Coaching as a Means to Enhance Performance and Persistence in Undergraduate STEM Majors With Executive Function Deficits

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This study examined the performance, persistence, and preferences of 120 undergraduate STEM majors with executive function deficits at a large Hispanic serving institution in the southeast United States. The study utilized a match-pairs experimental design with random assignment to treatment (i.e., executive function coaching, n=60) or control (business as usual, n=60) conditions. A cost reduction model was implemented with graduate special education majors acting as executive function coaches for the STEM majors. Findings indicated students in the treatment condition expressed statistically significantly higher scores on cumulative grade point average at the conclusion of the study. In addition, students in the treatment condition were more likely to persist in their STEM majors. Implications for practice are discussed.

Keywords: STEM, executive function, coaching, postsecondary, students with disabilities

INTRODUCTION

Individuals with high incidence disabilities, such as specific learning disabilities, autism spectrum disorders, and attention deficit disorders are historically underrepresented members of the science, technology, engineering, and mathematics (STEM) workforce (National Science Foundation, 2019). High-functioning individuals with disabilities have the potential to flourish in STEM careers such as computer science, data science, electrical engineering, software development, and medical careers (National Science & Technology Council, 2018). However, many lack the requisite executive function (EF) skills necessary for success at the postsecondary level. Deficits in EF inhibit content learning, self-efficacy, and self-determination (Dunn, Shannon, McCullough, Jenda, & Qazi, 2018). To be successful in STEM careers, students need 21st-century knowledge and skills, including authentic and dynamic problem-solving, collaboration, proficient EF, and critical analysis abilities (Schwab, 2016). However, these cognitive and interpersonal skills can be challenging for students with EF deficits (Koch, 2016).

Executive functions are defined as the process of physical, cognitive, and emotional self-control and self-regulation necessary to maintain an effective goal-directed behavior (Torske, Naerland, Oie, Stenberg, & Andreassen, 2018). They include several interrelated constructs such as planning, task initiation, organization, cognitive flexibility (i.e., the ability to fluidly shift from one task to another), working memory, emotional regulation, and self-control (Diamond, 2013). Postsecondary students with EF dysfunction often exhibit neurologic impairments related to the medial frontal cortex (Hsuan-Chen, White, Rees, & Burgess, 2018; Miyake & Friedman, 2012). This directly impacts their ability to independently persist in introductory STEM courses where ill-structured problems are presented without explicit instructions or clearly defined rule sets (White & Mitchell, 2013). Despite these challenges, research indicates EF skills can be enhanced using coaching practices focused on metacognitive awareness, self-determination, and student autonomy (Parker & Boutelle, 2009).

Challenges for Individuals With High Incidence Disabilities

Undergraduates at large universities (i.e., >20k students) may encounter a plethora of difficult barriers to circumvent (National Academies of Science, Engineering, & Medicine, 2018). For example, introductory STEM courses are often taught in large lecture halls with more than 100 pupils. Students then participate in smaller lab experiences, where the intention is to provide more personalized instruction. However, these labs are often staffed by graduate assistants who have little to no formal teacher training (National Academy of Sciences, 2012). Language barriers add to the complexity as graduate assistants, who may be English learners, try to translate their understanding of the content in areas such as statistics or physics to English. The results can be disheartening for students, leaving them disenfranchised with STEM before they have an opportunity to gain success. As a result, only 11% of students with disabilities major in STEM, persist until graduation and gain employment in a STEM field (National Science Foundation, 2019).

The National Science Foundation (2014) requested proposals for research on innovative frameworks to enhance the performance and persistence of undergraduates with disabilities who intend to major in STEM. "STEM persistence" is operationally defined as a student-level construct. Persistence occurs when students possess self-efficacy along with requisite content knowledge and social skills for continued participation in STEM courses and careers (Green & Sanderson, 2018). Persistence differs from "STEM retention" (i.e., How do we keep students here?) by shifting the focus to student-level intervention groups, which can be effective in as few as eight weeks (Grahm, Frederick, Byars-Winston, Hunter, & Handelsman, 2013).

This manuscript reports the findings of a novel performance and persistence intervention model at a large Hispanic Serving Institution in the southeast United States. The project staff systematically investigated how a successful model for enhancing undergraduate STEM learning and persistence at a small rural college could be transferred to a large urban institution while concurrently lowering costs. Koch (2016) summarized the rural college model as having broad content accessibility through the use of the Universal Design for Learning (UDL) framework. In addition, the author noted the importance of coaching and mentoring for content knowledge, employment, and EF development. Coaching is a short-term personalized approach to help individuals acquire specific skill sets, while mentoring is a longer-term, relationship-driven process to help individuals assimilate into novel environments (Carr, Holmes, & Flynn, 2017).

Universal Design for Learning

Universal Design for Learning is a framework for the design and implementation of instructional materials meeting the needs of students by proactively circumventing curriculum barriers (Rappolt-Schlichtmann, Daley, & Rose, 2012). Instruction is guided by three principles: (a) multiple means of engagement (i.e., considering how to engage students through a variety of pathways), (b) multiple means of representation (i.e., providing content through multiple methods), and (c) multiple means of action and expression (i.e., providing opportunities for students to demonstrate their understanding in multiple ways). Each principle is delineated further by guidelines and subsequent checkpoints (CAST, 2018).

The implementation of UDL focuses on integrating the three principles above across four instructional domains: 1) Clear goals, 2) intentional planning for learner variability, 3) flexible methods and materials, and 4) timely progress monitoring (Nelson & Basham, 2014). These critical elements are implemented using a five-step model: 1) Establish clear outcomes, 2) anticipate learner variability, 3) establish clear assessment and measurement plans, 4) design the instructional experience, and 5) reflect and develop new understandings. Universal Design for Learning harnesses the power of technology-enhanced, evidence-based strategies, and resources to support instruction for all students (Smith et al., 2019).

Coaching, Mentoring, and Advising Students With Disabilities in STEM

Literature on coaching students with disabilities in postsecondary settings has continued to emerge for more than a decade. For example, Parker and Boutelle (2009) noted coaching utilizing reflective questioning could lead to improvements in self-determination and self-regulation for individuals with attention deficit disorder. Field, Parker, Sawilowsky, and Rowlands (2013) found students who were randomly assigned to a coaching intervention exhibited statistically significant improvements in EF. Other studies involving postsecondary students in STEM found coaching led to improvements in self-confidence, self-regulation, motivation, and determination to succeed (e.g., Bellman, Burgstahler, & Hinke, 2015; Mitchell & Gansemer-Topf, 2016; Rando, Huber, & Oswald, 2016). D'Alessio and Banerjee (2016) reported coaching could be used as part of the academic advising process to enhance persistence toward a degree. However, DuPaul, Dahlstrom-Hakki, Gormley, Fu, Pinho, and Banerjee (2017) noted a limited number of empirical studies examined the efficacy (i.e., benefits under ideal research conditions) and effectiveness (i.e., benefits under real-world conditions) of EF coaching. The present study begins to fill this void in the research.

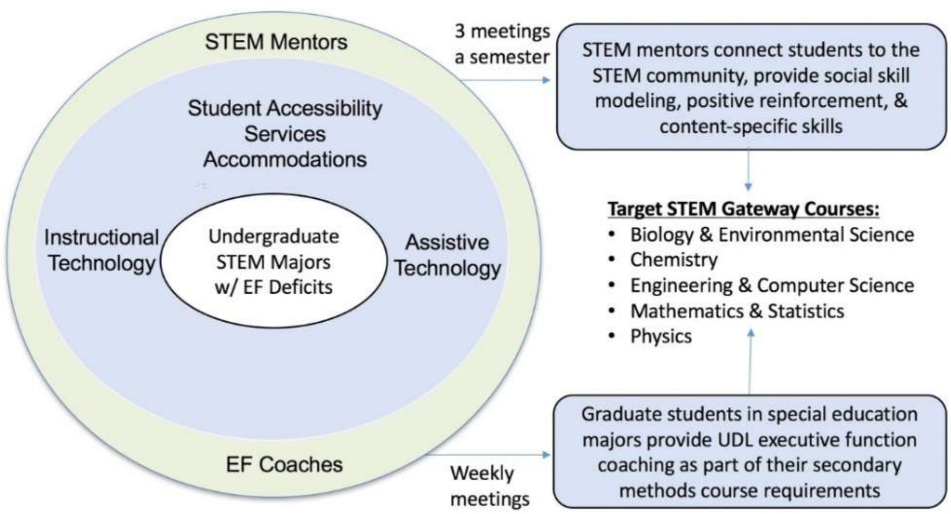
In a review of self-determination literature spanning more than 40 years, Ju, Zeng, and Lanmark (2017) identified a clear need to enhance self-determination and EF for postsecondary students with disabilities. Prevatt, Smith, Diers, Marshall, Coleman, Valler, and Miller (2017) added to this, identifying coaching as a means to enhance motivation and goal completion for postsecondary students with ADHD. Goudreau and Knight (2018) adapted a coaching model from the International Coaching Federation to provide a more directive approach to educating students about how their abilities impact EF. The authors reported coaching led to enhancements in students' EF abilities. However, costs associated with this level of support (i.e., $50,000 per student per year) are beyond the reach of many students. The present study aimed to lower this cost substantially.

Another approach for supporting students with disabilities is through mentoring programs. Mentoring is a relationship-driven process where the mentor shares expertise, knowledge, and advice with the mentee (Gregg, Wolfe, Jones, Todd, Moon, & Langston, 2016). Empirical evidence supports the hypothesis mentoring can enhance executive function skills for individuals with disabilities (e.g., Anastopoulos & King, 2015). Specifically, mentoring has been found to enhanced goal-setting and motivation (Eddy, Canu, Broman-Fulks, & Michael, 2015). In addition, mentoring has been found to increase mindfulness (e.g., Gu, Xu, & Zhu, 2018) and planning (Fleming, McMahon, Moran, Peterson, & Dreessen, 2015). Finally, mentoring can enhance college students' organizational skills (LaCount, Hartung, Shelton, Clapp, & Clapp, 2015).

Conceptual Model

The iCAN coaching model was developed and iteratively refined over the course of the first year of the study (Fall 2015 – Summer 2016). Initial conceptualizations were rendered following semi-structured interviews with undergraduate STEM majors, academic advisors, and faculty at a private rural college in the northeast United States. The college is a leader in providing services for individuals with disabilities. Lessons learned from the interviews were applied at a large public Hispanic-serving institution in the southeast United States. Version 1 of the model was developed at the conclusion of the fall 2015 semester. This version was piloted with 9 undergraduate STEM majors in spring 2016 and refined at the conclusion of the semester as version 2. The final iteration, version 3.0 (see figure 1), was developed during the summer of 2016 following additional follow-up semi-structured interviews with EF coaches. In order to reduce costs, EF coaches were recruited from students pursuing a Master's degree in special education at the university. Coaching occurred as part of their secondary methods course, which was taught by the project's principal investigator. Novel online course modules and assessments (see Appendix A) were developed to enhance coaches' abilities to provide EF and social skill instruction for STEM majors with EF deficits. The goal of the model was to provide students with specific skills leading to enhanced course performance, persistence, and meaningful employment in a STEM field at little cost to the students or University. In addition, the model was meant to improve Master's students' abilities to provide meaningful instruction at the secondary level. Mentors were recruited from existing projects at the university, such as Girls Excelling in Math and Science (GEMS). STEM mentors were charged with engaging students with disabilities in the STEM community, reducing institutional barriers such as selecting courses aligned with students' strengths and challenges and providing participating students with early research activities at the university.

FIGURE 1
VERSION 3.0 OF ICAN IMPLEMENTATION MODEL



METHODS

Research Questions

Three research questions guided the investigation: (RQ1) Are there differences in performance, as measured by GPA, between students with EF deficits in the treatment and control conditions? (RQ2) Are there differences in STEM persistence, as measured by a change in major from STEM to non-STEM, between students in the treatment and control conditions? (RQ3) Which aspects of the iCAN model do STEM majors with EF deficits report as most beneficial to their academic and social development?

Research Design

A mixed-methods, matched pairs, experimental design was employed during the project.

Participants

All student participants in the study were registered with Student Accessibility Services and recognized as a student with a disability by the university. As such, all students in both treatment and control conditions had access to university designated accommodations such as extended time on tests, alternate test locations, etc. The director of Student Accessibility Services sent an email describing the study to all STEM majors who were registered with Student Accessibility Services each week for the first three weeks of the semester. The email included a link to the project website and application. Interested undergraduate STEM majors completed a 9-question application survey, which asked students about the nature of their disability, their major, and what they hoped to gain by participating in the project. Students with suspected EF deficits based on their Student Accessibility Services office classification (e.g., Attention Deficit Disorder) were contacted and interviewed using a standardized protocol by one of the project staff. Two hundred and seventy-four undergraduate STEM majors completed the screen and expressed interest in participating in the study. Students were excluded from the study if their primary disability was physical (e.g., blindness). Project expectations were explained, and IRB consent obtained. Students who were enrolled in at least one of eight introductory STEM courses (i.e., biology, environmental science, chemistry, engineering, computer science, mathematics, and statistics) were randomly selected and asked to take the Barkley Deficits in Executive Function Scale for adults (BDEFS; Barkley, 2011). Students who expressed EF deficits in at least two subsections of the BDEFS were selected to participate in the study. Matched pairs were created when two participants expressed similar impairments in two or more EF subsections (e.g., organization and self-motivation). One hundred and twenty students were randomly selected for participation in the study, with 60 in the treatment condition and 60 in control. Forty percent of the sample was male (n=48). Sixty-eight percent of participants were white (n=82), twenty percent African American (n=24), and thirteen percent Hispanic (n=16). The attrition rate for the study was 21%. See Table 1 for sample distribution.

TABLE 1
DESCRIPTIVE STATISTICS OF THE SAMPLE

Condition	Freshman	Sophomores	Juniors	Seniors	Total
Treatment	9	11	28	12	60
Control	9	11	28	12	60

Instruments

Cumulative Grade Point Average (GPA) on a 4-point scale was used as a performance measure. An independent samples t-test indicated there were no statistically significant differences in GPA between the treatment and control conditions at the outset of the intervention. GPA was gathered a second time following completion of the study in May 2018.

Persistence data (coded 1 – stayed in STEM or 2 – changed from STEM) were gathered following the completion of the study in May 2018.

Barkley Deficits in Executive Function Scale

Participants completed an electronic long-form version of the BDEFS for adults. The BDEFS for adults is an empirically validated 89-item self-report measure containing five executive functioning constructs: 1) time management, 2) organization, 3) self-restraint, 4) self-motivation, and 5) emotional regulation. Ratings for each item utilize a 4-point Likert scale (i.e., never, sometimes, often, very often). The test is designed to take 20 - 30 minutes to complete. Reported reliability (Cronbach's alpha) ranged from .75 to .98 for factor scores and from .68 to .99 for summary scores.

Semi-Structured Interviews

Sixty students in the treatment condition participated in semi-structured interviews at the conclusion of the study. Questions focused on academic and social aspects of college life in a STEM major. Broad questions were designed to illuminate the institutional, situational, and individual barriers or scaffolds influencing the students' decisions. Specific questions asked students to identify how they engaged in the STEM community and why they chose to persist or pivot to a different major. Students were asked to identify the types of technologies and community supports they found most beneficial when participating in STEM courses.

Individual Case-Studies

Coaches of students in the treatment condition completed a case study for their undergraduate STEM major. Case studies followed a standardized protocol including information about the student, their EF scores on the BDEFS, evidence-based EF compensatory strategies used with the student during the intervention, and outcomes of strategy implementation. Case studies were supported using detailed field notes, video and audio recordings of the coaching sessions, and discussion groups with other coaches who had students with similar EF deficits. The final section of the case study included a reflection on the process and student outcomes over the course of the semester.

Post-intervention Survey

A 16-item post-intervention survey was developed by the researchers to analyze critical aspects of the iCAN model. Content validity was established using a Delphi process with coaches, mentors, professors, experts in STEM fields, and participants (Fletcher & Marchildon, 2014).

Procedure

Four semesters (i.e., Fall 2016, Spring 2017, Fall 2017, Spring 2018) were included in the study. Graduate students in the special education program at the university served as EF coaches for undergraduate STEM majors during the study. All coaches were certified special education teachers who were enrolled in a secondary (i.e., 6 – 12th grade) methods course. Coaching a postsecondary STEM undergraduate was an optional activity for students in the course. Each coach participated in the following virtual course modules prior to coaching a student: 1) CITI training (i.e., human subjects research and responsible conduct of research), 2) Evidence-based practices in STEM, 3) Universal Design for Learning, 4) Executive Functions, and 5) Coaching best practices. A description of the contents of each module can be found in Appendix A. Coaches were assessed after each module to ensure their ability to implement the intervention with fidelity. Each graduate student had one undergraduate STEM major to coach for one semester. Undergraduate STEM majors were paired with graduate coaches during week five of the semester.

Concurrently, undergraduate STEM majors completed the intake process and BDEFS. Barkley scores were used by the project team to create matched pairs. The matched pairs were split with one student being randomly assigned to treatment and the other to control by week 4 of each semester. A protocol was developed and shared with all project coaches to ensure treatment fidelity. Coaches interpreted the BDEFS scores, confirmed their analysis with the instructor, then shared the results with the undergraduate STEM major they were coaching. The pair worked collaboratively to identify short and long-term goals for the semester. STEM majors identified EF areas where coaching would be most beneficial. Coaches then developed a personalized UDL lesson plan to teach a particular EF skill (e.g., task initiation via prompts from their cellular phones). Coaches revisited the strategies each week to determine if they were helpful to the STEM major. They asked STEM majors to explain what worked, what didn't, and why. When an intervention was not successful, the coach guided the student through a reflective process using Socratic Questioning (Sahamid, 2016) and co-constructed a novel compensatory strategy that would be more beneficial to the student. Critical aspects of the coaching intervention as identified by Koch (2016), are presented in Table 2.

TABLE 2
CRITICAL ASPECTS OF THE COACHING MODEL

Coaching strategies
Build trusting relationships
Active listening
Cognitive reframing
Socratic Questioning
Growth mindset
Positive reinforcement
Humor
Wait time/patience
Prompting
Embrace UDL framework

Implementation Fidelity

Coaches used virtual conferencing software such as Zoom or Adobe to meet with students. Meeting activities, time (in minutes), and date were recorded using the software. This allowed the project staff to ensure treatment fidelity and provide additional support to coaches if necessary (Carroll, Patterson, Wood, Booth, Rick, & Balain, 2007). Coaching consistency was established by observing 30% of the video logs and field notes from coaches. If coaches were not utilizing 80% of the strategies identified in Table 2 over a 2-week period, a member of the project staff contacted the coach and co-developed a plan to align the coaching experience with evidence-based practices in Table 2. Coaching consistency during the intervention ranged from 74% - to 100%. Consistency from two coaches was lower than 80%. The coach and student data from those two groups were removed from the analysis.

Meeting times ranged from 90 – 248 minutes per semester. The average number of meetings between coaches and participants was eight. Coaches created detailed field notes and reported their data to project staff on a weekly basis or more frequently when requested. Sixty case studies for students in the treatment condition were completed in response to this protocol. Case studies identified EF areas of competence and those in need of bolstering along with UDL methods for teaching EF skills. A screenshot from a virtual meeting between a coach and participant is presented in figure 2. Executive function outcomes associated with the intervention are presented in Table 3.

FIGURE 2
EXAMPLE OF VIRTUAL COACHING USING ADOBE CONNECT

TABLE 3
EXECUTIVE FUNCTION OUTCOMES RESULTING FROM COACHING MODEL

Executive function outcomes: Enhance participants'
Short and long-term goal setting
Verbal & non-verbal communication
Self-determination
Self-advocacy
Self-efficacy
Emotional regulation
Assistive Technology (AT) use
Note-taking abilities
Ability to manage a schedule
Task-management (initiation, persistence, completion)

Participants were also connected with a STEM content area mentor with a background similar to their major. STEM content mentors were predominantly undergraduates in their junior or senior year. They were selected from a STEM mentor network at the university. Each met with the principal investigator three times during the semester for a project briefing and protocol training, mid-semester check-in, and post-semester reflection. Mentors met with mentees monthly or more frequently when requested by the mentee. STEM mentors and mentees chose how and when they would connect throughout the semester. Some met face-to-face while others preferred virtual meetings or text messaging. Mentors were responsible for helping mentees navigate institutional barriers, such as who they should see if they had a problem in a particular course. In addition, STEM mentors were charged with engaging the mentee in the STEM community through club activities, organizations, and meetings. The average number of meetings between STEM mentors and mentees was three per semester.

Analysis

An a priori G*Power version 3.1.9.2 (Faul, Erdfelder, Buchner, & Lang, 2009) analysis was conducted to determine sample size requirements. Test family = t tests; Statistical test = Means: Difference between two dependent means (matched pairs); Input parameters: Tails = two, Effect size dz = .5, α err prob = .05, Power = 0.95; Output parameters: Total sample size = 54. Our sample included 120 participants, 60 in treatment and 60 in control, thus exceeding sample size requirements.

Quantitative analysis included an independent samples t-test with grade point average (GPA) measured on a 1 – 4 scale for research question 1. A separate independent samples t-test was conducted for research question 2, with change in major coded 1 if the student stayed in a STEM major or 2 if the student changed to a non-STEM major. Analysis of research question three included descriptive statistics from the 16-item post-intervention survey, triangulated with case study data and interview transcripts from the participants. Interviews were transcribed using datalyst online transcription software (2018). The transcriptions were reviewed by the primary interviewer. The accuracy of the transcriptions was >99%. Clarifications were made to the transcription after member checking with the participant.

NVivo qualitative data analysis software version 11.2.1 (2015) was used to process, analyze, and interpret the interview transcripts. NVivo is a tool for management and categorization of large bodies of data (i.e., interview transcription). Typical qualitative designs neglect to represent the data with statistical means. Oftentimes frequency counts are utilized as a reference point, but the truest expression of these data are often indices (i.e., an index) yielding a hierarchy of categories (Pope, Ziebland, & Mays, 2000).

Results

RQ1: STEM Performance

An independent-samples t-test was conducted with GPA as the dependent measure and condition (i.e., treatment vs. control) as the independent variable. The analysis included 120 participants, 60 in each condition. SPSS Version 25 (IBM Corp, 2017) software was used during the analysis. There was a significant difference in scores with students in the treatment condition (M=3.23, SD=0.41) outperforming the control (M=2.75, SD=1.18) condition; $t(118)= -2.94$, $p = .004$, $d = 0.54$.

RQ2: STEM Persistence

STEM persistence was established through an examination of the student's unofficial transcripts at the conclusion of the spring semester in 2018. Again, 120 participants were compared across the treatment (n=60) and control groups (n=60). Despite several of the students in the treatment condition reporting they might change majors, none of them did. There was a statistically significant difference in the number of students with disabilities who changed majors with students in the treatment condition (M=1.0, SD = 0.00) outperforming those in the control (M=1.13, SD= 0.34); $t(118) = 3.01$, $p = .003$, $d = 0.54$. The percentage of students who changed majors in the treatment group was 0%, while students in the control condition changed to a major outside of stem approximately 8% of the time.

Analysis of the 60 case studies and post-intervention surveys allowed the project team to identify which UDL supports and coaching strategies were most effective for STEM majors. These are presented in Tables 1 & 2.

RQ3: Most Useful Aspects of the iCAN Model

STEM majors reported Student Accessibility Services accommodations and coaching from graduate students in special education were the most beneficial supports they received. These were followed by services from the assistive technology center and peer mentors. The majority of students felt face-to-face meetings were most beneficial. This was an unanticipated finding. The project team thought students would prefer virtual meetings in order to add flexibility to the coaching process. Future research should examine whether this finding was the result of network, software, hardware challenges, or a perception of face-to-face meetings providing more personalized coaching.

The earliest models from this project relied heavily on virtual conferencing technologies as a means to ensure treatment fidelity and dosage. Some students appreciated this flexibility. Others reported limitations during the video conferencing, such as a lack of sound or video feed. These problems were amplified in Fall of 2016 with Hurricane Matthew and again in 2017 with Hurricane Irma. It became apparent significant limitations existed with the technologies the students were using and the infrastructure network on which it was being applied. As a result, the project team gave students the choice to have meetings in face-to-face, online, or hybrid settings. Students reported this flexible approach, which aligned with the UDL framework, allowed them to maximize their time during coaching sessions.

When asked how often participants would like to meet with peer mentors, responses ranged from once a semester (32%) to weekly (26%) with the majority (42%) wishing to meet on a monthly basis. The majority of undergraduates (79%) reported the peer mentors most valuable role was assisting with job acquisition skills. When asked how often the students used technology during the semester, fifty-eight percent reported always, fifteen percent replied sometimes, 13 percent replied about ½ of the time, and 13% responded never. When asked to identify the types of technology students found most useful, the majority of students reported digital calendars and digital reminders. These were followed by note-taking software, speech-to-text software, Read & Write literacy software, and text-to-speech software.

The project team also inquired about the types of coaching strategies the students found most useful. Active listening was the top-rated coaching skill followed by Socratic Questioning (Sahamid, 2016), patience, humor, knowledge of academic strategies the participant could try, and flexibility in their coaching approach. Finally, some students expressed a notion coaches should be held more accountable for contacting students while other undergraduates felt the inverse was true.

DISCUSSION

Traditional executive function assessments can show pre-posttest changes resulting from an intervention. However, these outcomes are only meaningful if they are transferable to other metrics such as GPA performance and persistence in a STEM major. Results of the independent samples t-tests for both performance and persistence in a STEM major indicated a statistically significant difference with the treatment group outperforming the control group in both cases. There were medium effect sizes associated with both research questions. The intervention model was developed to reduce costs while providing enhanced performance and persistence in STEM. Each of these objectives was accomplished by leveraging graduate students in the exceptional education program as EF coaches.

DuPaul et al., (2017), along with Goudreau and Knight (2018), identified a need for additional empirical efficacy and effectiveness coaching intervention studies at the postsecondary level. This study adds to the literature on coaching EF skills by demonstrating benefits for both undergraduate STEM majors and their coaches. Undergraduate STEM majors in this study reported knowledge gains related to STEM content learning strategies, procedural skills, and EF strategies they were using on a regular basis. Coaches confirmed these self-reported gains during the weekly meetings with students, where they asked specific questions about the strategies the students were using, how they were impacting learning outcomes, and how the strategies were affecting their GPA.

Many coaches reported learning more about secondary students with disabilities from the experience than in other courses because they were able to backward map the skills from postsecondary to middle and high school students. Current secondary special education teachers described the challenges of the postsecondary students as highly similar, if not identical to, the challenges they were seeing in middle and high school students with high-incidence disabilities. The intervention helped them understand the value of transition planning and the manner in which EF skill deficits can be identified, taught, and assessed using a student-driven coaching model as first advocated by Parker and Boutelle (2009) a decade ago. The study provided evidence EF skills could be enhanced in postsecondary students when they were explicitly taught and assessed (Ladyshewsky, 2017). Most importantly, the investigation showed these EF gains led to enhanced performance as measured by overall GPA and persistence in a STEM major.

Other findings related to the study indicated the importance of a flexible approach to coaching. Universal Design for Learning was the first module in the coaches' coursework. Coaches reported this approach framed their thought processes as they proceeded through the remainder of the course. At the core of this framework is the anticipation of learner variability and flexible approaches to teaching and assessing content (Nelson & Basham, 2014). Participants in the study agreed, reporting the flexibility within the coaching sessions allowed them to maximize their productivity.

The fact students preferred face-to-face meetings over technology-enhanced interactions was unanticipated. In fact, the project team had initially conceptualized the project as an entirely technology-based intervention. Gregg et al., (2017) reported virtual mentoring led to growth in self-advocacy skills, but some sub-populations, such as students with learning disabilities, showed lower aspirations following the intervention. Based on the current research, it appears interventions should use a flexible framework in order to engage students using the modality they most prefer.

Technology use by students was lower than anticipated. Future studies should examine whether this finding is the result of economic disparity, a belief the technology is not helpful, or some other factor. Coaches repeatedly modeled how specific technologies could reduce students' cognitive load and enhance performance. The majority of the technologies used in the coaching sessions were free to students as members of the university. However, some students did not use the technologies. Some students with autism spectrum disorders reported the use of technologies equated to cheating, even though all students in the class had access to the same technologies. In their view, an assessment was only valid if preparation for it occurred in a traditional manner. Future research should examine the origins of this belief and how it might be altered.

LIMITATIONS OF THE STUDY

This early-stage research has several limitations worth noting. First, coaches in the study were not certified by an accrediting body. While a limitation, the procedural safeguards in the study, and positive outcomes related to performance and persistence indicated, negative impacts associated with treatment implementation fidelity were minimized. Second, the number of Hispanic students participating in the study was lower than anticipated given the university is a certified as a member of the Hispanic Association of Colleges and Universities (HACU). Post-hoc analysis indicated this was likely the result of study recruitment efforts, which occurred primarily through the Student Accessibility Services Office. While 24% of students in STEM majors at the university were Hispanic, less than 1% of those students were registered with Student Accessibility Services. Therefore, they might not have been aware of the study. Future research should examine the causes of this finding. Finally, the limitations of the technology devices and infrastructure must be considered. While substantive increases in hardware and network capacity have occurred during the past decade, it became apparent student-owned devices did not consistently possess the memory or processing speed necessary to reliably connect coaches and students using videoconferencing software. This should be accounted for in future research.

IMPLICATIONS FOR PRACTICE

The coaching model presented here represents a substantial cost savings for colleges and universities wishing to enhance EF skills for STEM majors. Costs were reduced from the $50,000 per student, per year, presented in other studies (e.g., Goudreau & Knight, 2018) to $1,000 a year by including certified special education teachers in a Master’s degree program as coaches. The $1,000 included EF pre and post-assessments, nine to twelve weeks of EF coaching intervention using the Universal Design for Learning framework, and mentoring. Additionally, coaches reported working with the postsecondary STEM majors helped them understand the benefits of coaching students with EF skill deficits at the secondary level. Finally, they learned how successful students with disabilities can be when provided with adequate support networks.

Colleges and universities without special education programs might consider partnering with coaching preparation programs where students are working toward professional certification. Organizations such as the International Coach Federation, Certified Professional Coach, and World Coach Institute require supervised coaching hours as students work toward certification. This collaborative effort could prove mutually beneficial as students with disabilities receive EF coaching, while individuals working toward certification receive needed volunteer hours. The coaches in the present study were not certified coaches, yet they still provided statistically significant improvements in performance and persistence.

CONCLUSION

This study utilized a matched-pairs experimental design to examine the performance, persistence, and preferences of 120 students with EF deficits in STEM majors. Findings indicated students who received EF coaching from special education graduate students displayed higher GPAs and persistence rates in their STEM majors. The project team was able to substantially reduce intervention costs by utilizing special education graduate students as coaches as opposed to hiring full-time coaches. In addition, coaches reported substantive benefits from working with postsecondary STEM majors. Future research should extend this work by examining whether this approach is a viable option in other universities with both STEM majors and teacher preparation programs.

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APPENDIX A

Module	Materials	Assessment
CITI Training	Human subjects research mini module. Responsible conduct of research mini module. Carroll, C., Patterson, M., Wood, S., Booth, A., Rick, J., & Balain, S. (2007). A conceptual framework for implementation fidelity. *Implementation Science*, 2, article 40. doi: 10.1186/1748-5908-2-40 Katz, J Katz, J. (2015). Situational evidence: Strategies for causal reasoning from observational field notes. *Sociological Methods & Research*, 44(1), 108-144.	Multiple choice and true/false quizzes. Field notes from initial coach's meeting with student.

Evidence-based practices in STEM	Basham, J. D. & Marino, M. T. (2013). Understanding STEM education and supporting students through Universal Design for Learning. *Teaching Exceptional Children*, 45(4), 8-15. Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A. & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science*, 341, 1455-1456. Gregg, N., Wolfe, G., Jones, S., Todd, R., Moon, N., & Langston, C. (2016). STEM e-mentoring and community college students with disabilities. *Journal of Postsecondary Education and Disability*, 29(1), 47-63. Koch, A. (2016). Project iCAN: A STEM learning and persistence model for postsecondary students with disabilities. University of Central Florida. Orlando, FL. Rosi Rosica, C. (2016). Translating STEM education research into practice. *Australian Council for Educational Research.* Retrieved from https://research.acer.edu.au/cgi/viewcontent.cgi?article=1010&context=professional_dev	Multiple choice, true/false, and open-ended quiz. Discussion post.
Universal Design for Learning	CAST (2018). Universal Design for Learning Guidelines version 2.2. Retrieved from http://udlguidelines.cast.org Curry, C., Cohen, L., & Lightbody, N. (2006). *Universal Design in science learning. The Science Teacher*, 73(3), 32-37. Edyburn, D. L. (2010). Would you recognize Universal Design for Learning if you saw it? Ten propositions for new directions for the second decade of UDL. *Learning Disability Quarterly*, 33(1), 33-41. Israel, M., Ribuffo, C., & Smith, S. (2014). *Universal Design for Learning: Recommendations for teacher preparation and professional development* (Document No. IC-7). Retrieved from http://ceedar.education.ufl.edu/tools/innovation-configurations/ Nelson, L. L., & Basham, J. D. (2014). *A Blueprint for UDL: Considering the design of implementation.* Lawrence, KS: UDL-IRN. Retrieved from http://udl-irn.org	Universal Design for Learning lesson plan.
Executive Functions	Barkley, R. A. (2011). *Barkley deficits in executive functioning scale (BDEFS for adults)*. New York: Guilford. Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64, 135–168. doi: 10.1146/annurev-psych-113011-143750 Eddy, L. D., Canu, W. H., Broman-Fulks, J. J., & Michael, K. D. (2015). Brief cognitive behavioral therapy for college students with ADHD: A case series report. *Cognitive and Behavioral Practice*, 22(2), 127-140. Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science*, 21(1), 8-14. doi: 10.1177/0963721411429458 Pessoa, L. (2014). Understanding brain networks and brain organization. *Physics of Life Reviews*, 11(3), 400-435.	Interpretation of student BDEFS scores. Outline of compensatory strategies to address BDEFS score.

Coaching Best Practices	Bellman, S., Burgshahler, S., & Hinke, P. (2015). Academic coaching: Outcomes from a pilot group of postsecondary STEM students with disabilities. *Journal of Postsecondary Education and Disability*, 28(1), 103-108. D'Alessio, K. A., & Banerjee, M. (2016). Academic advising as an intervention for college students with ADHD. *Journal of Postsecondary Education and Disability*, 29(2), 109-121. *Learning focused coaching protocol*. (2015). Retrieved from http://beetlesproject.org/cms/wp-content/uploads/2015/12/Learning-Focused-Coaching-Protocol.pdf Mitchell, J. J., & Gansemer-Topf, A. M. (2016). Academic coaching and self-regulation: Promoting the success of students with disabilities. *Journal of Postsecondary Education and Disability*, 29(3), 249-256. Parker, D. R., & Boutelle, K. (2009). Executive function coaching for college students with learning disabilities and ADHD: A new approach for fostering self-determination. *Learning Disabilities Research & Practice*, 24(4), 204–215. doi.org/10.1111/j.1540-5826.2009.00294.x Prevatt, F., Smith, S. S., Diers, S., Marshall, D., Coleman, J., Valler, E., & Miller, N. (2017). ADHD coaching with college students: Exploring the process involved in motivation and goal completion. *Journal of College Student Psychotherapy*, 31(2), 93-111.	Discussion post. Philosophy of person-centered planning discussion. Field notes from coaching intervention. Transcript analysis from coaching intervention. Video & audio analysis from recorded intervention sessions.
Working Memory	Maxcey-Richard, A. M., & Hollingworth, A. (2013). The strategic retention of task-relevant objects in visual working memory. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 39, 760-772. Redick, T. S., Shipstead, Z., Wiemers, E. A., Melby-Lervag, M., & Hulme, C. (2015). What's working in working memory training? An educational perspective. *Educational Psychology Review*, 27, 617-633. Sala, G. & Gobet, F. (2017). Working memory training in typically developing children: A meta-analysis of the available evidence. *Developmental Psychology*, 53, 671-685. Schwaigjhofer, M., Fischer, F., & Buhner, M. (2015). Does working memory training transfer? A meta-analysis including training conditions as moderators. *Educational Psychologist*, 50, 138-166. Zhang, D. (2017). Effects of visual working memory training and direct instruction on geometry problem solving in students with geometry difficulties. *Learning Disabilities: A Contemporary Journal*, 15(1), 117-138.	Multiple choice quiz. Case study intervention plan.

Note: Each module, with the exception of the CITI Training, contained multiple representations of the content (e.g., journal articles, video examples, PowerPoint presentations), making it consistent with the UDL framework. The materials shown here are for illustrative purposes and do not represent the exact content included in each module. Several of the articles were published online and not yet in print during the first semester of study implementation.