Exceptional Children.
- Golshani, F. (2005). Putting Ability to Work. *IEEE Multimedia*, 12(3), 1.
- Grigal, M. & Hart, D. (2010). Think College: postsecondary education options for students with intellectual disabilities. Baltimore, MD: Paul H. Brookes Publishing Co.

- Halpern, A. S., Yovanoff, P., Doren, B. & Benz, M. R. (1995). Predicting participation in postsecondary education for school leavers with disabilities. *Exceptional Children*, 62, 151-164.
- Izzo, M. V., Hertzfeld, J. E., Simmons-Reed, E., & Aaron, J. A. (2001). Promising practices: Improving the quality of higher education for students with disabilities. *Disability Studies Quarterly*, 21.
- Izzo, M. V., & Lamb, M. (2002). *Self-determination and career development: Skills for successful transitions to postsecondary education and employment*. (White Paper). Retrieved March 23, 2011, from http://www.ncset.hawaii.edu/publications/pdf/self_determination.pdf.
- Izzo, M. V., Yurick, A., Nagaraja, H. N., & Novak, J. A. (2010). Effects of a 21st-Century curriculum on students' information technology and transition skills. *Career Development for Exceptional Individuals*, 33(2), 95-105.
- Kochhar-Bryant, C., Bassett, D. S., & Webb, K. W. (2009). *Transition to postsecondary education for students with disabilities*. Thousand Oaks, CA: Corwin Press.
- May, A. L., and Stone, C. A. (2010). Stereotypes of individuals with learning disabilities: Views of college students with and without learning disabilities. *Journal of Learning Disabilities*, 43(6) 483-499.
- Newman, L., Wagner, M., Cameto, R., Knokey, A. M., & Shaver, D. (2010). *Comparisons across time of the outcomes of youth with disabilities up to 4 years after high school. A report of findings from the National Longitudinal Transition Study-2 (NLTS2)*. Menlo Park, CA: SRI International. Retrieved March 17, 2011, from www.nlts2.org/reports/2010_09/nlts2_report_2010_09_complete.pdf.
- Repetto, J. B., Webb, K. W., Garvan, C. W., & Washington, T. (2002). Connecting student outcomes with transition practices in Florida. *Career Development for Exceptional Individuals*, 25, 123-139.
- Rumrill, P. (2001). Contemporary issues in postsecondary education for students with disabilities: Roles and responsibilities for educators and rehabilitation professionals. *Journal of Vocational Rehabilitation*, 16, 133-144.
- Sevo, R. (2011). *Basics about disabilities and science and engineering education*. Under the direction of Robert L. Todd, Center for Assistive Technology and Environmental Access, Georgia Institute of Technology, Atlanta, GA. Retrieved March 12, 2011, from <http://stores.lulu.com/sevo>.
- Swaner, L. E., & Brownell, J. E. (2008). *Outcomes of high impact practices for underserved students: A review of the literature*. Washington, DC: Association of American Colleges and Universities. Retrieved March 17, 2011, from www.aacu.org/inclusive_excellence/Research.cfm.
- Thoma, C. A., & Wehmeyer, M. L. (2005). Self-determination and the transition to postsecondary education. In E. E. Getzel & P. Wehman (Eds.), *Going to college*, pp. 49-68. Baltimore: Paul H. Brookes.
- U.S. Government Accountability Office. (2003). *College completion: Additional efforts could help education with its completion goals* (GAO-03-568). Washington DC: U.S. Government Printing Office.
- Wehmeyer, M. L. (2003). Self-determination, vocational rehabilitation, and workplace supports. *Journal of Vocational Rehabilitation*, 19, 67-69.
- Wehmeyer, M. L., & Palmer, S. B. (2003). Adult outcomes for students with cognitive disabilities three-years after high school: The impact of self-determination. *Education and Training in Developmental Disabilities*, 38, 131-144.
- Wehmeyer, M. L., & Schwartz, M. (1997). Self-determination and positive adult outcomes: A follow-up study of youth with mental retardation or learning disabilities. *Exceptional Children*, 63, 245-255.
- Zhao, C. M., & Kuh, G. D. (2004). Adding value: learning communities and student engagement. *Research in Higher Education*, 45(2), 115-138.

About the Authors

Margaretha Vreeburg Izzo received her BA degree in psychology and special education from D'Youville College, her MA in vocational special education from George Washington University, and her PhD in special education from The Ohio State University. She is currently a professor in psychiatry at The Ohio State University and serves as associate director of the OSU Nisonger Center as well as program director of the Special Education and Transition Services division at the OSU Nisonger Center. Dr. Izzo has over 30 years experience in the field of special education research. Her primary research interests include transition, self-determination, and vocational rehabilitation for young adults with disabilities. She can be reached by email at Margo.Izzo@osumc.edu.

Alexa Murray received a BA degree in psychology from The University of Mississippi, a MGS (master in gerontological studies) degree from Miami University of Ohio, and a MA in clinical mental health counseling from The Ohio State University. She is currently a program manager in the Special Education and Transition Services division at The Ohio State University Nisonger Center. She has over 10 years experience in special and general education research. She can be reached by email at Alexa.Murray@osumc.edu.

Bianca McArrell received her BA in psychology from The Ohio State University. Her experiences include working as a research coordinator for the Special Education and Transition Services division at The Ohio State University Nisonger Center, where she has also served as a program manager and ability advisor for the Ohio STEM Ability Alliance. She currently works as a program manager in research education at The Ohio State University College of Medicine. Her research interests include etiology and locus of control in relation to self-efficacy. She can be reached by email at Bianca.Mcarrell@osumc.edu.

Sarah Priest received her BA degree in psychology from The Ohio State University and her MA in teaching from Oregon State University. Her professional experiences include serving in the Young Adult Transition Corps, an AmeriCorps program assisting youth with disabilities with transition from school to adult life. She has also taught at the elementary school level. She is currently a program coordinator for the Ohio STEM Ability Alliance project at The Ohio State University Nisonger Center. She can be reached by email at Sarah.Priest@osumc.edu.

Authors' Note

This research was supported by National Science Foundation Grant GRT00012452 awarded to The Ohio State University Nisonger Center. This research was also supported by Ohio Rehabilitation Services Commission and Ohio Board of Regents Grant GRT00020848 awarded to The Ohio State University Nisonger Center. In addition, NSF Grant HRD-0929006 facilitated the publication of this article.

Asynchronous Online Access as an Accommodation on Students with Learning Disabilities and/or Attention-Deficit Hyperactivity Disorders in Postsecondary STEM Courses

Laura Graves

Paul A. Asunda

Stacey J. Plant

Chester Goad

Tennessee Technological University

Abstract

The purpose of this study was to investigate whether asynchronous online access of course recordings was beneficial to students with learning disabilities (LD) and/or Attention Deficit/Hyperactivity Disorder (ADHD) enrolled in science, technology, engineering, and mathematics (STEM) courses. Data were collected through semi-structured interviews lasting 40 minutes. A total of 11 student participants with LD and/or ADHD were interviewed. Student participants were enrolled in math, biology, and chemistry courses that utilized asynchronous online access of digital recordings. Interview data were individually analyzed and compared through a cross-case analysis. Students reported that the use of asynchronous online access enhanced their learning experiences according to six themes: clarity, organization, asynchronous access, convenience, achievement, and disability coping mechanism.

Keywords: STEM, access, disabilities, universal design, web-based

Graduating with a degree from a postsecondary institution has become an achievable goal for many students. However, for some students, especially those with learning disabilities (LD), the manner in which coursework is presented becomes a gatekeeper to reasonable access (Burgstahler, 2008). The Individuals with Disabilities Education Improvement Act of 2004 (IDEIA, Pub. L. No. 108-446) defines LDs as a variety of processing disorders. In the same vein, the National Joint Committee on Learning Disabilities (1991) defines LD as “a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, writing, reasoning or mathematical abilities” (p. 20). Specific LD may include dyslexia, dyscalculia (mathematical reasoning disorder), and dysgraphia (writing processing disorder) (Gregg, 2009).

According to Kirk, Gallagher, Coleman, and Anastasiow (2009), “Attention-deficit hyperactivity disorders [ADHD] can be considered a specific form of learning disability related to an individual’s inability

to attend to or focus on a given task” (p. 115). ADHD is a neurobiological disorder, which affects adults as well as children and is generally characterized by a lack of attention, impulsivity and in some cases hyperactivity (Children and Adults with Attention-Deficit/Hyperactivity Disorder, 2010). Symptoms related to the diagnosis of ADHD must persist at least over a six month period, occur before the age of seven, and must transpire over at least two different environments (American Psychiatric Association, 2000). While ADHD is not a specific LD, individuals with ADHD are likely to experience academic difficulty that may result in school failure. Co-morbidity of ADHD and LD is elevated when attention and academic failure are combined (Al Otaiba & Fuchs, 2006; Pennington, 2004).

Gardner (1983) observed that students with LD and/or ADHD often are asked to focus in ways that oppose their learning strengths, for example, focusing on auditory processing tasks when their strength lies in mnemonic representations. In such instances, the students’ executive function becomes limited when

processing weaknesses are the focus of classroom instruction. Such occurrences tend to force these groups of students to take notes rapidly, which may interfere with their ability to focus on listening.

The Americans with Disabilities Act of 1990 (ADA, Pub. L. No. 101-336) ensures that otherwise-qualified students with disabilities receive equal access to postsecondary education. As explained by Gordon, Lewandowsky, Murphy, and Dempsey (2002), “The goal of the ADA, unlike the Individuals with Disabilities Education Act (IDEA) is to provide equal access to programs, services, and facilities, not to ensure entitlement to academic success” (p. 361). Although academic success is not guaranteed to any college student, a lack of supports may be considered a form of exclusion for some students with disabilities since without needed supports they may not have the same access to a postsecondary education as their non-disabled peers (Gregg, 2009). In light of this view, students with LD and/or ADHD may require formal accommodations to enable them to achieve equal access to learning in college courses (Brown, 2006; Mapou, 2009). Burgstahler (2008) defined the term *accommodation* as a “means offering an adjustment or modification to make a product or environment accessible to an individual with a disability” (p. 11). Such formal accommodations may include a variety of instructional and assessment strategies such as repeated modeling of procedures, numerous short breaks during instruction, seating to minimize distractions, flexible scheduling, extra time for assignments and tests, use of instructional techniques that address a variety of sensory modalities, and access to technology. Technology accommodations may include audio textbooks, digital recording of lectures, note takers, and access to copies of course overhead/PowerPoint presentations prior to class presentation (Gregg, 2009; Mapou, 2009).

In science and mathematics courses, additional accommodations might include calculators, computer-assisted instructional software, and large display screens (DO-IT, 2002-2007). Maccini, McNaughton, and Ruhl’s (1999) review of research revealed that students with LD can experience difficulties in acquiring and retaining algebraic reasoning, the foundation of most science, technology, engineering, and mathematics (STEM) disciplines. Trammell (2003) found that many students with LD and/or ADHD improved their grades with the support of a variety of accommodations including taping of class lectures and access to

textbooks on tape. Given that the types of accommodations and levels of support services available to students with LD and/or ADHD vary by institution, it was not surprising that Madaus (2006) found support services to be a factor in a student’s selection of a college. Madaus also found that students with LD who completed college had positive outcomes for post-graduation employment.

With increased scientific research, technological innovations, and the growth of the Internet, many educational experiences for all learners now include computers and other technological devices that may help students learn more efficiently (Domine, 2009). According to Mapou (2009), “Assistive technology and widely available computer software can be very helpful for adults with reading disabilities, written-language disabilities, or ADHD. Universal design using computer software in postsecondary education settings can reduce the need for formal accommodations” (p. 169). Provision of technology by itself may not be sufficient to meet learners’ needs. Postsecondary students with LD and/or ADHD have been found to benefit from individualized instruction in the strategic use of increasingly ubiquitous technology learning tools. Parker, White, Collins, Banerjee, and McGuire (2009) asserted that students should attain a level of proficiency with technology “used by the institution and faculty to deliver coursework and communicate with students to succeed in today’s postsecondary environments” (p. 133).

The ubiquitous nature of the Internet may provide continuous access to lecture content developed and digitally archived through computers applications. Today, the Tablet PC using innovative digital pen technology provides a tool that educators can use in designing learning environments that may engage most learners. The Tablet PC is a portable computer with a rotating screen locking on top of the keyboard, transforming the notebook computer into a notepad for handwriting directly on the screen. The active digitizer and digital “ink” emulate natural handwriting with options for pen, felt-tip marker, or highlighting representations. While traditional blackboards and whiteboards provide limited access to the critical content displayed, the on-board video recording of a digital whiteboard from the Tablet PC provides a flexible solution for continued access to content establishing better reinforcement for long-term learning strategies. For example, the live annotations on the digital whiteboard can be video

screen captured with a synchronous audio recording of the instructor's lecture.

Two specific software applications of Tablet PC technology were employed throughout this research: Elluminate Live! (Blackboard Collaborate, 2011) and Camtasia Relay (Tech Smith Corporation (1995-2010)). These applications were not the focus of the research but tools of implementation that provided recording, playback, and web publishing capabilities. Steinweg, Williams, and Stapleton (2010) found in initial reports that the use of Tablet PCs in postsecondary education has a positive impact on students with a variety of disabilities. Instructors in the STEM disciplines used the Tablet PCs as the tool for recording and archiving course content for student asynchronous online continual access with the goal of aiding efficiency of learning.

Designing an inclusive environment using digital pen-technology and asynchronous online access for diverse populations uses universal design (UD) as its foundation. Nichols and Quaye (2009) stated, "The theory of universal design strives to create optimal conditions for accommodating the changing needs of multiple constituents" (p. 51). "With UD, the consumer is not expected to adjust to the limitations of an inflexible product or environment; rather, the application adjusts to the needs and preferences of any user" (Burgstahler, 2008, p. 7). Universal design can be considered both a process and a goal. As a process, UD is product driven and provides students with options to access a variety of environments. In the present study the product is asynchronous online access, which allows individual students to choose when and how much access is needed. Enhanced instructional access by students with a variety of learning needs is the desired outcome of UD. Burgstahler (2008) noted that applying UD principles results in products and learning environments that are welcoming and useful to groups that are diverse in many dimensions, including gender, race and ethnicity, age, socio-economic status, ability, disability, and learning styles.

The Center for Applied Special Technology (CAST) [n.d.] suggests faculty consider the *what, how and why* of learning through multiple means of representation, expression, and engagement when creating curriculum. According to Rose, Harbour, Johnston, Daley, and Abardanel (2008), accessible pedagogy is the cornerstone of Universal Design for Learning. Postsecondary faculty who use digital pen-technology and recordings, which can be archived and accessed

later via a web-based location, may increase all students' accessibility to course content in a manner that promotes asynchronous learning. By providing all students with asynchronous usability, or the ability to download lectures, instructor notes, and other vital course components outside of regular class meetings, instructors who offer online archived medium may be providing students the opportunity to study at times more conducive to their individual learning needs. In some cases, this type of access could eliminate the need to disclose a disability or register with an Office of Disability Services altogether. Such an outcome could effectively allow some students to avoid the "documentation disconnect" identified by the National Joint Committee on Learning Disabilities (2007) that often impedes or prolongs the process necessary to receive even basic accommodations such as note-taking and permission to record lectures.

Universal design meets the needs of the community of learners while focusing on access for many individual learners. Rose et al. (2008) stated that Universal Design for Learning is developed to be flexible and "anticipates the need for alternatives, options, and adaptations to meet the challenge of diversity" (p. 46). In light of this observation, Winick and Gomez (2008) stated that Universal Design for Learning also allowed many students with LD to "disappear" into the general population becoming invisible or unidentifiable as compared to their non-disabled peers. McGuire and Scott (2006) suggested that, as the paradigm of UD continues to develop and as faculty become more attuned to the needs of individual students, certain accommodations could be requested less frequently. Providing asynchronous online access may provide students with LD and/or ADHD an alternative learning environment that engages various modalities meeting the goal of UD. It must be noted that the application of UD will not be fully usable or accessible for all learners (Burgstahler, 2008). However, the goal of providing educational access to diverse groups of learners at the postsecondary level should be considered for individual, group, and environmental appropriateness (Rose et al., 2008).

One approach to providing educational access at the postsecondary level is through asynchronous web-access. Asynchronous web-accessed instruction integrates traditional accommodations provided in postsecondary settings for students with LD with an emerging technology being implemented on college

campuses for the general student population. Asynchronous web-accessed instruction provides students with and without disabilities access to video recordings of computer screen activity including annotated digital whiteboard, PowerPoint slide content, and synchronous audio of lectures presented by the instructor. The recordings are formatted so that they can be accessed from any Internet-connected computer following the class session and can be paused, rewound, and fast-forwarded to locate particular class segments. While traditional accommodations of note takers and audio recorders may identify students with LD or other disabilities, asynchronous online access of digital recordings does not. In this way, video recorded pen-enabled tablet computing can replace traditional accommodations with an integrated audio/video screen recording made available to all students outside a classroom, thus protecting the anonymity of students with non-apparent disabilities such as LD and ADHD. The researchers recognize that audio recorders and the provision of note takers have been supported by access legislation for many years. Although the current research does not explore anonymity issues, the use of asynchronous online course access may potentially enhance a student's anonymity within the educational setting.

Purpose

The purpose of this study was to investigate if asynchronous online access of STEM course content is an effective accommodation for students with LD and/or ADHD in postsecondary STEM courses. This study was part of a larger study funded by the National Science Foundation, called the "Effects of Teaching with Tablet PCs with Asynchronous Student Access in Postsecondary STEM Courses on Students with Disabilities" (NSF RE FRI Award #0726449). For the purpose of this study, LD included any cognitive disorder such as dysgraphia, dyscalculia, or dyslexia as labeled by the state of Tennessee. Students with ADHD were also included in the study due to an elevated risk of academic failure at the postsecondary level.

Simultaneous audio/video computer screen recording is of particular significance in STEM classes. Much of STEM instruction consists of drawing diagrams, solving mathematical equations, or balancing chemical equations. Instructors typically write or draw images on a traditional white board while orally describing the solution or interaction (Stage & Kinzie, 2009). Students can struggle to copy what is on the

board while hoping to remember what the instructor said. Due to the pace of instruction and detailed nature of the content, STEM students may make errors in note taking, forget explanations, and leave the lecture with incomplete and/or inaccurate notes. These problems can be magnified for students with LD and/or ADHD whose information processing is less focused or slowed; who may have difficulty discriminating between symbols, signs and numbers; and who may be easily distracted. In a class using asynchronous online access of digital recordings, all students including those with LD and/or ADHD can focus on the lecture/discussion without the burden of taking notes, can access the recordings in locations with minimal distractions, have a complete and accurate record of what was said and demonstrated, and can utilize the recordings to meet their individual ways of learning.

Instructors in the STEM disciplines participating in the study were trained by two special education professors and two technology specialists in the use of Tablet PCs as their instructional white board, the process of uploading course content for asynchronous online access, disability education, and pedagogical instructional practices related to meeting the needs of diverse populations within a postsecondary classroom. A total of 20 instructors were trained in the course of this study, which was implemented across three semesters. Training occurred at the beginning of the semester. Online guides and technology support were provided throughout the study to ensure fidelity of implementation. This study explored the following research question: what is the impact of asynchronous online access of recorded STEM course work as an intervention for students with LD and/or ADHD?

Method

The guiding research question lent itself to the use of qualitative methodology. Merriam and Simpson (1995) posited that a qualitative approach enables a researcher to study how people make sense of and interpret the meanings attached to their words and experiences. Qualitative interviewing methodology enables inquiry and understanding of a societal or human condition, experience, or problem, based on construction of a complex picture that is formed mentally and analyzed inductively (Creswell, 1994). Bogdan and Biklen (2003) explained that qualitative research engages a limited number of participants in

a deep systematic analysis of a phenomenon and is an appropriate research method when desired outcomes include description, interpretation, and a detailed understanding of the phenomenon. The three researchers used face-to-face interviews to better understand the challenges and successes that students with LD and/or ADHD experienced in asynchronous STEM learning environments.

The epistemology for this research was constructionism, the focus being the construction of meaning from the perspectives of students with LD and/or ADHD with regard to their study habits in STEM courses that had asynchronous access. Crotty (1998) stated that constructionism is the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world and developed and transmitted within an essentially social context. This study examined how participants constructed study habits and experiences within the context of asynchronous access of learning material. This inquiry was designed to be a collective case study with each participant being viewed as a unit of analysis. According to Stake (2000), a collective case study is an instrumental case study extended to several cases. An instrumental case study is the examination of a particular case to provide insight into an issue. The case study approach was selected for several reasons. Merriam (1998) and Bogdan and Biklen (1998) postulated that case study research seeks to understand specific issues and problems of practice through a detailed examination of a specific group of people, a particular organization, or a selected activity. To this end, 11 participants were investigated individually as cases and jointly examined to better understand their experiences and study habits in STEM courses that provided access to web-accessed recordings of class content.

Participant Selection

This study sought to identify whether students with LD and/or ADHD who were enrolled in math, biology, and chemistry courses benefited from asynchronous online access to course instruction and materials. Participants were enrolled in one of three different postsecondary institutions. Institutions A and B were two-year community colleges. Institution A served urban students in a large metropolitan area. Institution B served students in a rural area while Institution C was a four-year university located in a rural setting serving

students in a Micropolitan area. A micropolitan area consists of core counties with a population between 10,000 and 50,000 persons along with counties surrounding the core county that share a “high degree of social and economic integration with the central county as measured through commuting” (Office of Management and Budget, 2000, p. 82238). The study was limited to institutions within a radius of 100 miles from the researchers. In addition to driving the long distances to conduct interviews in participants’ natural settings, a challenge to the study was the frequency with which interview appointments were cancelled or the participants never showed up.

To participate in the study, participants had to meet the following criteria: (a) provided documentation of either an LD and/or ADHD to the Office of Disability Services, and (b) enrolled in a STEM course (math, biology, or chemistry) during the Spring 2008 to Spring 2009 semesters. Students had to have a current diagnosis of an LD and/or ADHD. There are many students at the postsecondary level that have not self-disclosed or may have never been identified as having an LD or ADHD. Nichols and Quaye (as cited in Harper and Quaye, 2009) state, “Statistics on students with disabilities are subject to fluctuation. If students do not disclose their disability, it prevents postsecondary institutions from accessing information about them that may be useful in providing them accommodations and services” (p. 40). During advisement, the Office of Disability Services reviewed student files to determine which students met the criteria to participate in the study. Students were then contacted by the Office of Disability Services. Fourteen students agreed to participate during Spring 2008 to Spring 2009 and signed informed consent. Of the 14 students, 11 agreed to be interviewed at the end of their participation semester. Three of the 14 did not respond to requests to be interviewed. Eleven of the interviewed students were White and one student was African American.

Data Collection

Data collection consisted of face-to-face interviews with each participant and lasted up to 40 minutes. A semi-structured interview with open-ended questions was constructed to aid in data collection. Berg (2001) stated that semi-structured interview guides allowed the interviewer to probe far beyond answers that might be generated by pre-prepared standardized questions. Likewise, Patton (2002) posited that open-ended in-

Table 1

Demographics of Student Participants

<u>Participant #</u>	<u>Institution</u>	<u>Gender/Race</u>	<u>Course Enrolled</u>	<u>Documented Disability</u>
1	Urban CC*	F/Black	BIOL 2020	LD
2	Rural CC*	M/White	BIOL 1120	ADHD
3	Rural U*	M/White	CHEM 1120 BIOL 1120 MATH 1910	LD
4	Rural U	M/White	MATH 1910	LD
5	Rural U	F/White	MATH 1530	ADHD
6	Rural U	M/White	MATH 1130	LD
7	Rural U	F/White	BIOL 1010	ADHD
8	Rural U	M/White	MATH1130 BIOL 1010	LD/ADHD
9	Rural U	M/White	MATH 2110	ADHD
10	Rural U	M/White	CHEM 1110	LD
11	Rural U	M/White	CHEM 1110	LD/ADHD

*Urban CC: Urban Community College; Rural CC: Rural Community College; Rural U: Rural University

interview questions enabled researchers to understand and capture participant's views.

During the interviews, the lead researcher asked the participants about the courses they were enrolled in that allowed access to web recordings, how often they accessed the asynchronous online recordings, whether recordings increased or decreased the time they spent reviewing course materials, whether access of web recording impacted their learning in the course, how web-accessed recording changed their attitudes toward STEM courses in college, and in the future, if they would choose a class that allowed asynchronous online access to recordings as opposed to one that did not. All interviews were audio recorded and transcribed verbatim.

Data Analysis

One of the researcher's challenges is to obtain and verify the true meaning of each participant's responses to the questions asked (Gall, Gall, & Borg, 2003). To begin making meaning of collected data, the 11 interviews were analyzed separately as described by Miles and Huberman (1994) during data reduction, data display, conclusion drawing, and verification phases. The data analysis process helped the researchers approach the data without preconceptions about participants' experiences as well as build a general explanation of study habits of each of the individual cases even though the cases varied in their details. During this process the researchers reflected on the purpose of the study and the guiding research questions as they noted phrases and

words that revealed each participant's experiences.

The researchers then identified text segments that contained the same meaning and sought to derive *in vivo* codes from transcripts by identifying repetitive, descriptive, and interpretive phrases of participants' experiences, which were then developed into categories such as clarity and convenience. Boeije (2009) stated that *in vivo* codes are not just catchy words; rather, they pinpoint the meaning of a certain experience or event. The *in vivo* codes (i.e., clear, studying strategies/mechanism, accessibility, good layout, ease of access, better organized, convenience, improved test scores, and confidence) identified in this study produced nine initial categories. Participants' explanations and ideas that had similar meanings were collapsed into the appropriate category. Afterward the researchers wrote memos to themselves describing identified categories to further reduce the data. This process produced a list of all expressions relevant to participants' perspectives, grouped into categories with accompanying text segments that were examples of those categories. Additional text segments identified by the researchers were then added to the relevant category.

After data reduction, the researchers proceeded to use Microsoft Word to display and organize data for case analysis and cross-case analysis. Miles and Huberman (1994) defined cross-case analysis as searching for patterns, similarities, and differences across cases with similar variables and similar outcome measures. Data and similar interactions (e.g., terms like "convenience" "ease of access") in which study participants used related terms to express their experiences were further grouped together into identified categories. The researchers then embarked on developing themes by grouping identified categories that had similar meaning into core themes. For example, "good layout" and "better organized" were collapsed to form the core theme, organization. As the researchers continued sorting the data and identifying relevant core themes, they reviewed the purpose of the study to stay on course.

Researchers seek to incorporate the language and principles of qualitative analysis practices to comprehend a phenomenon of interest in whatever setting they are studying (Patton, 2002). In this study, the researchers sought to reconcile their differing perspectives of data analysis findings and verification phases through triangulation and journaling as suggested by Patton (2002). Miles and Huberman (1994) stated that verification, which is in tandem with conclusion drawing, entails revisiting the data as many times as necessary

to cross-check or verify the emergent conclusions. To this end, the researchers reviewed the initial nine categories searching for left-out subtopics, including contradictory points of view and new insights, refining the categories at four different times. During this process we emailed each other the Microsoft Word tables with probable themes representing collapsed categories. From these exchanges, we reduced the nine categories to six core themes: comprehension, organization, asynchronous access, convenience, achievement, and coping mechanisms.

The researchers then embarked on establishing reliability of agreed themes by collaborating with three colleagues involved in qualitative work at their respective institutions (Mays & Pope, 1995). Mays and Pope use the term "reliability" and claim that it is a significant criterion for assessing the value of a piece of qualitative research. To establish the inter-rater reliability of the six core themes, the researchers shared analyzed data with three colleagues through email correspondence over a month. Upon receipt of ratings from colleagues, the researchers calculated the percent agreement and coefficient alpha for each theme as suggested by Banerjee, Capozzoli, McSweeney, and Sinha (1999). Percent agreement reflects the number of times all three raters agreed upon an identified theme as present or absent divided by the total number of their agreements and disagreements, multiplied by 100. Since three raters analyzed the transcripts, the percents agreement expected by chance was 25%. Therefore, agreement greater than 25% supported consistency among the raters. Percent agreements for each theme were: comprehension = 85%, organization = 76%, asynchronous access = 100%, achievement = 87%, convenience = 62%, coping mechanism = 90%. Next, we calculated the coefficient alphas using the three colleagues as items to evaluate the degree of rater consistency. The coefficient alphas for identified themes were as follows: comprehension = 0.89, organization = 0.81, asynchronous access = 1.00, achievement = 0.93, convenience = 0.67, coping mechanism = 0.96. The strong degree of inter-rater reliability, with the exception of convenience, indicated high levels of agreement in how the researchers and raters understood coded comments and the thematic categories into which they were grouped. The raters suggested that we change the name of the core theme "coping mechanisms" to "disability coping mechanism" and "comprehension" to "clarity." These changes were made.

Results

Participant responses collected and analyzed during the study led the researchers to categorize data according to the commonalities and themes that emerged with no observed priority or order. Verbatim quotes from participants are used throughout this section to emphasize core themes. Analysis of student interviews resulted in the emergence of six ways that asynchronous online access to lecture content recorded by professors using Tablet PCs facilitated students' learning in STEM courses. Students felt that the technology enhanced clarity of course concepts and skills, increased organization of course materials, provided asynchronous access, increased convenience, improved achievement, and provided a disability coping mechanism.

Clarity

All the participants perceived clarity as a key component in their learning process. Participants found asynchronous access of course materials to reduce inconsistencies in their own note taking as well as to improve comprehension of class material. Participants observed that asynchronous access was beneficial to visual learners, leading to an increased awareness of instances of instructional materials presented in class. Specifically, Participant 10 stated, "I mean...I could see going over stuff again, and again it made me understand more." Participant 7 also shared the same sentiment by saying, "I would probably read over my notes again, like...if I needed clarification or something." Participant 11 added that he got distracted very easily in class, "...so being able to go back and listen to recordings definitely helped. It cleared a lot of things." Participant 9 had the following to share, "Dr. B. notes, his PowerPoint's, presentations also have his hand scribbled notes down there as well so it is very visual."

According to participants of this study, clarity implied that asynchronous online access of information reduced inconsistencies in class notes, improved comprehension, and brought to realization learning experiences to visual learners, positively impacting their learning. Participants realized that accessing the asynchronous online recordings had a positive overall effect of their perception of STEM related courses.

Organization

Organization implied that, when course content was accessed asynchronously, participants found it to be well structured, helping them study the material. However, Participant 1 expressed frustration by noting, "I think we should have more training or an overview in class first on how to access and use web-based recordings. It is not sometimes easy to get on and figure out how the stuff is put on there." On the other hand, several participants, 11, 9, and 8 thought the material was easily laid out once downloaded.

Participant 11 noted, "I felt it was easy to navigate the web recording, but...I didn't have any trouble with them." Participant 9 stated, "I have looked up the web recording, ...they are pretty easy to, I am pretty computer savvy so I don't know, some people may have difficulty than others but it was easy for me." Participant 8 said, "I like how, yeah, the slides were done. It helped me a lot though, if I didn't figure out something, I could just go to the Internet and they had the slides. He had the slides pre-made for class so I could just read what he was saying." Though a majority of the participants stated that materials seemed to be structured once retrieved from the Internet. This helped with studying content intuitively. Participants 4 and 9 observed that some instructors seemed not to know how to use pen technology to present materials in a structured format.

Asynchronous access

STEM-related courses were designed to have an asynchronous component to accommodate students with LD and/or ADHD. In other words, students were provided with class material that was uploaded to a web server for their convenience so that they would be able to access it anytime for studying purposes. Its success depends on the instructor's technical knowledge and maintenance of the transmission medium. Study participants noted that asynchronous access supported their learning habits; however, they pointed out that the venture was dependent on the instructors' ability to understand and operate the technology. In addition, reduction of background noise experienced in web recordings, availability of enough bandwidth and ease of connection to stream the recording, and instructor's voice not synchronized with visual presentation created moments full of frustration for students. As Participant 1 remarked:

It was kind of difficult to get on...online to listen to that so then when I finally did then one time I couldn't hear nothing....the connection is kind of slow and trying to get exactly where you are supposed to go to get on it for the pop-up screen and then you have to hit something else...if it was more a little accurate or more fast it would have been a little better.

Participants 10 and 9 shared the same viewpoint. Participant 10 stated, "There is always the low signal strength and then it progressively worsens." Participant 9 said:

You can't always depend on technology; it goes down from time to time. I have had a couple of incidences where it affected my class and I couldn't either get an assignment or view something or couldn't send something to my professors...for some reason it always seem to happen at the worst time.

Convenience

Participants explained that they liked the availability of class lectures and material that met their needs being available on demand. In other words, asynchronous access of course content provided expediency to learning situations for study participants. Participants could study independently and review course notes with more confidence at their own pace without the feel of time constraints and pressures experienced in a typical classroom. Participants also expressed that they never felt comfortable asking questions of the instructor or their friends. Instead, they were able to view the web recording as many times as was necessary to master the material even though it might have been posted by a different instructor. Participant 10 stated:

...multiple recordings from different instructors teaching same course are helpful because if you don't understand teacher A but you understand teacher B then I'm going to listen to teacher B when I'm enrolled in A because the way registration goes, sometimes you just can't get the teacher you want

Participant 2 said, "I was a little bit sick and couldn't make it to class. The recordings were definitely beneficial then so, I mean, anytime you may

have a circumstance where you can't make it to class then it is encouraging." Participant 1 said:

If there's something I'm not paying attention to or didn't focus in class, and cannot find it in my notes, I can, you know...I can always go back there, pull it up on the web and keep listening to it over and over again until probably I get a better understanding of it.

Other participants agreed it was convenient to have class materials online. Participant 9 thought it was beneficial to access the notes online; Participant 8 thought it was good to have it online because it showed more, visuals were helpful when studying. Participant 7 stated, "When I didn't understand something I would go back and redo it or sometimes it helped to re-listen to it." On the contrary, Participant 8 pointed out this possible unintended consequence, "It can also get you into the habit of being lazy; like my roommate, he didn't go to class really."

Achievement

Achievement implies that students with LD and/or ADHD are able to recognize an improvement in their study habits as well as anticipate higher test scores and grades. This is evidenced when Participant 10 stated, "Recordings have immensely impacted my learning, again I am a visual learner so it's easier for me to see and hear than just listen." Participant 3 noted, "I could have probably been doing much better on my tests from the beginning if I knew about these recordings, you know. I have an attention and focus issue."

The rest of the participants thought their learning process and appreciation of STEM courses had been positively impacted by the recordings. Participant 11 had previously enrolled for the STEM course, withdrew halfway on medical grounds, and was repeating the STEM course said, "Having taken this class before, I feel I have a better grasp of things...I feel, I feel a lot better about this class than I did last semester," Participant 9 said:

It helps me feel more confident about the course...the teacher of the course does a very good job teaching it and the web based just reinforces his teaching....if you miss something you can always go back to it. You always have something to reference if you've got a question, if you copied

something wrong or not, or if you did not get something... It's definitely a tool that when you need it, it's a very, very good tool to have. I'm expecting to get an "A" in this course.

Participant 3 noted, "At first I struggled with it because I was trying, I wasn't used to math on the Internet. I wasn't used to biology...but since I've gotten the hang of it. Like, just adjusting I think it is a good thing."

Disability coping mechanisms

According to the participants of this study, accessing asynchronous online information has helped them self-accommodate the impact of their LD and/or ADHD. Participant 4 said, "I have been brought up to not use my disabilities as a hindrance..., I do like having the accommodations and everything like that. It does make learning easier." Participant 11 stated:

Web-based recordings have been beneficial in helping me understand concepts better. With some of the things I have, the disabilities that I can't always pay attention one hundred percent, and so being able to go back and catch stuff I missed definitely helps.

Participant 10 reported:

You can't be expected to have a recording of every lecture or meeting...so it is good to have this opportunity but I also need to be able to learn to cope with it so that when I get into the work field then I can be able to function like everybody else.

Participant 7 acknowledged:

The class seems to be easy in the beginning and get tougher later on and when you have classes during instructor's office hours you can't go ask him a question. For an individual who is more auditory, online access allows you to go back and review the material while listening to the instructor's voice explaining course content.

Participant 11 perceived online recordings as a back-up and not a tool to be dependent upon while Participant 2 felt asynchronous online access offered more choices for referencing notes and materials online.

Discussion

Historically faculty have focused curriculum development on theory and research while the Office of Disability Services and other student affair offices have focused on pedagogical practice (Harper & Quaye, 2009). The theory of universal design brings together faculty and various student affairs offices through practical pre-planning of classroom instruction, assignments, and anticipated student outcomes. It is important to acknowledge that access to information through UD "does not signify that learning will occur; rather, learning also requires an awareness of students' divergent needs and an understanding of how to enable [students] to reach their potential" (Nichols & Quaye, 2009, p. 51).

While it is not possible to compare the participants' perceptions to all students with LD and/or ADHD, findings of this study align with UD tenets of multiple means of representation, expression, and engagement. Instructors' use of multiple means of expression enhanced students' ability to study course materials. The use of asynchronous online access of recordings could help facilitate the studying of course material by clarifying inconsistencies in a student's class notes. Precision in note-taking can impact comprehension, enhance learning, and result in a higher grade. Online access of lecture material that includes illustrations of key concepts in conjunction with an audio explanation may promote a clearer understanding of course content. In this setting, multiple means of representation occurs when access of course content is available in class as well as outside of class, reducing distractions and clarifying variations in note-taking in the educational setting (CAST, n.d.).

Asynchronous online access of course content helps students with LD and/or ADHD self-accommodate, or successfully cope with their disability within the context of a postsecondary STEM course. Auditory learners can listen to the instructions which may include multiple steps as many times as necessary while visual learners can review the content as needed. CAST (n.d.) finds multiple means of expression occurs by allowing the strength of the learner's working memory an opportunity to actively organize information to meet his or her learning needs.

The use of technology in planning and delivering course content in a structured format promotes multiple means of engagement. Rose et al. (2008) found unrestricted access through web-based archived recordings

may lead to increased learning as well as a decrease in the need for specific accommodations. Individual student choice of how and when access occurs meets the requirements of the necessary sustained attention and effort of that student for learning to take place and promotes autonomy (CAST, n.d.).

Implications for Practice

Colleges and universities may need to further address the unique needs of students with LD and/or ADHD at the postsecondary level (Harper & Quaye, 2009). Approaching student needs through UD is a proactive rather than reactive approach (Burgstahler, 2008). Examples of proactively planning instruction for diverse populations including students with disabilities may consist of providing accessible curriculum for students through various delivery methods, providing course content in an accessible manner, and building faculty awareness of diverse populations (Burgstahler, 2008).

Asynchronous online web access of recorded course content could be a part of a proactive approach to designing curriculum in both STEM and non-STEM courses. Providing new, tenure-track, and tenured faculty training opportunities in the planning of course content could address both disability education and asynchronous online access technology. Faculty could be encouraged to use technology to meet the wide range of abilities and learning strengths of students in their courses. This would mean an availability of increased training for all faculty in order to become knowledgeable in the usage and implementation of online recordings accessed via the Web, as well as an understanding of teaching pedagogy that allows the seamless integration of course content and instructional strategies. Higbee (2008) found one of the greatest challenges for faculty “is trying to predict the needs of potential students” (p. 68). It should be noted that students with disabilities also need to assume an active role in their educational choices. Colleges and universities cannot be held responsible for meeting all needs of students. Students need to be aware of their own learning strengths and weaknesses and work toward positive outcomes with self-determined beliefs and practices.

Limitations

As with all educational research, there are limitations to this study that must be addressed. Due to the small number of participants, caution must be used in

generalizing findings to larger populations. Participants interviewed were registered through the Office of Disability Services at each institution as having an LD and/or ADHD. However, there possibly were other students who may have qualified to participate in the study but chose to remain undisclosed. Students not registered through the Office of Disability Services were not interviewed. The study may have been strengthened if students without disabilities had been given the opportunity to share their perceptions, too. Also, students with other documented disabilities such as Asperger’s syndrome, post-traumatic stress disorder, or psychiatric disorders may have provided deeper insights into the use of asynchronous online course content as an accommodation. It should also be noted a total of 44 students with LD and/or ADHD (as defined for the purpose of the study) chose to participate in the larger NSF study. Of the 44 participants, 24 were in experimental STEM courses with the accommodation. Although multiple timeslots were available for student participants, only 11 students of the 24 were able to schedule interviews.

Conclusion

Asynchronous online access of course curriculum in the STEM disciplines appears to be helping students gain knowledge of course content. Universally designed curriculum may include asynchronous online access of recorded course content. Further research is needed in the area of asynchronous online access, UD, and students with disabilities.

References

- Al Otaiba, S., & Fuchs, D. (2006). Who are the young children for whom best practices in reading are ineffective? *Journal of Learning Disabilities*, 39(5), 414-431.
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.
- Americans with Disabilities Act of 1990, Pub. L. No. 101-336, § 2, 104 Stat. 328 (1991).
- Banerjee, M., Capozzoli, M., McSweeney, L., Sinha, D. (1999). Beyond kappa: A review of interrater agreement measures. *The Canadian Journal of Statistics*, 27(1), 3-23.
- Berg, B. L. (2001). *Qualitative research methods for the social sciences* (4th Ed.). Needham Heights, MA: Allyn & Bacon.
- Blackboard Collaborate (Version 11) [Computer software]. Blackboard Inc. <http://www.blackboard.com/Platforms/Collaborate/Products/Blackboard-Collaborate/whats-new.aspx>
- Boeije, R. H. (2009). *Analysis in qualitative research*. Los Angeles, CA: Sage.
- Bogdan, R. C., & Biklen, S. K. (1998). *Qualitative research for education: An introduction to theory and methods* (3rd ed.). Needham Heights, MA: Ally & Bacon.
- Bogdan, R. C., & Biklen, S. K. (2003). *Qualitative research for education: An introduction to theory and methods* (4th ed.). Boston, MA: Pearson.
- Brown, T. E. (2006). *AD/HD and the challenges of early adulthood*. Retrieved February 1, 2010, from <http://www.drthomasebrown.com/pdfs/EarlyAdulthoodChallenges.pdf>
- Burgstahler, S. E. (2008). Universal design in higher education. In S. E. Burgstahler & R. C. Cory (Eds.), *Universal design in higher education: From principles to practice* (pp.3-20). Cambridge, MA: Harvard Education Press.
- The Center for Applied Special Technology. (n.d.). Retrieved from <http://cast.org>
- Children and Adults with Attention-Deficit/Hyperactivity Disorder (CHADD). (2010). Retrieved June 1, 2010. <http://www.chadd.org>
- Creswell, J. W. (1994). *Research design: Qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.
- Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*. Thousand Oaks, CA: Sage.
- DO-IT. (2002-2007). *Learning disabilities*. Retrieved January 23, 2007, from <http://www.washington.edu/doit/stem/ld.html>
- Domine, E. V. (2009). *Rethinking technology in Schools*. New York: Peter Lang.
- Gall, M. D., Gall, J. P., & Borg, W. R. (2003). *Educational research: An introduction* (7th ed.). New York: Allyn and Bacon.
- Gardner, H. (1983). *Frames of mind*. New York: Basic Books.
- Gordon, M., Lewandowski, L., Murphy, K., & Dempsey, K. (2002). ADA-based accommodations in higher education: A survey of clinicians about documentation requirements and diagnostic standards. *Journal of Learning Disabilities*, 35(4), 357-363.
- Gregg, N. (2009). *Adolescents and adults with learning disabilities and ADHD: Assessment and accommodation*. New York: Guilford Press.
- Harper, S. R., & Quaye, S. J. (2009). *Student engagement in higher education: Theoretical perspectives and practical approaches for diverse populations*. New York: Routledge.
- Higbee, J. L. (2008). The faculty perspective: Implementation of universal design in a first-year classroom. In S. E. Burgstahler & R. C. Cory (Eds.), *Universal design in higher education: From principles to practice* (pp.61-72). Cambridge, MA: Harvard Education Press.
- Individuals with Disabilities Education Improvement Act of 2004, Pub. L. No. 108-446, § 30, 118 Stat. 2647 (2004).
- Kirk, S., Gallagher, J. J., Coleman, M. R., & Anastasiow, N. (2009). *Educating exceptional children* (12th ed.). Boston: Houghton Mifflin Harcourt Publishing Company.
- Maccini, P., McNaughton, D. B., & Ruhl, K. (1999). Algebra instruction for students with learning disabilities: Implications from a research review. *Learning Disability Quarterly*, 22,113-126.
- Madaus, J. W. (2006). Employment outcomes of university graduates with learning disabilities. *Learning Disability Quarterly*, 29(1), 19-31.
- Mapou, R. L. (2009). *Adult learning disabilities and ADHD: Research-informed assessment*. New York: Oxford University Press.
- Mays, N., & Pope, C. (1995). Rigour and qualitative research. *British Medical Journal*, 311(6997),109-112

- McGuire, J. M., & Scott, S. S. (2007). Universal Design for instruction: Extending the universal design paradigm to college instruction. *Journal of Postsecondary Education and Disability*, 19(2), 124-134.
- Merriam, S. B., & Simpson, E. L. (1995). *A guide to research for educators and trainers of adults* (2nd ed.). Malabar, FLA: Krieger.
- Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: JosseyBass.
- Miles, M. B., & Huberman, A. M. (1994) *Qualitative data analysis: An expanded sourcebook*. 2nd ed. Thousand Oaks, CA: Sage.
- National Joint Committee on Learning Disabilities. (1991). Learning disabilities: Issues on definition. *Asha*, 33(5), 18-20.
- National Joint Committee on Learning Disabilities. (2007). The Documentation Disconnect for Students with Learning Disabilities: Improving Access to Postsecondary Disability Services. *Learning Disability Quarterly*, 30(4), 265-274.
- Nichols, A. H., & Quaye, S. J. (2009). Beyond accommodation: Removing barriers to academic and social engagement for students with disabilities. In S. R. Harper & S. J. Quaye (Eds.), *Student engagement in higher education: Theoretical perspectives and practical approaches for diverse populations* (39-60). New York: Routledge.
- Office of Management and Budget. (2000). Standards for defining metropolitan and micropolitan statistical areas; Notice. *Federal Register*, 65(249). Retrieved from <http://www.whitehouse.gov/omb/fedreg/metroareas122700.pdf>
- Parker, D. R., White, C. E., Collins, L., Banerjee, M., & McGuire, J. M. (2009). Learning technologies management system (LiTMS): A multidimensional service delivery model for college students with learning disabilities and ADHD. *Journal of Postsecondary Education and Disability*, 22(2), 130-136.
- Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.
- Pennington, B. (2004). *Co-morbidities of dyslexia, ADHD, & speech language disorders*. Paper presented at the John F. Kennedy Center of Research on Human Development, Vanderbilt University, Nashville, TN.
- Rose, D. H., Harbour, W. S., Johnston, C. S., Daley, S. G., & Abardanel, L. (2008). Universal design for learning in postsecondary education: Reflections on principles and their application. In S. E. Burgstahler & R. C. Cory (Eds.), *Universal design in higher education: From principles to practice* (pp.45-59). Cambridge, MA: Harvard Education Press.
- Stage, F. K., & Kinzie, J. (2009). Reform in undergraduate science, technology, engineering, and mathematics. *The Journal of General Education*, 58(2), 85-105.
- Stake, R. E. (2000). Case studies. In Norman K. Denzin & Yvonna S. Lincoln (Eds.), *Handbook of qualitative research* (pp.435-453). Thousand Oaks: Sage.
- Steinweg, S. B., Williams, S. C., & Stapleton, J.N. (2010). Faculty use of tablet PCs in teacher education and K-12 settings. *TechTrends*, 54(3), 54-61. doi: 10.1007/s11528-010-0404-5
- Tech Smith Corporation (1995-2010). Camtasia Relay (Version 1.0) Available from <http://www.techsmith.com/camtasiarelay.asp>
- Trammell, J. K. (2003). The impact of academic accommodations on final grades in postsecondary setting. *Journal of College Reading and Learning*. 34(1), 76-90.
- Winick, S. L., & Gomez, C (Eds.). (2008). *Disability compliance for higher education: 2008 yearbook*. Horsham, PA: LRP Publications.

About the Authors

Laura M. Graves received her undergraduate degree in Special Education from the University of Tennessee and Ph.D. from Tennessee Technological University. Her experience includes 18 years of teaching in both special education and general education classrooms in Tennessee. She has served as a cadre member for Reading First; serves on the Disability Services ADA Advisory Committee; serves as the corresponding secretary for the TN-IDA; serves as a mentor for the Student Council for Exceptional Children; and is currently the BASE-TN Service Obligation and Employment Verification Coordinator. She served as the PI for the *Effects of Teaching with Tablet PCs with Asynchronous Access in Post-Secondary STEM Courses on Students with Learning Disabilities* (TTASA-SWLD) [award #0726449]. She is currently an assistant professor in the Department of Education at Tennessee Technological University. She can be reached by email at: lgraves@tntech.edu

Paul A. Asunda received his BA degree in Education from Kenyatta University in Nairobi, Kenya, and Ph.D. from the University of Georgia. He is currently an assistant professor in the Department of Workforce Education at Southern Illinois University Carbondale. Dr. Asunda teaches web-based courses that seek to prepare individuals to be conversant with different technological trends and how to integrate them at their place of work. His research focuses on investigating best practices in teacher education and preparation in the areas of Career/Technical Education. Dr. Asunda is also involved in research that seeks to integrate; mathematics, science, and technology (STEM) related activities in the workforce education curriculum as it relates to preparing a workforce that is responsive to 21st century work environments. He can be reached by email at: PAsun07@siu.edu

Stacey Plant received her BA degree in web design from Tennessee Technological University. Her experience includes working as a project manager of custom web development projects for the Technology Institute and serving as the technical programmer for TTASA-SWLD research grant through the National Science Foundation. She is currently an instructional media specialist for the Technology Institute at Tennessee Tech and self-employed web developer servicing higher education affiliated organizations. Her research interests include progressive enhancement and responsive design with focus on accessibility in web development. She can be reached by email at: splant@tntech.edu

Chester Goad, received both his BS degree in secondary education and his M.A. degree in instructional leadership from Tennessee Technological University and is currently a doctoral candidate at the University of the Cumberlands. His experience includes having worked as a teacher and administrator in public and private schools, and as congressional projects director within the U.S. House of Representatives. He has over ten years experience in higher education in both community college and university settings and he is currently the President of TN-AHEAD. In addition to adjunct teaching, he currently serves as Director of Disability Services for Tennessee Technological University. His research interests include: universal access initiatives, campus and community collaboration, transition, academic coaching, leadership and public policy. He can be reached by email at: cgoad@tntech.edu

Authors' Note

This material is based upon work supported by the National Science Foundation under Grant No. 0726449. In addition, NSF Grant No. HRD-0929006 facilitated the publication of this article. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Evaluation of Programmatic Interventions to Improve Postsecondary STEM Education for Students with Disabilities: Findings from SciTrain University

Nathan W. Moon
Tristan T. Utschig
Robert L. Todd
Ariyana Bozzorg

Center for Advanced Communications Policy
Georgia Institute of Technology

Abstract

This article discusses the evaluation of programmatic interventions to enhance postsecondary STEM education for students with disabilities. SciTrain University, a federally funded project to provide instructor training on accessible teaching according to universal design principles, is presented here as a case study on evaluation for similar programs. This article highlights the evaluation process, including relevant evaluation questions and selection of indicators, use of a mixed-methods approach, and development of instruments. We give particular attention to the utilization of longitudinal participants in order to document the project's effectiveness. Project evaluators used demographic and performance data, classroom observations, and online journals to determine the efficacy of the training provided to these longitudinal participants. For these three activities, we discuss the development and deployment of instruments and offer some preliminary findings. Finally, the article concludes with a brief discussion of internal project assessment and its role in project refinement. Given a dearth of scholarship on the evaluation of programs to enhance STEM education for students with disabilities, this article seeks to provide some practical insights into the potential for mixed-methods approaches.

Keywords: STEM education, disability, postsecondary, evaluation, universal design for learning (UDL)

In recent decades, policymakers and educational leaders have emphasized accountability and utilization of evidence-based practices in secondary and postsecondary education (Layzell, 1999; Harvey & Williams, 2010; Shin, 2010). However, researchers have pointed to a continued lack of data on postsecondary students with disabilities and the need for appropriate indicators to document their success (Burke, Hedrick, Ouelette, & Thompson, 2008). Of particular concern is the efficacy of programs to improve enrollment in, retention within, and completion of science, technology, engineering, and mathematics (STEM) degrees at the postsecondary level. Projects sponsored by the National Science Foundation's (NSF) Research in Disabilities Education (RDE) and the U.S. Department of Education's Office of Postsecondary Education (OPE) have prioritized the improvement of postsecondary STEM education for students with disabilities (Burgstahler & Bellman, 2009;

Izzo, Murray, & Novak, 2008; Stefanich, Gabrielle, Rogers, & Erpelding, 2005; Stumbo, Lindahl-Lewis, & Blegen, 2008).

The need for more evidence-based practices has been noted in practically every aspect of disabilities education, including the transition to postsecondary education (Webb, Patterson, Syverud, Seabrooks-Blackmore, 2008). As the National Council on Disability (NCD) has observed, "the amount of rigorous, evidence-based research on programs that promote positive outcomes for students with disabilities is severely limited" (Frieden, 2004, p. 6). In addition, there is a dearth of scholarship on how such programs might be evaluated.

In response, this article presents SciTrain University (SciTrain U), an OPE-funded demonstration project at the Georgia Institute of Technology and University of Georgia designed to enhance the abilities

of STEM faculty to make instruction more accessible for students with disabilities through a combination of in-person and web-based training (Utschig, Moon, Todd, & Bozzorg, 2011). Using SciTrain U as a case study, we discuss methodologies for evaluating programs to support STEM education for students with disabilities. In the course of highlighting key evaluation findings, this article presents indicators for determining programmatic efficacy, considers methodologies for gauging project performance, and discusses challenges faced by the project and efforts to resolve those difficulties.

Background Discussion

Scientific leaders and policymakers have called for the cultivation of a diverse STEM workforce in the United States (National Science Foundation, 1996, 2000, 2004). This concern was reiterated by the National Science Board in its 2010 report, "Preparing the Next Generation of STEM Innovators," which offers two interrelated observations. First, American prosperity in STEM in the coming years will rely increasingly upon "talented and motivated individuals who will comprise the vanguard of scientific and technological innovation" (National Science Board, 2010, p. 1). Second, every student in the United States "deserves the opportunity to achieve at his or her full potential" (National Science Board, 2010, p. 1). In summary, excellence and equity in STEM education go hand-in-hand. However, this goal can be realized only if underrepresented groups attain a larger proportion of the nation's STEM degrees.

Americans with disabilities historically have been underrepresented in postsecondary STEM education, particularly because these students face tremendous barriers to access and participation in these programs (Burgstahler, 1994; Wolanin & Steele, 2004). Participation of students with disabilities tends to decrease longitudinally throughout the STEM education process. U.S. census data have shown that people with disabilities constitute 10% of the nation's general workforce, but only two percent of its STEM professionals (Committee on Equal Opportunities in Science and Engineering, 2006; National Center for Education Statistics, 2004; U.S. Department of Education, 2001).

The problem is complex. First, teachers, instructors, and professors are frequently unable, unprepared, or otherwise ill-equipped to recognize and address the needs of students with disabilities (Stefanich, 2007). As

a result, course content may be inaccessible, as many faculty fail to develop their courses in accordance with the principles of universal design for learning (UDL) (Burgstahler & Cory, 2008; Rose & Meyer, 2006; Rose, Meyer, & Hitchcock, 2005). Instructors may not be aware of strategies or technologies to help them accommodate students, or they may lack the necessary institutional support or resources to make accessible pedagogy a reality (Stefanich, 2001). In addition to the issue of instructional practice, there is a second matter of social inclusion. Research has demonstrated that students with disabilities, particularly learning disabilities, frequently experience negative attitudes from faculty and peers (Stage & Milne, 1996). By the time some of these students reach college, they are commonly discouraged from pursuing STEM degrees. When they enroll in STEM courses, many are not fully included in more rigorous learning activities such as labs, thus diminishing their potential engagement and prospects for success (DO-IT Staff, 2001). As such, there remains a pressing need for resources to ensure that STEM instruction is accessible and inclusive.

The UDL concept is the philosophical foundation for inclusive teaching, and the literature demonstrates that many inclusive strategies are effective. Orr and Hammig's (2009) survey of pedagogical techniques found that in 21 of 38 studies, inclusive techniques and learner supports were in use. These studies provide evidence for the ability of inclusive instruction to minimize the need for students with disabilities to seek formal accommodations. Nevertheless, there is room for further inquiry. Despite its increasing deployment in K-12 education, UDL is not as widely implemented in postsecondary education. One broad conclusion gleaned from a review of the scholarly literature is a shortage of research on UDL and accommodations as they apply to the university setting (Moon, Todd, Morton, & Ivey, 2011).

SciTrain University

SciTrain U is designed to enhance the capacity of university STEM faculty and staff to improve learning for all students, including those with disabilities, through the application of UDL practices. In doing so, this project relies on two major components. First, in-person workshops are delivered with the intent of educating faculty about disability awareness and working with students with disabilities. In accord with the

project's UDL emphasis, workshops have focused less on disability accommodations and more on using accessible pedagogy to improve learning outcomes for all students. The workshop developer has given particular attention to three STEM learning environments: large lecture classrooms, laboratories, and online learning environments. For each of these, workshops have focused on multiple approaches to make learning more effective for all students. For example, group note-taking activities and personal response systems (PRS, or "clickers") are discussed as means to improve instructional outcomes in lecture-based courses, while the development of inquiry-based labs are discussed for lab-based courses.

Workshops are developed and delivered by a lead instructional technologist at Georgia Tech's Center for the Enhancement of Teaching and Learning (CETL). The workshop developer has almost 15 years of experience in distance education and has worked closely with faculty regarding the use of technology in conventional and virtual classroom settings. The workshop developer has collaborated with biology and marine sciences faculty at the University of Georgia and chemistry and applied physiology faculty at Georgia Tech to ensure the incorporation of appropriate STEM content knowledge within SciTrain U workshops. Workshops on different topics are offered at each of the two participating campuses three to four times per semester; they are occasionally offered more than once whenever interest is relatively high. As the project has progressed, the workshop developer has revised the face-to-face workshops in response to survey findings as well as to update content. For more information about workshops, please visit <http://www.catea.gatech.edu/scitrainU/login.php>.

Building upon the workshops, the project website hosts online courses for deployment of project resources at other institutions. Considerations of accessibility, usability, simplicity of design, and visual appeal drive the website's design, as does clear "branding" for the project, simplified page layouts and functionality, and deliberate use of high contrast and white space. The site provides STEM instructors with three types of content: background information on common disabilities, an overview of disability accommodations, and information about inclusive pedagogy. The site provides modules on transitioning from secondary schools, introduction to UDL, learning disabilities, attention-deficit/hyperactivity disorder (ADHD), au-

tism, mobility and dexterity disabilities, deafness and hearing impairments, low vision and blindness, and disability laws. In illuminating the types of disabilities that instructors might encounter, the modules discuss a variety of methods to accommodate learning needs. The web materials also address assistive technologies and how best to integrate their use within classroom and laboratory learning.

Evaluation and Assessment

To document SciTrain U's effectiveness, considerable project resources are allocated for an evaluation and assessment team. Two lead evaluators are based at Georgia Tech's CETL and Center for Advanced Communications Policy (CACP), and their team has generally included one undergraduate assistant and up to three graduate assistants at any given time. While many of the resources associated with the project typically have been based at CETL, two of the graduate assistants are closely associated with the disability services centers at Georgia Tech and UGA.

Evaluation Methodology and Approach

Synthesizing data is often difficult for evaluation teams unless a specific approach is utilized. This evaluation team's methodology involves combining two mixed-methods approaches for analyzing data: McConney, Rudd, and Ayres' Results Synthesis Method and Campbell's Pattern Matching method. The Pattern Matching method recommends that evaluators work from a model such as a program logic model and identify whether each aspect of the model enables or prevents the program from reaching its intended impact (McConney, Rudd, & Ayres, 2002). The Results Synthesis Method guides evaluators in working with stakeholders to identify the value of each evidence set, such as classroom observations and focus groups (Campbell, 1966). This allows the evaluators to more accurately depict the strength or weakness of the ties among each block on the logic model.

Aside from the analysis of performance data on students enrolled in project-affiliated courses, SciTrain U's evaluation has rested mainly upon qualitative methods, including classroom observations, faculty workshop surveys, student surveys, website surveys, online journals, and focus groups. Where observational methods are utilized, multiple evaluators have taken part to insure interrater reliability. Likewise, all open-

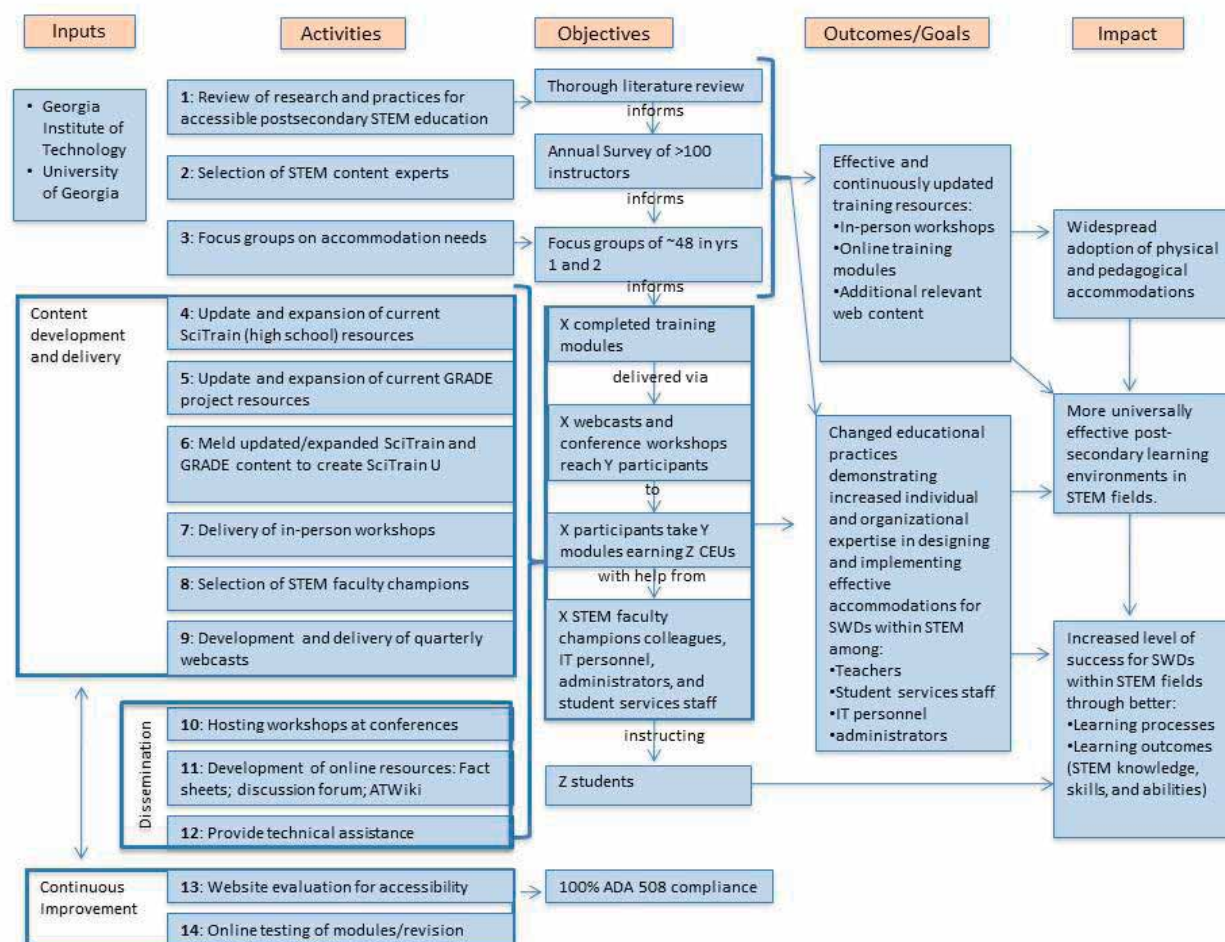


Figure 1. SciTrain U Logic Model.

ended responses to surveys and online journal entries have used at least two coders to maximize reliability.

Indicator Selection

Scholars concerned with the evaluation of postsecondary STEM education have observed that the basic availability or, more frequently, unavailability of data should not dictate the approach for undertaking evaluations (Coates, 2007). These same principles hold true for programmatic interventions to support students with disabilities. If evaluation is to determine educational efficacy, then it must be considered from the beginning through the development of meaningful indicators and the provision of data collection and analysis for such ends. With this guiding principle in mind, evaluators sought to determine the appropriate indicators at the outset of the project and then formulated data collection efforts in response. Evaluation questions and corresponding indicators emerge from the logic model

(see Figure 1), which governs the evaluation process and details the prospective inputs, project activities, objectives, outcomes and goals, and impact.

Evaluation of SciTrain U provides data for formative and summative feedback along three key tracks. In the first track, the Referenced Program Performance Indicators specifically address the U.S. Department of Education's Government Performance and Results Act (GPRA) Goal #3, *Ensure the accessibility, affordability, and accountability of higher education, and better prepare students and adults for employment and future learning*. The referenced program performance indicators provide critical information on student course completion patterns and on faculty adoption of SciTrain U resources. The second track, Knowledge Synthesis, combines SciTrain U's research findings with institutional knowledge developed from prior projects. These include SciTrain: Science and Math for All, which is oriented at improving science and

Table 1

SciTrain U Evaluation Questions

Track 1: Referenced Program Performance Indicators

- a. What is the rate at which students with documented disabilities complete courses taught by SciTrain U-trained faculty? What is the rate at which students without documented disabilities complete courses taught by SciTrain U-trained faculty? What, if any, is the difference in these two rates?
- b. What percentage of SciTrain U-trained faculty incorporates elements of training into their classrooms?

Track 2: Knowledge Synthesis

Based on current literature and recent SciTrain and GRADE findings, what learning environments will prove most successful for program stakeholders?

Track 3: Program Implementation Measures

- a. Which stakeholders are provided with what resources?
 - b. What do participants learn as a result of program participation?
 - c. What actions are the various stakeholders taking toward improving content/pedagogical knowledge, organizational capacity, and available resources?
 - d. Who adopts which aspects of inclusive instruction?
 - e. What organizational barriers or accelerators hinder or promote inclusive instructional practice adoption?
-

mathematics instruction for students with disabilities in secondary education, and Georgia Tech Research on Accessible Distance Education (GRADE), which focuses on accessibility of distance education for students with disabilities. The third track, Program Implementation Measures, provides necessary formative assessment feedback for program benchmarking and improvement as the program is being implemented. This track culminates with a loop back to Track 1. The process for each track is addressed by the project evaluation team through the use of a set of targeted evaluation questions designed to elicit meaningful data collection and analysis (see Table 1).

The GPRA-derived indicators comprising Track 1 were ascertained through data collection efforts involving longitudinal participation by affiliated faculty at Georgia Tech and UGA. In order to determine completion rates of students with disabilities taught by SciTrain U-affiliated instructors, evaluators analyzed

demographic and performance data collected by the disability services centers and registrar's offices at both institutions. In order to establish the percentage of SciTrain U-trained faculty incorporating elements of training into their classrooms, as well as the nature of those practices, longitudinal participants participated in classroom observations and kept online journals detailing their experiences in the project.

Instrument Creation and Use

A "development" mixed-methods approach was used to generate evaluation instruments, including workshop surveys, focus group protocols, and classroom observation instruments (Greene, 2007). Information from a baseline literature review informed the evaluation team in its development of these instruments. The knowledge synthesis effort also resulted in a list of characteristics the program expected to see transferred from instruction into practice. This "trans-

fers list” assisted in the creation of these instruments. Also, Greene’s “complementarity” mixed-methods approach was applied, which means that the classroom observations served to complement other data collection efforts by providing a deeper description of how faculty apply what they have learned into their classrooms and also to confirm or disconfirm the self-reported information from surveys and focus groups (Greene, 2007).

Longitudinal Participants

In order to evaluate the effectiveness of the project, longitudinal participants were recruited from both participating institutions. A total of 15 faculty members, nine from Georgia Tech and six from UGA, were recruited for this project. Collectively, they represented departments of biology, chemistry, mathematics, astronomy, marine sciences, and applied physiology (i.e., health). In order to ensure their continued involvement for the duration of the project, the longitudinal participants were compensated with modest stipends, as well as additional honoraria for taking part in supplemental project activities. As discussed below, their retention for the duration of the project posed a challenge. Nevertheless, most of the participants continued for at least four terms, or two years, of the project period.

Relying upon a mixed-methods approach, three types of data specific to longitudinal participants were collected in order to evaluate SciTrain U’s effectiveness and document change-over-time impacts. First, performance and demographic data for enrolled students with disabilities were collected in order to satisfy the GPRA-derived indicators. Second, classroom observations were undertaken twice a term for each of the participants in order to assess the accessibility of classroom and laboratory instruction. Third, participants were required to submit entries for an online journal that recorded their experiences in the project. In addition to these data collection efforts, participants also attended workshops.

Performance and Demographic Data

In order to determine the effectiveness of SciTrain U as a programmatic intervention to improve the learning outcomes of students with disabilities, evaluators collected both performance and demographic data on students with documented disabilities enrolled in SciTrain U-affiliated courses. These data are collected in order to

determine the rate at which students with documented disabilities complete courses taught by faculty trained in project activities, and the rate at which other students without disabilities complete those courses.

In order to assess these outcomes, evaluators developed collaborative partnerships with the disability services centers and registrar’s offices at both participating institutions. Graduate research assistants tasked to the disability services centers at Georgia Tech and UGA facilitate identification of students with documented disabilities enrolled in project-related courses. Because of a lack of systematized data reporting at these institutions, a project-specific spreadsheet instrument was developed that allows identification numbers for all students on file with disability services to be compared against enrollment rosters for each of the courses. Once students are identified, queries are submitted to the registrars to provide pertinent demographic and performance data immediately following the end of the term. Demographic data gathered include students’ gender, race, disability, class standing, and major, and performance data includes course grades (including incompletions and withdrawals), semester grade point averages (GPA), and overall GPA.

In spring 2009, the evaluation team collected its first set of performance data from the courses of four longitudinal participants at Georgia Tech. This dataset established a baseline for evaluating subsequent progress, and it revealed that in courses taught by SciTrain U-trained faculty, 94.45% of students with disabilities (17 of 18) successfully completed the courses in question. The one student who withdrew did so due to circumstances not related to the student’s disability or academic performance in the course. More specifically, 88.24% of students who completed a course under evaluation (15 of 17) received a passing grade in the course (Grade distribution: A=9; B=4; C=2; D=0; F=2). More widely, 16 of the 18 students evaluated were in good academic standing, with one on academic warning and another on probation at the time.

In fall 2009, there were a total of 21 students with documented disabilities across six courses at Georgia Tech taught by SciTrain U-trained faculty. In the Math 1711 course, there were four students with disabilities. Their average grade for the course was a B- (2.75) (utilizing a four-point grading scale, A=4, B=3, C=2, D=1, F=0). Math 1113 had one student with a disability, who earned an A in the course. The first section of Chemistry 1510 had three students with disabilities, with an aver-

age of C+ (2.33), while the second section of Chemistry 1510 had one student who earned a C in the course. The first section of the freshman-level health/wellness seminar, Health Performance Science (HPS) 1040, included three students with disabilities, with an average of a B (3.00) in the course. The second section of HPS 1040 included 9 students with disabilities, with an average of a B (3.00) in the course. In addition, overall GPAs and semester GPAs were tracked.

The comparison between fall 2009 and the spring 2009 baseline suggests a complementary set of conclusions. First, while a course-by-course comparison may not reflect an improvement in student performance, overall, the project does appear to be making a broader impact in terms of the numbers of students with documented disabilities reached, their course completion rates, and passing grades earned. As noted, the number of students impacted by the project at Georgia Tech to date, in terms of longitudinal participants and students enrolled, makes statistical significance difficult. This suggests a second point, which is that qualitative data may be just as relevant as indicators of student success as performance data.

Classroom Observations

Drawing upon the scholarly literature on UDL approaches to postsecondary classroom instruction (Fahsl, 2007; Fuller, Bradley, & Healy, 2004; Higbee, 2003; Orr & Hammig, 2009), project evaluators developed a classroom observation instrument (see Figures 2 and 3) to conduct beginning-of-term and end-of-term observations for each longitudinal faculty participant. This 48-item instrument considers six elements of inclusive and accessible pedagogy: classroom environment, visual aids, oral communication, “clickers” (i.e., electronic personal response systems), classroom notetakers, and electronic learning support (i.e., course management software). Observations are made by two raters, which always include at least one of the two lead evaluators. Graduate research assistants tasked to the project also participated in observations, and training was provided in person and reiterated through the development of an evaluation team manual. During an observation, observers mark the item as “Yes,” “No,” or “N/A,” depending on whether the behavior was observed. An affirmative answer is generally meant to indicate that the instructor adheres to the principles of UDL, where a negative generally suggests that such adherence was not observed. While the polar nature of

the observation form permits scoring, both individually and as a group, notetaking is also done to provide clarification and feedback for participating instructors, as well as to allow for more detailed explanations or descriptions of the observations.

Faculty participants are observed twice per term, and the same two scorers are involved in both beginning-of-term and end-of-term observations. (In order to expedite scheduling of observations and avoid potential conflicts with tests or special activities, faculty participants were provided with advance notice of the days they were observed.) Use of the same observers, as well as discussion of findings at the end of each observation to resolve any inconsistencies, ensures some degree of reliability. The team also has developed an observation guide that accompanies the instrument, and it contains an item-by-item explanation to assist raters in making their observations. Both the instrument and guide have been subject to periodic review, and slight refinements have been made in response to prior experiences.

As of fall 2010, evaluators had completed 80 observations of 15 longitudinal participants. Four of the participants had been involved continuously throughout the three terms of the study, and five of the participants had been involved for two terms. At the time of the analysis, the remaining six participants only had a baseline measure. As previously noted, the instrument consists of 48 items (three items were simple counts and 45 were categorical) that probe six aspects of instruction. A corresponding “accessibility score” is derived from the 45 coded items. The scores are a sum/composite of these items, allowing for a maximum of 45 and a minimum of -45. “Yes” responses are coded as a 1, and “no” responses are coded at a -1, while “N/A” responses are coded as 0 { $Y = 1, N = -1, N/A = 0$ }. A corresponding scoring rubric was devised, in which a score of < 0 denotes “poor,” 1-15 is “fair,” 16-30 is “good,” and 31-45 is “excellent.” The underlying rationale for the scoring rubric was that any score below 0 was undesirable from an accessibility standpoint.

The following graph (see Figure 4) presents long-standing participants’ accessibility scores averaged across all their observations. A corresponding graph (see Figure 5) shows the aggregate change-over-time results from the observations. The regression line suggests a trend of increasing accessibility scores over the project’s course. When examining accessibility across

**Classroom Observation Form****Date:****Time Start:****End:****Teacher:****Course:****Student #**

Classroom Environment	Y	N	N/A	Notes:
Closes door and/or blinds	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Welcomes or greets students	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Reminders given about electronics during class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Reminders given about acceptable classroom etiquette	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Action taken to motivate students in class or in general	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Language used does not stereotype students	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Flexibility to address individual needs demonstrated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Students provided with multiple ways to learn	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Content is made personally relevant to student lives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Visual Aids	Y	N	N/A	
Class outline presented/provided	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Handouts provided	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Handouts highly readable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Materials easily visible from back of classroom	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Materials uncluttered	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Materials well organized	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Variety of types of visual aids used	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Number of Student questions on visual aids: _____				
Clarity: _____ Comprehension: _____				
Oral Communication	Y	N	N/A	
Uses student names	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Faces class to speak when not writing on board	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Clearly audible from back of room	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Makes eye contact while speaking to students	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Clearly explains visual aids	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Gives clear instructions for student activities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Instructions for student activities repeated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Student interaction actively facilitated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Summarizes major points	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Number of Student questions in general: _____				
Clarity: _____ Comprehension: _____				

Figure 2. SciTrain U Classroom Observation Instrument, Page 1.

SCITRAIN U

Classroom Diagram

Teacher:

Course:

Clickers

Y N N/A

"clickers" are used in the classroom

☐ ☐ ☐

If used, students are able to easily connect

☐ ☐ ☐

If used, how much ____ #instances

____/ ____/ ____ # items per instance

Classroom Notetakers

Y N N/A

Class note takers used

☐ ☐ ☐

Offers printed materials that facilitate note taking

☐ ☐ ☐

Gives reminders of important points to include in notes

☐ ☐ ☐

Gives appropriate pauses for students to take notes

☐ ☐ ☐

Offers feedback or instruction on good note taking

☐ ☐ ☐

Electronic Learning Support

Y N N/A

Majority of students come to class with proper materials

☐ ☐ ☐

Online communication with instructor encouraged

☐ ☐ ☐

Online communication with other students encouraged

☐ ☐ ☐

--- to be observed outside of the classroom ---

Materials available at least 24 hours before class

☐ ☐ ☐

Materials provided in accessible format(s)

☐ ☐ ☐

Online communication with instructor facilitated

☐ ☐ ☐

Online communication with other students facilitated

☐ ☐ ☐

Options for students to post materials for class

☐ ☐ ☐

Options for students to post their own materials

☐ ☐ ☐

Lectures available by audio file

☐ ☐ ☐

Lectures available by video file

☐ ☐ ☐

Online audio/video materials clear/usable

☐ ☐ ☐

Students know when recordings will be available online

☐ ☐ ☐

Figure 3. SciTrain U Classroom Observation Instrument, Page 2.

the six sections of the instrument form, the increasing accessibility of class notetaking and electronic learning support, by term, corresponded to when workshops were held on these areas. When examining standardized

change in average accessibility by section, the analysis revealed improvements in class notetakers, oral communication, visual aids, and electronic learning support, in that order (see Figure 6).

Average Accessibility Score of Multi-Term Participants

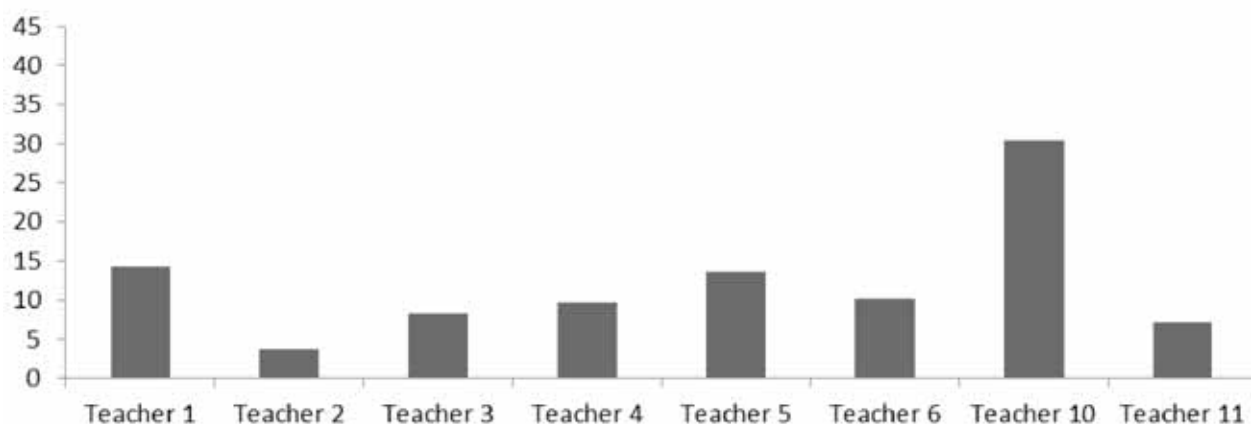


Figure 4. SciTrain U Longitudinal Participant Accessibility Scores, Averaged Across All Classroom Observations.

All Accessibility Scores across Time

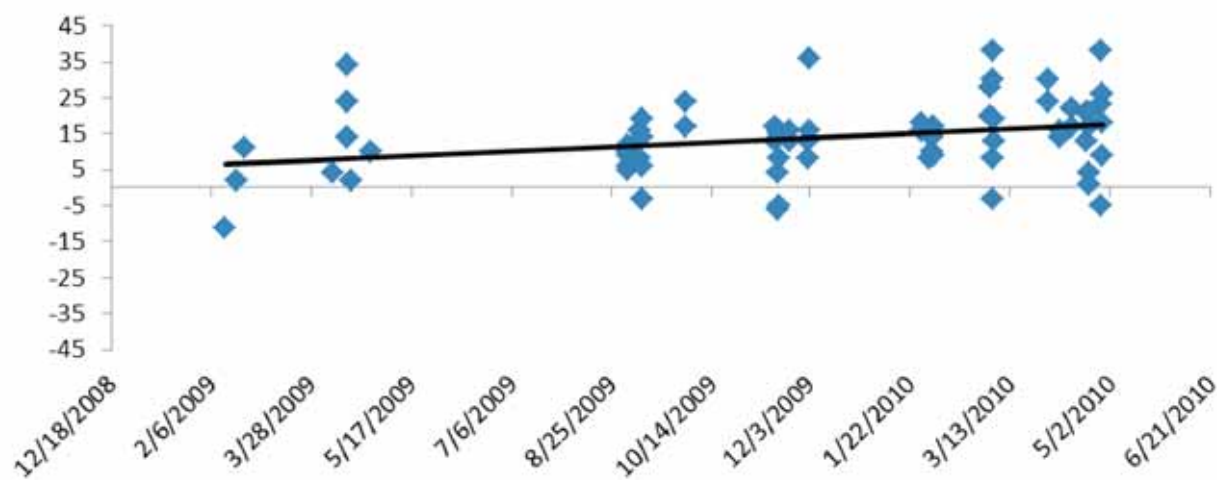


Figure 5. Change over Time of SciTrain U Longitudinal Participant Accessibility Scores.

Standardized Change in Averaged Accessibility across Participation for Instrument Sections

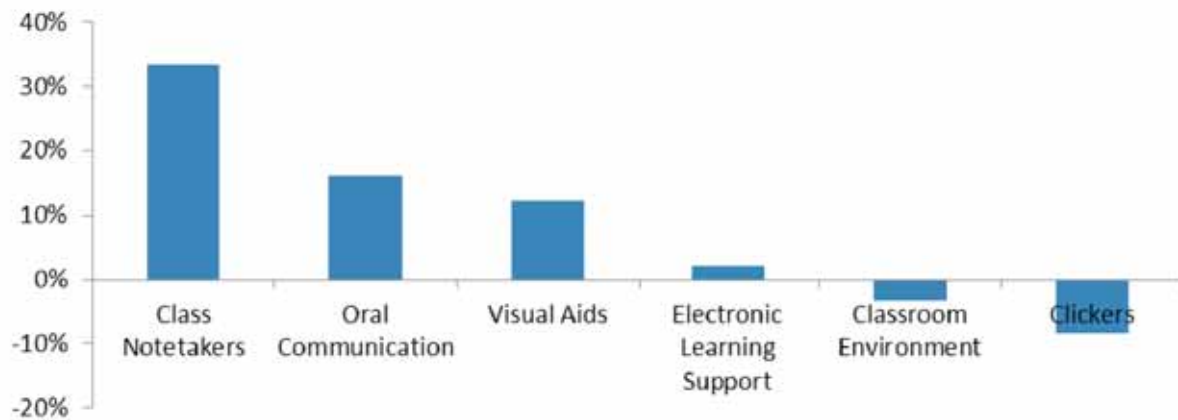


Figure 6. Standardized Change in Accessibility Scores for Each of the Six Instrument Sections.

Online Journal Reflections

Longitudinal respondents were also required to maintain weekly online journals. Each journal entry involved a response to an open-ended question regarding the relationship between the learning environment in the participant's classroom and students with disabilities. Group workshops conducted in parallel to the journal responses during the spring 2009 term addressed the use of online forums in the classroom, while workshops during the fall 2010 term focused on the use of online forums and collaborative learning activities in the classroom. For this reason, the majority of participant responses for spring 2009 and fall 2010 were concerned with the educational effect of online forums and group learning methods, respectively. Journal entries articulate teaching methods, instructor concerns, student feedback, implementation challenges, and overall learning. The journal entries also discuss specific changes and developments related to all students, particularly students with disabilities.

Analysis of faculty participant responses are conducted based on the following questions: 1) What aspects of inclusive instruction do faculty participants adopt? 2) What barriers or accelerators hinder or promote inclusive instruction practices? 3) What actions have faculty participants been taking toward improving content/pedagogical knowledge, organizational capacity, and available resources? 4) What do faculty participants learn as a result of the adoption of certain inclusive teaching methods? 5) What particular resources

and accommodations are provided to SWDs and how are they effective?

In order to answer those questions, evaluators employ a qualitative method to analyze pertinent responses. The main analytical procedure is to do preliminary coding (e.g., open coding), draw out some themes and concepts, and re-code to develop better defined categories and analyze data. This coding is spot-checked by a second researcher at least twice during the analysis process. Journal reflections are analyzed with three focuses: overall themes, change over time, and participant archetypes. By way of example, we present an overview of findings from spring 2010, during which eight participants submitted a total of 44 journal entries. They are referred to below as Participants A, B, C, D, E, F, G, and H (see Table 2).

Entries were first examined to determine overall themes. Discussions of teaching methods were most prominent, particularly group learning methods that were deployed in tandem with SciTrain U workshops on the topic. Five out of the eight faculty participants—Participants A, B, F, H, and G—used various grouping and interactive learning mechanisms as tools for promoting students' learning through collaboration. The variety of formats included group note-taking, group assignment, group class presentation, in-class group work, group-based field experience, and group tests. In addition to group-based learning, participants tried developing better class materials and using other teaching methods in order to promote students' learn-

Table 2

Summary of Journal Entries by SciTrain U Longitudinal Participants, Spring 2010

Participant	Number of Journal Entries	Course Subject	Main Inclusive Instruction Practices Used	School
A	1	Biology	Group note-taking, Group testing, Lecture podcast, Clickers, Online study materials, Posted PowerPoint (PPT)-slides, Extra exam time, Peer review evaluation	UGA
B	6	Math	Group note-taking and assignment, Peer review evaluation	GT
C	4	Health	Annotations, Online forum, Online chat room	GT
D	6	Biology	Online study materials, Online forum, Annotations, Adjusting physical environment	UGA
E	3	Chemistry	Extra exam time, Posting extended notes, Lecture podcast	GT
F	2	Astronomy	Group works in class, Color-coding the contents on ppt-slides.	UGA
G	5	Health	Group note-taking, Peer review evaluation	GT
H	17	Biology	A think-share-pair, Group works and assignments, Peer review evaluation, Field trip, Online forum, Inviting guest speakers for lab activity, A weekend work day	UGA

ing. Participants A, E, and D provided online study materials, including animations, interactive tutorials, video clips, newspaper articles, PowerPoint lecture slides, and handouts. Other strategies to improve student learning included open-book, pre-lecture quizzes, lecture podcasts, making lecture notes available online, enhancement of classroom discussions through online forums and chat rooms, and the use of other instructional technologies.

Another theme involved student receptivity to these inclusive instructional methods. Most faculty participants reported that students gave positive feedback in response to their group-based learning. Participant A cited that about 90% students recommended continuing group tests in the end-of-semester survey because “group test helped them learn the material more effectively, made the class less impersonal, and helped them enjoy the class more.” By contrast, some students complained about the group test/work, especially when they felt that their group was dysfunctional. In the same manner, Participant G found that the majority of students felt that group note-taking had an impact on improving their exam score. In the survey, students also remarked that “the group assignment made them attend class, read the information weekly, so that they stayed on track.” Participant G cited one student’s comment about the positive effect of group-based learning, representing that students learned how to cooperate with others by doing the group assignment. Near the end of term, Participant H contended that students had improvements in their public speaking skills as students reported being far more comfortable in front of class.

Students also responded to overall class materials and learning. Faculty participants A and D reported that students’ comments about online course materials were positive as they found it useful. Participant A implemented an open-book pre-lecture quiz in order for students to learn those materials, but some students complained about this pretest. While students wanted to take the exam after all materials were covered in class, the instructor felt that students had been better prepared for class after using pre-tests. Participant C reported that many students had interest in using the online forum in that 70% of students posted at least once, and more than 50% posted five or more times during the semester. In the survey, many of the students answered that the use of the online forum for class discussion was effective in promoting their understanding

of the course materials and suggested to continue the use of the forum.

Each faculty participant made comments specific to their students with disabilities. Participants A, G, and E provided students with documented disabilities extra exam time in a quiet room for individual tests in addition to accommodations already provided. Participant E generally allowed all students to have extended time to finish their exam, because “extra time let students have some time to think through the questions rather than to rush through and regurgitate facts that they have learned.” Participants C, D, and F expressed concern about visual aids and materials for their students with visual impairments. More specifically, Participant C was worried about the graphical nature of online course materials, since they are very visual, while Participant D raised the serious issue of a poorly arranged classroom:

There is insufficient control of the amount of natural light entering the room...the fluorescent lighting cannot be controlled at a sufficiently fine-grained level...when it is turned off, it is too dark to clearly read the chalkboard in much of the room...I can’t imagine what it would be like for those who are visually impaired.

Participant F used color-coding for information that was left off of posted class slides so that students could easily identify what is missing, assuming that this would be a disadvantage for colorblind students. Interestingly, there were no students with identified visual impairments enrolled in the class.

Four of the faculty participants (B, D, G, and H) have been enrolled in the SciTrain U project since its inception, allowing evaluators to document change-over-time impacts through analysis of the online journals. For example, Participant B noted positive experiences with the group note-taking assignments in fall 2009, especially where student engagement was concerned. This experience, however, shifted after the participant faced a cheating issue in a subsequent term, when one group downloaded other groups’ notes and re-posted it as their own work. Although Participant B still believed the effectiveness of the group-based learning, preventing student cheating became a prerequisite and, hence, an implementation challenge for continuing this method. In addition to warnings about the consequences of academic dishonesty, the participant

added a peer review component to the grade. After using the peer evaluation system in spring 2010, Participant B found that peer evaluation was not as effective as hoped. Many groups gave perfect scores to the members of the team regardless of their contributions.

Finally, journal entries were analyzed to discern participant-specific development in order to determine whether any archetypes emerged as a result of their participation in the project. Three broad categories of faculty participants were identified: Enthusiast, Skeptic, and Incremental Adopter. During the spring 2010 period, both Participants B and H were recognized as Enthusiasts based on their interest in further developing the group-based learning as effective pedagogy for promoting student learning. Participant B demonstrated particular enthusiasm for implementing group note-taking and group peer evaluation and ended the term with plans to improve the pattern of group study and add group projects to grade components in the future. Participant H found group-based learning to be very effective throughout the one-year period of study. By contrast, Participant D was a consistent Skeptic about the use of online forums to enhance classroom learning for the two semesters. This instructor encouraged students to discuss materials online, but very limited student participation led the instructor to answer most of the questions. In addition, the participant found that the online forum lacked the tools necessary to describe and write mathematical equations, a technical issue that has yet to be remedied. Falling between the archetypes of enthusiast and skeptic, Participant G represented the Incremental Adopter. This instructor found that prescribed group-based learning appeared to work well, as the majority of students commented that group notes were useful. However, the participant showed mixed feelings about the effect of the methods. While the quality of group note-taking as well as interaction in the class was improved, this instructor was not sure if this had a positive impact on students' grades. Participant G noted several implementation challenges stemming from the large, lecture-based course in which the approach was used. Despite these concerns, this instructor ended the term with plans to continue refining the methods in order to make them suitable for the class format.

Limitations and Challenges

While this article calls attention to the successes of SciTrain U through a discussion of its evaluation methodology and findings, the project was beset by a number of challenges. In addition to evaluating project outcomes, evaluation personnel were also tasked with internal assessment in order to determine challenges in need of resolution. In this article, we highlight two challenges in particular: relatively low enrollment by students with documented disabilities and difficulty securing longitudinal participants and faculty champions. While these challenges persisted throughout the project, the leadership team attempted to resolve these and other issues identified through the internal assessment process.

Internal Project Assessment

Internal assessment is accomplished through the application of the SII (Strengths, Areas for Improvement, and Insights) model as part of internal quarterly reporting (Wasserman & Beyerlein, 2007). These reports are used to summarize evaluation activity, identify effective programmatic results from which synergy can be built in related areas, pinpoint areas of immediate need along with specific advice to address those needs, and provide data that may be generalized to similar program efforts elsewhere. The SII reporting model is used to provide periodic ongoing assessment of program activities and the evaluation process itself.

Patton (1997) challenges evaluators to understand that evaluation use must be facilitated and emphasizes that it rarely, if ever, happens by chance. To ensure that the evaluation plan and findings provided useful, actionable information, the evaluation team presented timely information to allow for program modifications. As evaluation findings through the SII process have surfaced, the principal investigator and other personnel have worked to address identified challenges. Some of these improvements have included modifications to curriculum, instruction, and delivery methods; changes in technical assistance approaches and other dissemination methods; targeting specific support communities for more extensive training and assistance; and identifying potential new resources and partnerships not currently apparent. As these challenges are resolved, some have come to constitute project strengths.

Student-Side Engagement

SciTrain U is designed primarily as an instructor-oriented project in the sense that faculty training represents its main focus. Nevertheless, engagement of students, especially those with documented disabilities, remains fundamental. More practically, the enrollment of students with disabilities in SciTrain U courses is vital for evaluation of the project's efficacy. Enrollment was lower than expected during the first two years, complicating the generalizability of performance evaluations. Relatively low numbers of students in SciTrain U-affiliated courses undermined the statistical significance of data gathered through the evaluation process. In addition, there was a more fundamental need to determine the broad impact of the project on students.

In order to address recruitment of students, particularly at Georgia Tech, a GRA was tasked to the disability resource center. In addition to gathering demographic and performance data on behalf of the evaluators, the GRA served as a student liaison. During the summer, the head of disability services and the GRA held events at all six of the freshman and transfer orientation sessions. They met with incoming students with disabilities and parents regarding SciTrain U and the possible benefits it could offer, as well as pre-registering any students expressing an interest. As a result of these efforts, enrollment in project affiliated courses has grown substantially. Though the data have yet to be analyzed, a total of 44 students were enrolled for the fall 2010 term, substantially more than the baseline enrollment of 18 students with disabilities.

An online survey instrument for evaluating student perceptions of the accessibility of SciTrain U courses was also developed and distributed. Collecting self-report data from students enrolled in the courses of participating faculty, the survey gauges student perceptions about inclusion within the university and classroom environment as well as the accessibility of instructional methods and materials. While written ostensibly to obtain feedback from students with disabilities, the survey was designed to be administered meaningfully to all students in a course. Another key rationale of the survey is to collect data that can be roughly correlated to the findings of SciTrain U's classroom evaluation instrument. While this survey does not ask the same specific questions as that instrument, it broadly probes the same areas: the physical classroom environment, professor awareness of student needs, written materials (i.e. textbooks, course packets, hand-

outs), oral communications (i.e., lectures, discussions), and evaluation of student learning (tests, exams).

While such student feedback has the disadvantage of not probing specific items of interest in the SciTrain U classroom evaluation instrument, the instrument does confer a number of potential benefits. First, it provides some measure of the impact of SciTrain U on students themselves. While evaluators may assess through classroom observation how well instructors are putting workshop and online course module lessons into practice, this instrument provides a means for comprehending, if only in a rudimentary fashion, what such practices mean for the student. As this survey can be given at both the beginning and end of a course, it is also possible to gauge change over time. Second, the instrument is open-ended so that students can elaborate on issues that are important to them, allowing direct evaluation of programmatic impact on STEM education for students with disabilities and indirect evaluation of the program's impact on all students. While student-self reporting was not listed as an original evaluation tool, this instrument and its findings will help augment the evaluation of the effectiveness of SciTrain U through its correlation with classroom observation findings and by probing other dimensions of the program.

SciTrain U Scholars Program

One persistent challenge identified through the SII process has been a need for more faculty involvement in the SciTrain U project, especially at Georgia Tech. To address this need, project leadership developed the SciTrain U Scholars program to improve outreach through the use of faculty champions. A total of eight faculty members at Georgia Tech participated in the SciTrain U Scholars program during fall 2010. Among their primary activities, the group was tasked with making faculty contacts on behalf of the project (including individuals to pilot the online materials), giving presentations on their activities, and providing feedback on their involvement with the project.

A total of 32 contacts were made during this period, including six tenure-track faculty, eight non-tenure track faculty (i.e. academic professionals), and nine teaching assistants. Of this number, 27 were confirmed as online course participants. The main departments represented in these activities included mathematics, biology, mechanical engineering, aerospace engineering, computer science, applied physiology (i.e. health/

wellness), and learning services. Also, a total of 14 presentations were made, including five department meetings and three external conferences.

Scholars noted that the online tutorials provided significant feedback on their teaching and led to the adoption of more inclusive teaching methods in many cases. In terms of engagement with administration, they reported some success, including school chairs, curriculum committees, and several deans. When asked about challenges, a lack of time was the overwhelming response. In particular, there was a constant call to shorten the online course modules. Budget cuts and the continued lack of involvement by tenure-track faculty were also identified as challenges. Despite these issues, however, the project leadership has found this program to be relatively successful in boosting outreach efforts.

Discussion and Relevance for Practitioners

As a large-scale project designed to support and enhance postsecondary STEM education for students with disabilities, SciTrain U is representative of similar projects sponsored by National Science Foundation's (NSF) Research in Disabilities Education (RDE) and the U.S. Department of Education's Office of Postsecondary Education (OPE), and other federal agencies. Such projects are mandated to demonstrate their efficacy and potential for improving outcomes for these students, yet there is relatively little published on the evaluation of such projects. The evaluation approach discussed in this article may be of use for investigators seeking novel means to discern the effectiveness of these projects.

In order to maximize evaluation efforts, our project took a mixed-methods approach that may be relevant for similar projects. Several of our instruments are now being deployed at the beginning and end of each term. In addition, reliability is enhanced, where possible, through the use of multiple raters. The use of these instruments has allowed for data triangulation, whereby the various instruments provide different perspectives of the same project element under consideration. Feedback forms and focus groups provide unique insights into the workshops, while classroom observations, student surveys, and online journal reflections allow for a multi-perspective examination of longitudinal participation. In short, our use of multiple instruments that permit for triangulation has facilitated richer data analysis.

Conclusion

As a case study for the evaluation of programmatic interventions to enhance postsecondary STEM education for students with disabilities, the authors believe that SciTrain U contributes to scholarship and practice. The multi-faceted approach taken by the project evaluators, characterized by a mixed-methods approach that documents project effectiveness through longitudinal participants, may be of use for similar projects. Given a dearth of scholarship on the evaluation of programs to enhance STEM education for students with disabilities, this article seeks to provide some insights into the potential for mixed-methods approaches.

References

- Burgstahler, S. (1994). Increasing the representation of people with disabilities in science, engineering, and mathematics. *Journal of Information Technology for Development* 4(9), 1-8.
- Burgstahler, S., & Bellman, S. (2009). Differences in perceived benefits of internships for subgroups of students with disabilities. *Journal of Vocational Rehabilitation* 31(3), 155-165.
- Burgstahler, S. E., & Cory, R. C. (2008). *Universal Design in Higher Education: From Principles to Practice*. Cambridge, MA: Harvard University Press.
- Burke, M., Hedrick, B., Ouellette, S., & Thompson, T. (2008). Developing accountability metrics for students with disabilities in higher education: Determining critical questions. *Journal of Postsecondary Education and Disability* 21(1), 42-54.
- Campbell, D. T. (1966). Pattern matching as an essential in distal knowledge. In K.R. Hammer (Ed.), *The psychology of Egon Brunswick* (pp.81-106). New York: Holt, Rinehart & Winston.
- Coates, H. (2007). Excellent measures precede measures of excellence. *Journal of Higher Education and Policy*, 29(1), 87-94.
- Committee on Equal Opportunities in Science and Engineering, National Science Foundation. (2006). *2005-2006 biennial report to Congress*. Retrieved February 4, 2011, from http://www.nsf.gov/pubs/reports/2006_biennial_report.pdf
- DO-IT Staff. (2001). *The winning equation: Access + attitude = success in math and science*. Seattle, WA: University of Washington.

- Fahsl, A. J. (2007). Mathematics accommodations for all students. *Intervention in School & Clinic* 42(4), 198-203.
- Frieden, L. (2004). *Improving educational outcomes for students with disabilities*. Washington, DC: National Council on Disability. Retrieved January 29, 2011, from <http://eric.ed.gov:80/PDFS/ED485691.pdf>
- Fuller, M., Bradley, A., & Healy, M. (2004). Incorporating disabled students within an inclusive higher education environment. *Disability & Society* 19(5), 455-468.
- Greene, J. C. (2007). *Mixed-methods in social inquiry*. San Francisco, CA: Jossey-Bass.
- Harvey, L., & Williams, J. (2010). Fifteen years of quality in higher education. *Quality in Higher Education* 16(1), 3-36.
- Higbee, J. L. (Ed.). (2003). *Curriculum transformation and disability: Implementing universal design in higher education*. Minneapolis, MN: Center for Research on Developmental Education and Urban Literacy, General College, University of Minnesota.
- Izzo, M. V., Murray, A., & Novak, J. (2008). The faculty perspective on universal design for learning. *Journal of Postsecondary Education and Disability* 21(2), 60-72.
- Layzell, D. T. (1999). Linking performance to funding outcomes at the state level for public institutions of higher education: Past, present, and future. *Research in Higher Education* 40(2), 233-246.
- McConney, A., Rudd, A., & Ayres, R. (2002). Getting to the bottom line: A method for synthesizing findings within mixed-methods program evaluations. *American Journal of Evaluation* 23(2), 121-140.
- Moon, N. W., Todd, R. L., Morton, D. L., & Ivey, E. (2011). *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, Georgia Institute of Technology. Forthcoming.
- National Center for Education Statistics, U.S. Department of Education. (2004). *National postsecondary student aid study, 2000-2004*.
- National Science Board. (2010). *Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation's Human Capital*. Arlington, VA: National Science Foundation. Retrieved December 29, 2010, from <http://www.nsf.gov/nsb/publications/2010/nsb1033.pdf>
- National Science Foundation. (1996). *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology*. Retrieved February 1, 2011, from <http://www.nsf.gov/pubs/stis1996/nsf96139/nsf96139.txt>
- National Science Foundation. (2000). *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology*. Retrieved February 1, 2011, from http://www.nsf.gov/pubs/2000/cawmset0409/cawmset_0409.pdf
- National Science Foundation. (2004). *Women, Minorities, and Persons with Disabilities in Science and Engineering*. Retrieved February 1, 2011, from <http://www.nsf.gov/statistics/wmpd/pdf/nsf04317.pdf>
- Orr, A. C., & Hammig, S. B. (2009). Inclusive postsecondary education strategies for teaching students with learning disabilities: A review of the literature. *Learning Disability Quarterly* 32(3), 181-196.
- Patton, M. Q. (1997). *Utilization-focused evaluation: The new century text*. (3rd ed.) Thousand Oaks, CA: Sage Publications.
- Rose, D. H., & Meyer, A. (Eds.). (2006). *A Practical Reader in Universal Design for Learning*. Cambridge, MA: Harvard Education Press.
- Rose, D. H., Meyer, A., & Hitchcock, C. (Eds.). (2005). *The Universally Designed Classroom: Accessible Curriculum and Digital Technologies*. Cambridge, MA: Harvard Education Press.
- Shin, J. C. (2010). Impacts of performance-based accountability on institutional performance in the U.S. *Higher Education* 60(1), 47-68.
- Stage, F. K., & Milne, N. V. (1996). Invisible scholars: Students with learning disabilities. *Journal of Higher Education* 67(4): 426-445.
- Stefanich, G. P. (Ed.). (2001). *Science Teaching in Inclusive Classrooms: Theory and Foundations*. Cedar Falls, IA: Woolverton.
- Stefanich, G. P. (Ed.). (2007). *The Ontogeny of Inclusive Science*. Dubuque, IA: Kendall-Hunt Publishing Company.
- Stefanich, G. P., Gabrielle, A. J., Rogers, B. G., & Erpelding, C. (2005). Improving educator attitudes about inclusive science through dissemination workshops. *Journal of Science Education for Students with Disabilities* 11(1), 6-24.

- Stumbo, N. J., Lindahl-Lewis, P., & Blegen, A. R. (2008). Two mentorship case studies of high school and university students with disabilities: Milestones and lessons. *Journal of Rehabilitation* 74(3), 45-51.
- U.S. Department of Education. (2001). *To assure the free appropriate public education of all children with disabilities: Twenty-third annual report to Congress on the implementation of the Individuals with Disabilities Education Act*. Retrieved February 3, 2011, from <http://www.ed.gov/about/reports/annual/osep/2001/toc-execsum.pdf>
- Utschig, T., Moon, N., Todd, R., & Bozzorg, A. (2011). The SciTrain University project: Classroom innovation for ALL students. *International Journal of Process Education* 3(1), 51-64.
- Wasserman, J., & Beyerlein, S. (2007). SII method for assessment reporting. In S.W. Beyerlein, C. Holmes, & D. Apple (Eds.), *Faculty guidebook: A comprehensive tool for improving faculty performance* (4th ed.). Lisle, IL: Pacific Crest.
- Webb, K. W., Patterson, K. B., Syverud, S. M., & Seabrooks-Blackmore, J. J. (2008). Evidence based practices that promote transition to postsecondary education: Listening to a decade of expert voices. *Exceptionality* 16(4), 192-206.
- Wolanin, T. R., & Steele, P. E. (2004). *Higher education opportunities for students with disabilities: A primer for policy makers*. Washington, DC: The Institute for Higher Education Policy.

Authors' Note

This research is sponsored by the Office of Postsecondary Education, U.S. Department of Education, under grant number P333A080022. The opinions contained in this publication are those of the grantee and do not necessarily reflect those of the U.S. Department of Education. The authors wish to thank Melissa Ann Crane, Chris Langston, Brendan Leahy, Katie McNulty, David Morton, Stephen Rehberg, Esther Shin, Devon Thompson, Margaret Totty, Laura Waters, Joyce Weinsheimer, and Jungwon Yoon for their contributions. In addition, we wish to acknowledge that NSF Grant No. HRD-0929006 facilitated the publication of this article.

About the Authors

Nathan W. Moon received his PhD in the history and sociology of science and technology from the Georgia Institute of Technology in Atlanta. He is currently the associate director for research at the Center for Advanced Communications Policy (CACP) at Georgia Tech and also holds an appointment as research scientist. His current interests include the accommodation of learners with disabilities in STEM education, policymaking to support workplace accommodations, evaluation of STEM education programs, and the history of psychiatry. He may be reached by e-mail at: nathan.moon@cacp.gatech.edu

Tristan T. Utschig received his BS degrees in nuclear engineering and in physics from the University of Wisconsin – Madison, and a Ph.D. in nuclear engineering and engineering physics from the University of Wisconsin – Madison. His experience includes directing the engineering program at Lewis-Clark State College as a tenured Associate Professor of Engineering Physics, and serving as director of assessment for the Division of Natural Science. He is currently a Senior Academic Professional and the Assistant Director for Scholarship and Assessment of Teaching and Learning in the Center for the Enhancement of Teaching and Learning at Georgia Tech. His research interests include assessment for learning, using technology in the classroom, faculty development in instructional design and delivery, and peer coaching. He can be reached by email at: tris.utschig@cetl.gatech.edu

Robert L. Todd received his MS degree in Rehabilitation Counseling from Georgia State University and MS in Digital Media from the Georgia Institute of Technology. He serves as Director of the Georgia Tech Accessible Education and Information Laboratory and is currently a Senior Research Scientist in the College of Architecture. His research interests include improved STEM education for students with disabilities, new methods of delivering accessible online education, mediation of virtual worlds for accessibility and enhanced usability of web resources. He can be reached by email at: robert.todd@coa.gatech.edu

Ariyana Bozzorg received his B.S. degree in Psychology and M.S. in Human Computer Interactions from the Georgia Institute of Technology. His experience includes working as a behavior specialist in DeKalb County and serving as a local advocate for disability rights groups. He is currently a research coordinator in the Department of Veterans Affairs. His research interests include postsecondary education and markers of success for adults with disabilities and social factors that influence accessibility and performance. He can be reached by email at: aaron.bozzorg@gatech.edu

The Impact of a Working Conference Focused on Supporting Students with Disabilities in Science, Technology, Engineering, and Mathematics (STEM)

Audrey C. Rule

Greg. P. Stefanich

Robert M. Boody

University of Northern Iowa

Abstract

This paper examines the effects of a two-day working conference on attitudes and dispositions of educators and other professionals who have a responsibility to students with disabilities. During this professional meeting, participants shared their experiences and suggested strategies to better educate students with sensory and mobility disabilities. The purpose of this working conference was to stimulate dialogue to (a) improve attitudes toward, (b) investigate ways to better support, and (c) plan accommodations/supports for students with disabilities who have interests in science, technology, engineering, and mathematics (STEM) in secondary and postsecondary settings. Speakers and participants examined ways to support students transitioning from high school to postsecondary education, shared ideas to ease transitions from community colleges into STEM majors in four-year institutions, explored options for resolution of issues, and advanced recommendations for improving the quality of STEM education. A group of 66 professionals from a Midwest state and 159 upper division preservice students in teacher education participated as collaborative partners with speakers from exemplary programs during this working conference. Workshop participants had more positive attitudes toward teaching science for each of the four areas investigated: attitudes toward students, work-related dispositions, postsecondary dispositions, and work-related performance. The evidence indicates that a short-term working conference can significantly impact educators' preparedness, responsiveness to make accommodations, and attitudes toward including students with disabilities.

Keywords: working conference, inclusion, disabilities, professional development, attitudes, accommodations

The purpose of this study was to examine the effects of a working conference focused on science, technology, engineering, and mathematics (STEM) for students with sensory and mobility disabilities on educators' attitudes related to inclusive science education. This investigation contributes to the professional literature by determining the efficacy of this unique mode of professional development, which is neither a workshop nor a traditional conference. A *working conference* is a meeting during which expert professionals and stakeholders of the community (in our case, instructors, parents, students with disabilities, support personnel, administrators, and preservice teachers) combine their knowledge, experience, and perspectives to work collaboratively on a pressing and often controversial issue (Boody, Esveld, & Else, 1997). Time and structure are provided to stimulate

true dialogue between the parties. Ideas are recorded so that the results may be made public and built upon during future work. In this article, we: (a) review the literature on the efficacy of different professional development models, (b) examine the instrument used to measure participant attitudes toward students with disabilities who are pursuing coursework or careers in STEM fields, (c) describe our working conference and its outcomes related to participant discussions, (d) analyze pre- and post-test results of participant attitudes, and (e) draw conclusions regarding the efficacy of this form of professional development.

Efficacy of Professional Development Models

Professional development practices in the field of education constantly change as new models emerge. However, past practice is often abandoned on the

basis of just a few studies that demonstrate a more effective professional development model. A pertinent example of this is the adherence to a single model of long-term professional development predicated on criticisms of short-term professional development supplied by Joyce and Showers (1995). We argue that there are many factors in addition to “duration of professional development” that determine the effectiveness of such efforts. Ongoing evidence-based research is needed to continually examine approaches for efficacy in producing responsiveness to change among educators. Unfortunately, as Richardson and Placier (2001) remark in their review of the literature on teacher change, there are still “significant gaps in our understanding of change processes and our abilities to facilitate change” (p. 938).

In the past decade, some researchers have concluded that short-term staff development models involving theory and demonstration were ineffective in improving skills and their application to the workplace. Speck and Knipe (2001) stated, “Researchers have reached a clear consensus that one-time workshops for teachers are ineffective. The content is not transferred to the classroom, nor does it affect student achievement” (p. 84). They based that statement on the seminal publication of Joyce and Showers (1995) who emphasized the importance of practice, feedback, and coaching. Darling-Hammond, Ancess, and Falk (1995) similarly reported that teachers’ individual isolated efforts did not provide the power to significantly improve student achievement. They suggested that limited professional impact occurred without sustained long-term, district-wide initiatives and the inclusion of coaching. Joyce and Showers are often cited as reporting that only 5% of teachers applied a principle following presentation of the theory, while 10% were able to incorporate this idea in their teaching when modeling was included in the presentation, and up to 15% if practice and feedback were a part of the professional development session. Joyce and Showers claimed that when coaching during instruction was added, 80-90% of the teacher participants applied the theory.

Lumpe (2007) concurred with earlier authors’ conclusions, stating “one shot, workshop-based professional development is passé” (p. 125). He suggested the adoption of research-based professional development models that emphasize professional learning communities, which are based on a culture of collaboration and shared beliefs. Science teachers need to be at the

forefront of science education reform for inclusion of all students because they are the change agents in the classroom. Therefore, teacher belief systems need to be addressed as these personal convictions guide their actions (Haney, Lumpe, Czerniak, & Egan, 2002). Although intensive, longer-term, collaborative professional development is desirable because it often results in more substantial and lasting educator change, we believe that short-term efforts to stimulate awareness, examine beliefs, and promote collaboration can serve an important role in education reform.

A better understanding is needed of how the goals of a professional development initiative, the context of the professional development experience, and professional development strategies work together to effectively produce specific changes in the educational experiences for students. The working conference model allows for a rich exchange of ideas among a diverse group of professionals addressing a common goal through dialogue. Additionally, there is evidence that educators can, and do, change their practices with brief, targeted professional development experiences. Duffrin (2002) showed that when teachers feel a need and a readiness to learn something, they are more likely to choose to participate in professional development opportunities. Participants of a working conference may similarly seek additional professional development after sharing their insights and discussing issues with professional colleagues.

Exclusive use of long-term, district-wide professional development programs limits input from outside experts who may only be available for brief appearances. An advantage of the working conference format is that it connects knowledgeable professionals beyond the school district with those inside a particular institution, thereby providing a broader range of viewpoints for school reform. Lieberman and Miller (1999a) reported the critical need to balance the use of inside and outside expertise and accompanying research that informs professional school practice. Educators in that study reported that experiencing out-of-school professional development with colleagues convinced them to adopt new approaches, resulting in greater student participation and success (Lieberman and Miller, 1999b).

Research (Schumm & Vaughn, 1995; Stefanich, Gabriele, Rogers, & Erpelding, 2005; Yuen, Westwood, & Wong, 2004) has indicated that teachers of students in inclusive classroom settings report they lack the

knowledge, skill, and confidence to make instructional adaptations for students with disabilities. Additionally, researchers have observed that adaptations were not consistent, systemic, or as frequently implemented as the circumstances required. Therefore, changing classroom practices to accommodate students with disabilities is a needed but challenging task that requires motivation. For educators to be persuaded to improve their instructional skills and change their performance, they must be professionally involved in improving practice. The format of a working conference provides educators with an opportunity to provide input and take a more active professional role in the planning of change in practice. Blandford (2000) identified six elements of effective professional development: providing role models of good practice and attitude, arranging specific guidance/training, encouraging reflection, delegating with sensitivity, promoting developmental initiatives, and providing information and developmental opportunities. Although a short-term working conference cannot address all of the elements noted by Blandford, it can address many of them and provide a stimulus to implement the other elements.

Goals of the Working Conference

The working conference targeted specific beliefs and attitudes towards inclusive science education through speaker presentations and discussion questions. These goals can be grouped into categories with specific attitudinal outcomes (Stefanich et al., 2005) as shown in Table 1. A questionnaire was designed and administered to determine the effects of the working conference on these specific beliefs and attitudes.

Method

Organization of the Working Conference

The presentation and discussion sessions of the working conference occurred over a two-day period. There were three sets of presentations by panels of speakers each day that were followed by conversation among the eight participants seated at each of multiple tables in response to given questions. The third panel presentation on the second day (poster presentations of assistive technology devices created by engineering students) was followed by a summary and wrap-up by the conference hosts rather than table discussions. A detailed schedule of speakers and presentation topics has been provided in Rule, Stefanich, Haselhuhn,

and Peiffer (2009), but is summarized here. The five sessions addressed the following main topics: (a) community college STEM programs along with disability support services; (b) support services for students with disabilities at state institutions that focused on students pursuing STEM careers along with first-hand experiences and insights from a student with mobility impairments who majored in biology; (c) internships and mentorships for students with disabilities, together with information about disability services in adjoining states and department of education supports; (d) assistive technology programs, transition services to work, and funding opportunities; and (e) transition services, assistive technology, and supports for students with sight, hearing, and motor impairments. During an evening banquet on the first day, high school teachers, parents, and students with vision impairments discussed their experiences in STEM classes. Additionally, a keynote address at the start of the second day focused on challenges and supports in STEM careers for students with disabilities.

Discussion Response Data Collection

Data were collected during the group discussions that followed each panel of speakers. Conference attendees discussed two types of question sets after each set of panel presentations as volunteers typed responses into a Google Document through a laptop at each table. One set was based on de Bono's CoRT thinking skills (de Bono, 2000), such as determining the pluses, minuses, and interesting aspects of a statement (PMI) or listing the factors that affect a situation (Consider All Factors or CAF). Participant responses to the de Bono questions are discussed in Rule and Stefanich (in press). The other set consisted of two questions that were repeated for conversation after each panel presentation: "What new understandings or insights do you have about students with disabilities or services for students with disabilities pursuing STEM subjects, now, since the panel presentation?" and "What connections can you make between the information you just heard and what you already know, especially connections that lead to ways to help students with disabilities succeed in STEM subjects?" Responses to these questions are reported and qualitatively analyzed here using the constant comparison method in which similar responses were grouped and then further categorized by major trends shown (Charmaz, 2006; Richards, 2005).

Table 1

Attitudinal Goals of the Working Conference

General Category	Specific Outcome
Attitudes Toward Students	<p>To help participants recognize that students with disabilities have equal rights to develop to their full potential.</p> <p>To recognize that, with appropriate accommodations, students with disabilities can attain and succeed like all other students.</p> <p>To instill an awareness that students with disabilities can, and should, actively participate in laboratory activities and do not pose any additional risks for teachers or other students.</p> <p>To understand that high quality science instruction plays an important role in preparing students for future learning in all aspects of life.</p>
Postsecondary Dispositions	<p>To develop in participants readiness to teach all students in the science classroom.</p> <p>To familiarize participants with resources, strategies, possible specific accommodations, and specialized methods for meeting the needs of all students.</p> <p>To develop a familiarity with best practice research and the temperament to apply the correlates of effective schools in their teaching.</p> <p>To familiarize participants with teacher responsibilities under legislative mandates (IDEA, ADA, etc.), and to instill in them a commitment to comply with these legislative initiatives and policies.</p> <p>To instill an awareness of educators' safety and legal responsibilities in science classroom, laboratory, and/or field settings.</p>
Work-related Dispositions	<p>To instill in participants an awareness that meeting the needs of students with disabilities in a science setting is not providing something "extra," but simply providing an equivalent opportunity previously afforded to all other students while excluding or marginalizing those with disabilities.</p> <p>To develop a temperament to collaborate with others, especially those with academic preparation, in meeting the needs of students with disabilities.</p> <p>To be accepting of all individuals in their teaching, professional, and personal interactions.</p> <p>To communicate with students and guardians to help students establish and assume responsibility for high expectations and high levels of personal accomplishment.</p> <p>To create a commitment in participants to make learning-related adjustments to provide students with disabilities equivalent educational experiences in science.</p>
Work-related Performance	<p>To instill in participants a commitment to sustained physical and mental effort to obtain high learning outcomes for all students.</p> <p>To exercise creative talent and expend creative effort to select, design, and modify learning tasks so all students can attain learning outcomes commensurate with their talents and abilities in science.</p> <p>To adhere to a pattern of support, encouragement, and cooperation when working with students who are not responding to instructional opportunities.</p> <p>To modify instructional practices, management strategies, teaching practices, and time allocations to best serve the learning needs of all students.</p> <p>To help students develop meta-cognitive skills that promote positive decision-making and learning independence.</p>

Participants

There were two main groups of conference participants—practicing education professionals and preservice teachers. The practicing professional participant group included individuals from community colleges, regent institutions within the state and from neighboring states, the state department for the blind, area education associations, business and industry, middle schools, and high schools. These professionals were teachers, college instructors, disability support specialists, school-to-work specialists, administrators, state department of education personnel, and a few parents and students with disabilities. The second group consisted of preservice teachers who were enrolled in senior level science methods courses. The preservice student participants did not attend all of the program sessions. Most attended one or two speaker panel presentations with its following discussion. However, all participants were asked to complete the pre- and post-tests. Data analysis was conducted using the pre- and post-conference survey assessments completed by participants. The questionnaires were coded enabling us to match the individual pre-test and post-test responses. Complete responses were received from 31 of 63 (49.2%) professional participants and 82 of 159 (51.6%) preservice teacher participants. Demographic information about ethnicity, gender, professional capacity, or length of time teaching was not collected from the respondents.

Instrumentation

A 44 item questionnaire (Stefanich et al., 2005) was administered with eleven questions addressing each of these four areas, as elaborated in Table 1: attitudes toward students, work-related dispositions, postsecondary dispositions, and work-related performance. The questionnaire had 22 questions with a negative direction in which disagreement was the most desirable outcome and 22 questions with a positive direction in which agreement was the most desirable outcome (see Appendix). Working conference participants were asked to respond on a five-point Likert scale ranging from “strongly agree” to “strongly disagree.” For questions stated in a negative direction, a value of five was assigned to strongly disagree down to one for strongly agree. Opposite values were assigned to questions stated in a positive direction; five to strongly agree down to one for strongly disagree. Overall, mean scores in each category were tabulated for the statistical analysis.

Validity and reliability evidence for this questionnaire were gathered from a previous study (Stefanich et al., 2005). Content validity evidence for the survey questionnaire was obtained from written comments provided by practitioners, critiques of the questionnaire by authorities with STEM backgrounds, and feedback from multiple workshop recipients. Internal consistency estimates of reliability (Coefficient alpha) for the entire instrument (.96) and each of the sub-scales (Attitudes toward Students = .85, Work-Related Dispositions = .84, Postsecondary Dispositions = .85, and Work-Related Performance = .91) were uniformly high.

Analysis of Surveys

Questionnaire responses were scanned into electronic format and then analyzed using the Statistical Package for the Social Sciences (SPSS). Each item was examined individually and indices were created for total score and the four sub-scales. Analysis focused on (a) changes from pre-test to post-test, (b) differences between participants who were practicing professionals and those who were still preservice, and (c) interaction between the two independent variables. These three analyses were carried out using two-way ANOVAs for total score as well as the four sub-scale scores.

Results and Discussion

Qualitative Analysis of the Participant Discussion Responses

After each panel presentation, participants, seated in groups of eight, were asked to discuss a set of given questions. Two questions were repeated for each discussion: “What new understandings or insights do you have about students with disabilities or services for students with disabilities pursuing STEM subjects, now, since the panel presentation?” and “What connections can you make between the information you just heard and what you already know, especially connections that lead to ways to help students with disabilities succeed in STEM subjects?”

Table 2 shows new understandings from the first three panel discussions held on the first day of the conference. Participants indicated new understandings at the end of the first half of the conference in several areas:

- STEM teachers are generally not aware of the possibilities of assistive technologies enabling

students with disabilities to succeed.

- Community colleges in the Midwest seem to be leading the way in terms of educational support and career services.
- The psychological environment of students with disabilities needs to be addressed through improving self efficacy and through professional development of teachers and support staff.

Table 3 shows connections participants reported making on the first day of the conference. Insights made by participants include:

- Accommodations need to be provided early (preschool or elementary) for students and continue as long as needed.
- Students need to be self-advocates.
- STEM subjects are important for all students – students with disabilities should not be pulled out of science classes to address deficits in reading and mathematics.

Table 4 shows some new understandings reported at the end of the second day of the conference:

- Amazement at the variety of resources available to assist students with disabilities was expressed.
- Expectations should remain high but students with disabilities often require additional time to meet those expectations.
- It is important for students to assume responsibility for self-disclosure of disabilities and education of instructors in their needs.

Table 5 tells additional insights of participants on the second day of the conference:

- Educators need to address stereotyped attitudes and work collaboratively to connect students to needed resources.
- Assistive technologies are available for a variety of disabilities that allow full participation in STEM.

The data in Tables 2, 3, 4, and 5 indicate that conference attendees gleaned important information from the panels of speakers, much of it attitudinal in nature. For example, during discussions on the second

conference day, participants stated their realization that disabilities are a pervasive part of the human condition; we all have disabilities in some areas. On the first day, attendees mentioned that they had connected “individualization” to the current discussion because students with disabilities need to have their needs and accommodations considered individually. Participants also became more aware of the broad range of services and supports available to students with disabilities as evidenced in comments during dialogue both days of the conference. In comments that spanned the entire conference, they noted that it is important to start early in developing interests and preparing students with disabilities for coursework or careers in STEM fields. In addition, participants noted the importance of providing assistance when students struggle so they do not get behind or become discouraged in their work.

Recorded remarks on both days show conference participants suggested that teachers and support personnel teach self-advocacy to students with disabilities, encourage students, and provide role models of others with disabilities who have succeeded. Affective issues that surfaced during the conference included the idea that teachers should maintain high expectations for students with disabilities and involve them in science inquiry. Participants noted that they were now aware of mentorship and internship programs that are available, providing important experiences for students with disabilities. Additionally, attendees remarked about their new awareness of how assistive technology at school, work, and home expands the quality of life for students with disabilities; therefore teachers, employers, and support personnel need to know more about it. They also referred to the ideas presented by speakers with disabilities who discussed accommodations that worked best for them in science classes.

Attitude Survey Data Results

Workshop participation effects on educators’ attitudes. Table 6 provides the descriptive statistics (means, standard deviations, statistical significance) for attitude scores pre- and post-workshop in the four goal areas and overall. To examine the effects of workshop participation on educators’ attitudes toward disability and inclusion, five two-way ANOVAs were performed on the four attitude sub-scales, and the overall total score. These ANOVAs were of 2x2 mixed design, including one between-groups factor (group: professional or pre-service) and one within-subjects factor (time: pre-test

Table 2

New Understandings Reported by Participants During the First Day of the Conference

Generalized Concept	Examples of Supporting Responses
Starting earlier to assist students with disabilities in STEM fields is better	Look at STEM careers earlier in K-12 so that students can set goals. Teach self-advocacy earlier.
Better teacher/instructor preparation	Teachers are unaware of the possibilities for assistive technology. Schools aren't making use of everything that is available. Teachers need more professional preparation to improve services.
Range of services offered	Some schools make accommodations and some don't. Many STEM career options at community colleges. Community colleges offer more support and assistive technologies than high schools. Temporary disability services may be given while a student is obtaining documentation.
Philosophies	High schools make modifications; colleges make accommodations but not modifications of course requirements. Students need to know requirements for being hired so they can choose careers in which they can succeed. Self efficacy and self advocacy are very important.
Mentorships/internships	Having a mentor makes a student more comfortable about approaching new life experiences. Anyone can apply for mentorships and camps.
Cognitive and Psychiatric disabilities	Surprised at the large percentage of mental compared to physical disabilities. Schools are now focused on accommodating these invisible disabilities. Instructors need professional preparation to understand how to help students with mental disabilities succeed in their courses.
Science class accommodations	We can learn a lot from students with disabilities about what works for them. A clearer picture of the types of accommodations that can be made in science labs.
Science inquiry	Used to be reserved for honors students, but now for all students. Most students did rote textbook work in science class. If teachers are struggling with teaching it, how can they begin to make accommodations?

Table 3

Connections made by participants between ideas presented by speakers and other areas on the first day of the conference

Generalized Concept	Examples of Supporting Responses
Insights connecting multiple grade levels	<p>No matter the grade level or age of the students with a disability, the accommodation is similar.</p> <p>Need to start early in elementary grades to provide meaningful, engaging STEM activities so interest is there in high school.</p> <p>A student's accommodations may change across grades even though the disability remains.</p> <p>Students need to work on self-advocacy from early ages – they need to become experts in their disabilities. Parents should know about this also.</p>
Connections to individualizing	<p>Students with disabilities need to be considered on a case-by-case basis.</p> <p>Go with each student to the disability office the first year at college to get students started.</p> <p>Hire a teaching assistant familiar with the curriculum to help students with disabilities in the classroom.</p>
State core curriculum	<p>The core curriculum will have appropriate accommodations for students.</p> <p>This core curriculum is a big shift for educators in the way it focuses on inquiry in all subjects.</p> <p>Students with special needs usually get pulled out of science rather than out of math or reading, but with the core curriculum they will no longer be able to be pulled out from science.</p>

and post-test). Table 6 shows significant improvements for conference participants in all four goal areas and overall at the 0.01 level of significance.

Table 7 displays the data separated by groups (professionals and preservice teachers). First, for the sub-scale "Attitudes toward Students," professionals did not score significantly higher than preservice students $F(1, 104) = 3.61, p > .05$; attitudes improved significantly from pretest to posttest $F(1, 104) = 32.84, p < .001$, effect size (d) = .45; with no significant interaction $F(1, 104) = 2.14, p > .05$. Cohen's d is a commonly used effect size that measures the magnitude of a treatment effect (Cohen, 1988).

For "Work-Related Dispositions," professionals scored higher than preservice students $F(1, 104) = 5.78, p = .018$; attitudes improved from pre-test to post-test $F(1, 104) = 24.44, p < .001$; and there was a significant

interaction $F(1, 104) = 4.65, p = .033$. This interaction was produced by the professionals improving their attitude (effect size (d) = .60) more than did the preservice teacher candidates (although their attitude did increase as well, effect size (d) = .27).

For "Postsecondary Dispositions," professionals scored higher than preservice students $F(1, 104) = 7.68, p = .007$, effect size (d) = .56; attitudes improved from pre-test to post-test $F(1, 104) = 33.31, p < .001$, effect size (d) = .53; with no significant interaction $F(1, 104) = 3.26, p > .05$.

For "Work-Related Performance," professionals scored higher than preservice students $F(1, 104) = 5.79, p = .018$, effect size (d) = .31; attitudes improved from pre-test to post-test $F(1, 104) = 23.02, p < .001$, effect size (d) = .38; with no significant interaction $F(1, 104) = 2.97, p > .05$.

Table 4

New understandings from the second day of the conference

Generalized Concept	Examples of Supporting Responses
Available resources and services for students with disabilities	<p>Surprised at the vast amount and variety of resources for students with disabilities.</p> <p>Amazed at the resources available from the University of Iowa through the ICATER system.</p> <p>Know students with disabilities and now I know who to contact to help them.</p>
Home/school/work assistive technologies	<p>Interesting to see services, devices, and technologies that are not just in school.</p> <p>Can use devices at school, but also allowed to take them and use them at home.</p>
Disabilities are part of the human condition	<p>We all need to work together to see similarities and differences, because all humans have disabilities in different areas.</p> <p>People with disabilities need to be able to have fun even if it involves some risk.</p> <p>There are services so that college students with physical disabilities can lead a more independent life on campus.</p>
Encouragement and self esteem are important	<p>Students with disabilities sometimes need help, but won't ask for it.</p> <p>Knowing expectations and requirements for various careers helps when encouraging students.</p> <p>People who are blind have succeeded in many STEM fields: physics, chemistry, marine biology.</p> <p>Students with disabilities need think time for transitions.</p> <p>Expectations should be kept high for students with special needs.</p> <p>Help students when they first begin to struggle in a subject, so that they don't get far behind.</p>
Professional development for teachers concerning assistive technologies	<p>Assistive technology devices can be loaned to teachers so they can take them home for a few days to see how they work.</p> <p>ICATER does trainings on-site that are hands-on.</p>
Self-advocacy	<p>Students with disabilities should write research paper on own disability to increase understanding.</p> <p>Self-reporting and self-disclosure of disabilities should be encouraged.</p> <p>Encourage more self-advocacy for students with disabilities.</p>

Table 5

Connections made by participants between ideas presented by speakers and other areas on the second day of the conference

Generalized Concept	Examples of Supporting Responses
Affective issues	<p>Helping students earlier, as soon as they are beginning to learn to read, so that they don't get behind.</p> <p>Encouraging more self-advocacy.</p> <p>Assistive technologies can really expand the quality of life for persons who are blind.</p> <p>Believing in the students - getting rid of stereotypes</p>
Importance of knowing about resources	<p>Connecting some of my students with the resources they need.</p> <p>As a parent- useful to know about resources and who to contact for help.</p>
Preparing teachers	<p>Need to feel comfortable with assistive technology - teachers need to have time to try it.</p> <p>Important to keep up with new technologies.</p> <p>Show teachers success stories of students with disabilities using assistive technology.</p> <p>All teacher preparation institutions need to have assistive technologies available.</p>

Table 6

Mean scores, standard deviations, and t from respondents on attitude survey*

Category	Pretest Mean	Posttest Mean	<i>t</i>	Significance
Attitudes Toward Students	3.64 (0.44)	3.87 (0.51)	5.86	<.01
Work-Related Dispositions	3.91 (0.48)	4.08 (0.55)	4.41	<.01
Postsecondary Dispositions	3.54 (0.38)	3.74 (0.43)	5.65	<.01
Work-Related Performance	3.84 (0.48)	4.02 (0.56)	4.56	<.01
Overall Total	3.73 (0.37)	3.93 (0.44)	6.67	<.01

*Standard deviations shown in parentheses.

Table 7

Mean scores from respondents on attitude survey

Group	Attitude About Students		Work-related Dispositions		Postsecondary Dispositions		Work-related Performance		Overall	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Professionals	3.72	4.08	4.03	4.38	3.61	3.95	3.79	4.21	3.79	4.16
Preservice Teachers	3.59	3.81	3.82	4.00	3.48	3.67	3.77	3.97	3.66	3.86

Finally, for the overall score, professionals scored higher than preservice students $F(1, 104) = 5.79, p = .018$; attitudes improved from pre-test to post-test $F(1, 104) = 48.70, p < .001$; and there was a significant interaction $F(1, 104) = 5.49, p = .021$. This interaction was produced by the professionals improving their attitude (effect size $(d) = .86$) more than did the preservice teacher candidates (although their attitude did increase as well, effect size $(d) = .43$).

There was significant improvement from pre-test to post-test for both the professionals and for the preservice teachers in all areas of these results. When considering the four subscales and the total attitude changes, in almost every case, there was a difference between the professional participants and the preservice teachers, with the positive effect on the professionals always being higher. The reason there is an interaction in the total score and in one of the four subscales (work-related dispositions) is likely because professionals improved at a much greater rate than preservice teachers. This is also reflected in the differences in effect size between these two populations in total score: the attitude change of professionals showed a large effect size (0.86) while the attitude change of preservice teachers also showed a substantial but medium effect size (0.43). In contrast, other researchers (Roberts, Henson, Tharp, & Moreno, 2001) who have examined the efficacy of professional development programs of differing lengths (two-to-three weeks versus four-or-six weeks) in improving teacher efficacy for teaching science found only small effect sizes.

Insight can be derived from looking at the analysis of individual questions showing significant changes from pre-test to post-test that are shown in Table 8. For example, the most significant difference was noted on the statement: "Students with special needs are at risk in terms of safety in hands-on science lessons." Discussion of the results of this item is particularly appropriate because the comments made by blind participants who completed the pre-test prior to coming to the conference and inquired why the question was included. The essence of the conversation was, "Isn't safety a concern in planning hands-on science for all students?" The implication was, in planning and preparation, professional educators would not look at students with disabilities any differently than students without disabilities. However, the pre-test data of other participants clearly indicate that it is not the case. The conference had a major impact on improving attitudes about including all students in hands-on investigations and making science accessible for all students. The statement with the second-most significant pre-to-post difference closely parallels the previous statement, again reflecting changes in attitude about the importance and need for including students with special needs working with other students in science laboratory activities.

The statement with the third largest pre-to-post change reflected awareness among participants of a need to improve their general strategies to address students with disabilities in a science classroom or laboratory. This can be connected to research results of several stud-

ies (Schumm & Vaughn, 1995; Stefanich et al., 2005; Yuen, Westwood, & Wong, 2004) that showed teachers do not have enough strategies for teaching students with disabilities. Even this relatively short working conference experience helped change this endemic problem.

Finally, the last line of Table 8 shows participants' improved comfort in being in a setting where there are persons with visual disabilities (i.e., low-vision or blindness). This might be a direct consequence of the number of participants who had disabilities at the working conference including three individuals who

were blind. Feters, Czerniak, Fish, and Shawberry (2002) found that teachers' lack of skills led to anxiety when trying to implement a new teaching system of using hands-on science kits, but this situation was ameliorated by in-service work with the materials. In our study that addressed person-to-person interactions rather than use of new materials, hearing the perspectives of students and professionals with sensory and mobility disabilities similarly eased anxiety, increased understanding, and improved attitudes toward including such students in STEM classes.

Table 8

Mean Scores and t on statistically significant individual survey questions with p less than .01.

Question	Pretest Mean	Posttest Mean	<i>t</i>	<i>p</i>
Students with special needs are at risk in terms of safety in hands-on science lessons.*	2.91	3.43	-5.74	<.01
Students with severe special needs should be included in science laboratory activities with regular students.	3.98	4.50	-5.48	<.01
I am aware of general strategies to address students with disabilities in a science classroom or laboratory setting.	3.24	3.63	-4.54	<.01
I am aware of safety and legal issues relating to classroom science instruction.	3.13	3.50	-3.51	<.01
I provide additional laboratory time for students with special needs.	3.56	3.79	-3.38	<.01
Too much money is spent to address the unique needs of students with special needs.*	3.59	3.93	-3.36	<.01
It is impossible to expect a student with a physical disability to be an active participant in all laboratory exercises.*	3.84	4.13	-3.33	<.01
It is unrealistic to expect a blind student to be a chemist.*	3.99	4.29	-3.26	<.01
Special needs students gain self-esteem and confidence through science activities.	4.20	4.42	-3.12	<.01
I am more comfortable in a setting in which there are no people with visual disabilities (i.e., low-vision or blindness).*	3.12	3.39	-3.07	<.01

* Although these statements are phrased as on the original questionnaire (in the negative direction), the scores shown here have been adjusted as if the questions had been phrased positively, so that pretest to posttest movements could be easily compared between questions. Therefore, an increasing score from pretest to posttest on all questions shown here indicates an attitudinal change favoring students with disabilities.

Conclusions

Summary of Findings

The data from this study punctuate the importance of professional development for faculty and staff to improve the participation level of students with disabilities in hands-on science rather than serving as passive observers or marginalized participants. Working conferences such as the one reflected in this investigation can be an important first step in increasing awareness and improving attitudes about the inclusion of students with disabilities in STEM education. The goals of the working conference (shown in Table 1) were supported by the results of this study. As shown in Table 6, there were significant gains in all of the four goal areas. Therefore, this study indicates that a short-term working conference can change STEM-related attitudes towards students with disabilities, postsecondary dispositions, work related dispositions, and performance related dispositions, which were the four goal areas of the working conference.

Participants provided information on their perceptions of the best direction of future professional development. Responses from participants clearly reflected a need for additional professional preparation about resources and strategies to improve their knowledge and skills in making accommodations for students with disabilities in STEM classroom and laboratories. The need for greater collaboration was noted. The conference brought out the existence of limited awareness among professionals of other professional entities that serve students with disabilities, and limited contact between individuals from different agencies. Considerable satisfaction with networking opportunities, and appreciation of the opportunity to interact with other professionals who have different roles but similar desired outcomes for students with disabilities, were reflected in the narrative evaluation statements.

Three of the six elements of effective professional development as identified by Blandford (2000) were directly addressed by this working conference. Role models of good practice and attitude were provided by many conference speakers. For example, directors of offices of disability services discussed exemplary programs, and individuals with disabilities shared their educational and work-related experiences. Reflection was encouraged as participants engaged in discussions and problem-solving related to assisting students with disabilities in STEM education. The conference speak-

ers provided information about resources such as a mobile lab of assistive technology and professional development opportunities during their presentations and in their exhibits. Blandford's remaining three elements (arranging specific guidance and training, delegating with sensitivity, and promoting developmental initiatives) were addressed during discussions as suggestions for future actions.

The working conference employed here appears to be quite effective based on improving attitudes reflected in responses to the survey's questions. Although both groups reflected significant gain scores, professionals reflected significantly higher gains than the preservice teacher participants. Interaction effects were observed between the full-time professionals and the upper-division preservice teachers, which may reflect the lack of experience of preservice teachers and therefore readiness for growth, the shorter time-span of conference participation, or both.

A major finding of the study is that a working conference addressing the needs of science teachers working with students with disabilities produced significant positive changes in attitudes toward students with disabilities and evidence of increased commitment to make appropriate accommodations in consultation with students. In addition to giving participants knowledge and skills, the working conference enhanced collaboration and communication among those committed to improving science education of students with disabilities. Ample quantitative and qualitative evidence is seen in the efficacy of the working conference to positively impact the goal of greater equity in STEM education, contrary to published criticisms of short-term professional development programs. Working conferences such as the one investigated in this study can serve an important role in the continuing professional development of educators.

Limitations

This study is a summary and analysis of attitudes and discussion comments of participants attending a two-day working conference. Several elements in the design of the study are limitations. The participant groups consisted of volunteers and may not be equivalent to a random sample non-participant group. The sample populations were not stratified; therefore, there were not opportunities to compare participants and non-participants considering ethnicity, gender, teaching experiences, or professional expertise. The pre- and post-test intervals were short-term, adminis-

tered at the start of the conference and following the last session; long-term effects were not investigated. The instrument used in the study investigated only perceptions of the participants rather than observations of responsive behaviors to persons with disabilities with STEM career interests prior to and after the workshops. In this study, the attitudinal effects of a working conference in which participants were more fully engaged in problem-solving than typical workshops, was investigated. In our review of the literature, we were not able to locate studies that investigated the effects of conferences in this “working” format on teacher application of learning. The scope of this study did not address this criticism of short-term professional development, which is that teachers often do not apply what they learn at short-term workshops.

Implications

Short-term programs have a place in the overall toolkit of professional development strategies for the following reasons. A two-day working conference, such as the one described in this article, can provide attitudinal and conceptual change for teachers and professional staff with regard to including students with disabilities in science coursework or careers. Terehoff (2002) reported a dramatic increase in self-concepts when people make a transition from being a learner to a producer or doer. A working conference is more than a lecture or knowledge-dissemination process; it engages participants in discussion and digestion of the issues being addressed. This is similar to longer-term models that actively involve participants in grappling with issues. It is hard for university personnel with cutting-edge academic expertise and practicing professionals with specialized expertise to be involved in long-term intensive professional development projects because of the time commitment. The working conference model provides an opportunity to capitalize on the knowledge and skills of these outside experts.

With the understanding that more research is needed to affirm this investigation, the data and findings in this study challenge the blanket criticism of the ineffectiveness of short-term, one-time programs. Much depends upon the structure of the workshop, the context, and the participants. Although this research investigation did not measure K-12 student effects, the feedback from the participants reflects improved attitudes and greater commitment toward meeting the needs of all students, valuable professional development outcomes.

References

- Blandford, S. (2000). *Managing professional development in schools*. New York: Routledge.
- Boody, R. M., Esveld, L., & Else, D. (1997). The working conference: A model for collaborative dialogue and planning between educators and community. *Community Education Journal*, 25(3-4), 27-29.
- de Bono, E. (2000). *Edward de Bono's CoRT thinking lessons*. Oxford, U. K.: Cavendish Information Products, Ltd.
- Charmaz, K. (2006). *Constructing grounded theory: a practical guide through qualitative analysis*. Thousand Oaks, CA: Sage.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.
- Duffrin, E. (2002, June). Doing teacher training right. *Catalyst*, 13(9), 16.
- Darling-Hammond, L., Ancess, J., & Falk, B. (1995). *Authentic assessment in action*. New York: Teachers College Press.
- Fetters, M. K., Czerniak, C. M., Fish, L., & Shawberry, J. (2002). Confronting, challenging, and changing teachers' beliefs: Implications from a local systemic change professional development program. *Journal of Science Teacher Education*, 13 (2), 101-130.
- Haney, J. J., Lumpe, A. T., Czerniak, C. M., & Egan, V. (2002). From beliefs to actions: The beliefs and actions of teachers implementing change. *Journal of Science Teacher Education*, 13 (3), 171-187.
- Joyce, B., & Showers, B. (1995). *Student achievement through staff development: Fundamentals of school renewal*. White Plains, NY: Longman.
- Lieberman, A., & Miller, L. (1999a). *Teachers - transforming their world and their work*. New York: Teachers College Press.
- Lieberman, A., & Miller, L. (1999b). *Teachers caught in the action: Professional development that matters*. New York: Teachers College Press.
- Lumpe, A. T. (2007). Research-based professional development: Teachers engaged in professional learning communities. *Journal of Science Teacher Education*, 18, 125-128.
- Richards, L. (2005). *Handling qualitative data: a practical guide*. Thousand Oaks, CA: Sage.
- Richardson, V., & Placier, P. (2001). Teacher Change. In V. Richardson (Ed.) *Handbook of Research on Teaching* (4th ed.). Washington D.C.: American Educational Research Association.

- Roberts, J. K., Henson, R. K., Tharp, B. Z., & Moreno, N. P. (2001). An examination of change in teacher self-efficacy beliefs in science education based on the duration of inservice activities. *Journal of Science Teacher Education*, 12(3), 199-213.
- Rule, A. C., & Stefanich, G. P. (in press). *Using a thinking skills system to guide discussions during a working conference on students with disabilities pursuing STEM fields*. *Journal of STEM Education: Innovations and Research*.
- Rule, A. C., Stefanich, G. P., Haselhuhn, C. W., & Peiffer, B. (2009). *A Working Conference on Students with Disabilities in STEM Coursework and Careers*. ERIC Document Reproduction Service No. ED 505 568.
- Schumm, J., & Vaughn, S. (1995). Getting ready for inclusion: Is the stage set? *Learning Disabilities Research and Practice*, 10, 169-179.
- Speck, M., & Knipe, C. (2001). *Why can't we get it right? Professional development in our schools*. Thousand Oaks, CA: Corwin Press, Inc.
- Stefanich, G. P., Gabriele, A. J., Rogers, B. G., & Erpelding, C. (2005). Improving educator attitudes about inclusive science through dissemination workshops. *Journal of Science Education for Students with Disabilities*, 11(1), 6-24.
- Terehoff, I. I. (2002). Elements of adult learning in teacher professional development. *National Association of Secondary Schools Bulletin*, 86(632), 65-77.
- Yuen, M., Westwood, P., & Wong, G. (2004). Meeting the needs of students with specific learning difficulties in the mainstream education system: Data from primary school teachers in Hong Kong. *The International Journal of Special Education*, 20(1), 67-76.

Authors' Note

The information contained in this article is based upon work the Iowa Mathematics, Science, and Engineering Partnership (IMSEP) with funding "Planning for success in STEM for students with disabilities: A working conference," and with collegial support from "Midwest" a Regional Alliance supported by the National Science Foundation under Grant No. 0533197. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Iowa Board of Regents or the National Science Foundation. In addition, the Collaborative Dissemination Project under NSF Grant No. HRD-0929006 facilitated the publication of this article.

About the Authors

Audrey C. Rule received her B.A. degree in anthropology/archaeology and M.A. degree in geology from the University of Missouri-Columbia. She earned a Ph.D. in geology from the University of Wisconsin-Madison and has two additional Master's degrees in elementary education and gifted education from the University of Alabama-Tuscaloosa. Her experience includes working as an elementary classroom teacher and enrichment teacher for five years in various settings, including a public Montessori magnet school during which she earned American Montessori certification. She also taught at a residential summer science camp for students in grades 2-8 with vision impairments. She is currently an Associate Professor in the Department of Curriculum and Instruction at the University of Northern Iowa, teaching elementary science methods and courses in education of the gifted. Her research interests include science curriculum materials development, integration of higher-order thinking skills, and creativity. She can be reached by email at: audrey.rule@uni.edu.

Greg Stefanich received his B.S. degree in Chemistry, General Science from the University of Minnesota, Duluth and Ed.D. from the University of Montana. His experience includes four years of teaching in grades 3-12 and 41 years of service in post-secondary science education. He is currently a Regents Professor at the University of Northern Iowa. His research interests focus on accessibility for students with disabilities in the science classroom and science laboratory. He can be reached at: stefanich@uni.edu

Robert M. Boody received his B.S. in Accounting as well as his Ph.D. in Instructional Science from Brigham Young University. His experience includes a wide variety of research and program evaluation projects, as well as advising others in carrying out such studies. He is currently Associate Professor in the Department of Educational Psychology and Foundations at the University of Northern Iowa. His research interests include the use of research and assessment data for educational change, both at the institutional and programmatic levels, as well as at the individual teacher level. He can be reached by email at Robert.Boody@uni.edu.

Appendix

Survey of Attitudes Towards Teaching Science to Students with Disabilities

Directions: Please indicate the letter (see list below) that best represents your level of agreement or disagreement with the following statements.

A = Strongly Disagree

B = Disagree

C = Neutral, neither agree or disagree

D = Agree

E = Strongly Agree

1. Students with severe special needs should be included in science laboratory activities with regular students.
2. Too much money is spent to address the unique needs of students with special needs.
3. Teachers need special training to overcome prejudices and emotional barriers in working with students with special needs.
4. I am sensitive to teaching through the mind of the learners rather than expecting students to accommodate to my teaching.
5. Students with special needs are at-risk in terms of safety in hands-on science lessons.
6. It is unreasonable to expect a classroom to be open extra hours in order to allow the special needs student as an observer.
7. I feel inadequate in my preparation for teaching science to a student with a physical disability.
8. I put forth more effort to work with students that are not responding to instruction to enlist their support and cooperation.
9. Students with special needs increase the risk of other students in terms of safety in hands-on science lessons.
10. The attention given to special needs students detracts from teaching the other students.
11. All teachers of science should be required to participate in training on teaching science to students with special needs.
12. I engage in additional efforts to design, select or modify activities so that all students can achieve success appropriate with their talents and abilities.
13. In the majority of cases, it is best if peers conduct a science investigation with the special needs student as an observer.
14. The regular classroom teacher should not be expected to make major adjustments in order to serve special needs students.
15. I am aware of sourcebooks for making changes in my classroom environment and my teaching methods in order to accommodate student(s) with disabilities.
16. I modify my testing in assessment strategies and formats to allow greater numbers of students to experience a sense of success or accomplishment.
17. Special needs categories are too often used as an excuse for student failure.
18. The primary responsibility for communication concerning special needs students should rest in the hands of the special education teacher.
19. It is inappropriate to expect all science methods instructors in higher education to include topics and model lessons in teaching science to students with disabilities.
20. I work closely with parents or guardians to engage in cooperative efforts to serve the best interests of the child.
21. Special needs students gain self-esteem and confidence through science activities.
22. I wish I did not have to teach science to students with special needs.

23. Faculty in the area of special education should teach methods of teaching science for K-12 students with special needs.
24. I utilize Internet resources to seek out ideas that can help me be more responsive to addressing the needs of all students.
25. It is impossible to expect a student with a physical disability to be an active participant in all laboratory exercises.
26. Outdoor field trips are excellent opportunities for increasing the experiences of students with special needs.
27. There is no need for specialized methods of instruction in teaching science for students with disabilities in pre-service teacher preparation programs.
28. I modify my management strategies to make them more appropriate for the student diversity in my classes.
29. The majority of students with a physical disability also have cognitive impairments.
30. Care must be taken not to really challenge students with physical special needs in science because they are more likely to become frustrated and give up.
31. There is no need for specialized methods in teaching science for students with special needs in staff development programs or graduate classes.
32. I provide additional laboratory time for students with special needs.
33. It is unrealistic to expect a blind student to be a chemist.
34. I am more comfortable in a setting in which there are no people with visual disabilities (i.e., low-vision or blindness).
35. I am aware of general strategies to address students with disabilities in a science classroom or laboratory setting.
36. I am accessible to students with special needs outside of regular classroom instruction to respond to their individual needs.
37. It is unfair for a science teacher to encourage a person with severe motor/orthopedic special needs to pursue study in a career that involves active study like marine biology or geology.
38. I am accepting of student diversity in my own teaching.
39. I am aware of safety and legal issues relating to classroom science instruction.
40. I collaborate with other professionals in planning strategies for meeting the needs of all my students.
41. Care should be taken not to give special needs students unrealistic goal expectations which will inevitably result in frustration when they try to find employment.
42. I am comfortable in interacting with human diversity in my personal relationships.
43. I apply my knowledge of best practice research to improve my own teaching.
44. I work with my students to develop meta-cognitive skills (self-awareness, self-questioning, self-monitoring, self-reinforcement) to assist them in decision-making processes.

BOOK REVIEW

Greg. P. Stefanich
University of Northern Iowa

Burgstahler, S., Ed. (2009). *Making math, science, and technology instruction accessible to students with disabilities*. Seattle, WA: DO-IT University of Washington.

Making Math, Science, and Technology Instruction Accessible to Students with Disabilities, is a collaborative effort by a development team to provide educators with a resource for the dissemination of information about science and mathematics instruction for students with disabilities. Few practicing science educators (both K-12 and postsecondary) have had adequate preparation for addressing the diversity of students in their classes. The problem is particularly acute regarding students with disabilities who possess the capability of having a successful career in a STEM field. Complementary problems exist in addressing the needs of students with disabilities who require accommodations to develop general science literacy as informed citizens.

The authors express concern about underrepresentation and lower success rates of students with disabilities in STEM fields, both in the academic arena and STEM careers. They note that federal legislation mandates accommodations to ensure that students with disabilities have equivalent educational opportunities. These are required as an entitlement for students in K-12 and provided as an anti-discrimination measure to postsecondary students who are otherwise-qualified and request services. A major shortcoming is a lack of awareness within all grade levels of the science education community about characteristics of students with disabilities, available assistive technologies, accommodation strategies, and resources specific to science and mathematics. A corresponding shortcoming exists among many professionals with expertise in special education or disability services. The authors noted that too many of these individuals lack expertise in the STEM disciplines' content and assistive technology tools.

An overview of the rights and needs of students with disabilities is provided in the opening section. This explicit introduction explores themes regarding physical access, ethical and legal issues, and information access. Suggestions are offered regarding

self-advocacy and ways students can assume responsibility for the challenges they face in education and life in general. Numerous ideas are offered regarding information access, communication suggestions, and planning instruction that utilizes the principles of universal design. The book presents a four-step accommodation model that can be used to informally assess the sensory, physical, and cognitive challenges students with disabilities face, followed by options and strategies for addressing these challenges. The model works very well in preparing an educator to examine his or her instructional practices as it applies to the learning needs of an individual student.

Recent advances in technology have provided opportunities for access that did not exist before the twenty-first century. However, too few practicing science educators have an awareness and understanding of these tools. This book provides excellent first steps regarding access to computers, electronic resources, and assistive technologies. The book lacks a comprehensive overview and listing of adaptive instrumentation and tactile graphics for use by students with sensory impairments in science and mathematics. Also missing is information on accessible laboratory stations for students with motor/orthopedic impairments.

A second major focus of the book involves suggestions for pre-service and in-service professional development. These recommendations include "tips" about preparing a classroom that provides every student access to the information needed to learn, creating a comfortable learning environment, incorporating principles of universal design, and involving participants in a workshop. A series of stand-alone presentations on specific topics is shared. The presentations are brief and provide insights into different ways to frame an in-service program. Sample templates for PowerPoint or projector presentations are provided along with examples of instruments that can be used for workshop evaluation.

A third facet of the resource is a collection of four-to-six page briefs on a wide assortment of topics that can augment a particular element of disability access or instruction. These are excellent complements that can be shared as handouts with administrators, fellow educators, parents, and students. The final elements of the resource are DVD's containing: video clips that show students with disabilities working in STEM, suggestions from students about making instruction accessible and student-friendly, illustrations of students using computers and other adaptive materials, strategies for professional educators to work together as teams, and suggestions regarding the transition from K-12 into a postsecondary environment. The videos draw heavily from DO-IT Center programs that have been sponsored by the National Science Foundation since 1992.

The guide is an excellent resource for teacher educators, professional development specialists working with school districts, area education agency instructional strategists, or state department personnel. Science methods instructors can use the guide to address an area generally lacking in science and mathematics pre-service teacher education. It can provide practitioners with a wealth of introductory information. It provides a reference resource that can direct further learning for both the instructor and students. The video clips can be used to stimulate discussion and dialog among professionals.

The book has great potential for advancing educational reform by exposing science and mathematics educators to low incidence populations of students that require accommodations to be fully included in the learning process. For too long this responsibility has rested upon special education or disability services personnel who are rarely trained in STEM concepts or procedures. This book provides practical strategies and concrete examples of successful accommodation practices. If you work with students with disabilities, this book will refresh much of what you already know and may lead to fruitful new approaches. If you are a classroom teacher, postsecondary STEM educator, or educational strategist, it is an excellent reference for professional development.

About the Author

Greg Stefanich received his B.S. degree in Chemistry, General Science from the University of Minnesota, Duluth and Ed.D. from the University of Montana. His experience includes four years of teaching in grades 3-12 and 41 years of service in post-secondary science education. He is currently a Regents Professor at the University of Northern Iowa. His research interests focus on accessibility for students with disabilities in the science classroom and science laboratory. He can be reached at: stefanich@uni.edu

Author's Note

This material is based upon work supported by the National Science Foundation under Grant No. HRD-0533197. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation. In addition, I wish to acknowledge that NSF Grant No. HRD-0929006 facilitated the publication of this article.

Journal of Postsecondary Education and Disability

Author Guidelines

The *Journal of Postsecondary Education and Disability* welcomes submissions of innovative and scholarly manuscripts relevant to the issues and practices of educating students with disabilities in postsecondary educational programs. Manuscripts must be submitted electronically via e-mail to jped@ahead.org

Guidelines for authors:

Content

Manuscripts should demonstrate scholarly excellence in at least one of the following categories:

- Research: Reports original quantitative, qualitative, or mixed-method research
- Integration: Integrates research of others in a meaningful way; compares or contrasts theories; critiques results; and/or provides context for future exploration.
- Innovation: Proposes innovation of theory, approach, or process of service delivery based on reviews of the literature and research
- Policy Analysis: Provides analysis, critique and implications of public policy, statutes, regulation, and litigation.

Format

All manuscripts must be prepared according to APA format as described in *The Publication Manual* (6th ed.), American Psychological Association, 2010. For responses to frequently asked questions about APA style, consult the APA web site at <http://www.apastyle.org/faqs.html>

- Manuscript length typically ranges between 25 and 35 pages including figures, tables, and references. Exceptions may be made depending upon topic and content.
- Include 3-5 keywords.
- Write sentences using active voice.
- Authors should use terminology that emphasizes the individual first and the disability second (see pages 71-76 of the APA Manual). Authors should also avoid the use of sexist language and the generic masculine pronoun.
- Manuscripts should have a title page that provides the names and affiliations of all authors and the address of the principal author.
- Include an abstract that does not exceed 250 words. Abstracts must be double spaced on a separate page, or placed in an e-mail request.
- Provide a cover letter asking that the manuscript be reviewed for publication consideration and that it has not been published or is being reviewed for publication elsewhere.
- Tables and figures must conform to APA standards, and must be in black and white only. All tables and figures should be vertical and fit on the page, no landscape format.

Manuscripts must be submitted as e-mail attachments in Microsoft Word format to jped@ahead.org

Upon acceptance for publication

For manuscripts that are accepted for publication, the following items must be provided to the Executive Editor:

- An electronic copy of the final manuscript as an e-mail attachment.
- A 40-50 word bibliographic description for each author.
- A signed and completed Copyright Transfer form.

Manuscript submissions by AHEAD members are especially welcome. The JPED reserves the right to edit all material for space and style. Authors will be notified of changes.

Practice Brief Manuscripts

JPED will devote a few pages of general issues to a Practice Brief Section to expand the pool of innovative ideas. Practice Briefs will consist of practical strategies and programs used to support postsecondary students with disabilities. The body of the Practice Brief papers will be four pages long (excluding title page, abstract, reference page, Tables, and Figures). The Practice Briefs will not replace the regular research-based JPED papers. They will provide an opportunity for Postsecondary Disability Service staff to share their best practices. To write a Practice Brief for publication consideration, use the following to develop the paper:

- Title page
- Abstract (no more than 60 words)
- Literature Review (no more than two paragraphs, cite references using APA 6th edition style)
- Problem (one paragraph)
- Students and Location Information
- Strategy
- Observed Outcomes
- Implications
- References
- Tables and Figures (if needed)

If any questions, contact the JPED Editor David Parker at 317-730-0463 or e-mail: editor@ahead.org

Send your finished papers via e-mail to: jped@ahead.org for publication consideration. Each Practice Brief that is accepted for review will be sent to members of the JPED Practice Review Board. The Executive Editor will synthesize their recommendations when providing feedback and an editorial decision via e-mail.