



NSF Eddie Bernice Johnson INCLUDES Initiative: TAPDINTO-STEM National Alliance for Students with Disabilities in STEM, An Innovative Intersectional Approach of Diversity, Equity, and Inclusion for Students with Disabilities

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Abstract. Persons with disabilities are one of the most significantly underrepresented groups in STEM education and employment, comprising a disproportionately smaller percentage of STEM degrees and jobs compared to their percentages in the U.S. population [1]. TAPDINTO-STEM employs a collective impact approach with dozens of partnering institutions to increase the number of students with disabilities (SWDs) who complete associate, baccalaureate and graduate STEM degrees and enter the STEM workforce.

Keywords: Students with Disabilities · STEM Education · Mentoring

1 Introduction

The Alliance for Students with Disabilities for Inclusion, Networking, and Transition Opportunities in STEM (TAPDINTO-STEM) employs a collective impact approach with dozens of partnering organizations nationally to increase the number of students with disabilities (SWDs) who complete associate, baccalaureate and graduate STEM degrees and enter the STEM workforce. The Alliance is made up of 38 colleges and universities and 14 non-academic partners across the country, and has the following purpose, goals, and objectives:

- Purpose: Through the collective impact of the NSF INCLUDES TAPDINTO-STEM Alliance, post-secondary students with disabilities nationwide will increase the rate of persistence and graduation in STEM degree programs and increase their rate of transition to the STEM workforce.
- Goal: The project goal is to increase the quantity of persons with disabilities who complete associate, baccalaureate, and graduate degrees in STEM and enter the STEM workforce.
- Objectives: 1) Increase the quantity of students with disabilities (SWDs) completing associate, undergraduate, and graduate degrees in STEM. 2) Facilitate the transition of SWD from STEM degree completion into the STEM workforce. 3) Enhance communication and collaboration among institutions of higher education (IHEs), industry, government, national labs, and local communities in addressing the education needs of SWD in STEM disciplines.

2 Background and Related Work

Auburn University is leading this national alliance, which includes six regional hubs across the country. Auburn leads the Southeast Hub, and other hub lead institutions include Northern Arizona University (Mountain Hub), The Ohio State University (Northeast Hub), the University of Hawaii-Manoa (Islands Hub), the University of Missouri-Kansas City (Midwest Hub) and the University of Washington (West Coast Hub). The University of Missouri-Kansas City also serves as the backbone organization for the alliance, providing support in communications, data collection, dissemination, and organization.

This Alliance was created following the successful implementation of the Alabama Alliance for Students with Disabilities in STEM (AASD-STEM) [2], funded by NSF under the Research in Disabilities Education (RDE) program in 2009, and the Southeast Alliance for Persons with Disabilities in STEM (SEAPD-STEM) [3] under the NSF INCLUDES program in 2016. The TAPDINTO-STEM Alliance brings together leaders and researchers from several former NSF RDE Alliances, using their experience and expertise to expand this important work from regional efforts to a national scale.

The infrastructure created by the alliance allows for more partners to continue joining the movement, more connections to be made, and the opportunity for collaborative change to lead to expansion, sustainability, and scaling up of the Alliance and its activities (Fig. 1).

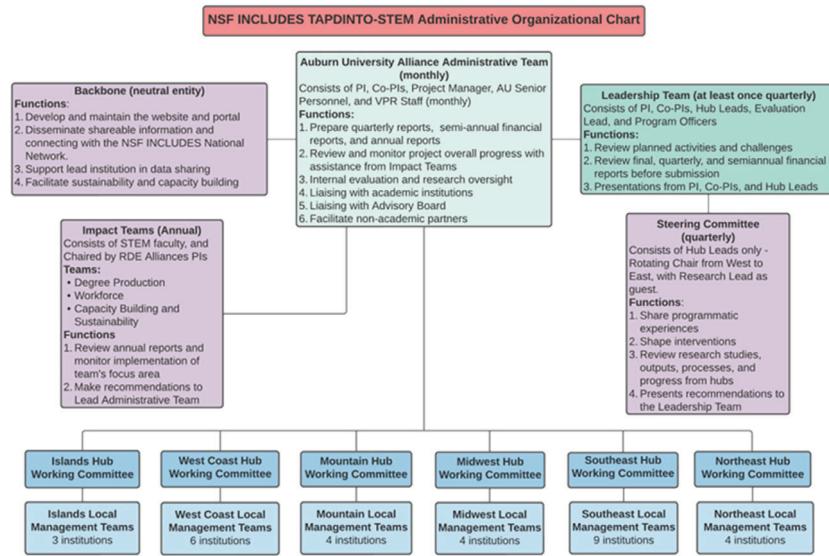


Fig. 1. TAPDINTO-STEM Organizational Chart

3 Research and Implementation

The primary intervention for the Alliance is mentoring and e-mentoring of SWD by peers and STEM faculty and professionals. This mentoring model is built on work that was done in previous NSF-funded projects for persons with disabilities and other NSF-supported programs for women, underrepresented minorities, and low-income and first-generation students. Other Alliance interventions for students include:

- Recruitment
- Faculty and peer mentor support
- Internship opportunities
- Conferences and graduate school/career fairs
- Social science research
- Capacity building institutes for students, faculty, and staff
- Creation of campus student organizations for SWD
- Webinars
- Networking opportunities

In addition to these activities, each hub is conducting its own research project as described below, focusing on topics that include (Fig. 2):

- Institutional factors and student persistence
- Impact of student support services on academic, social and employment outcomes
- Bias, discrimination, stigma and intersectionality
- Mentoring model through the lens of the Loss/ Momentum Framework
- Research in disabilities in a multicultural setting
- Longitudinal transition study of NSF-funded students with disabilities

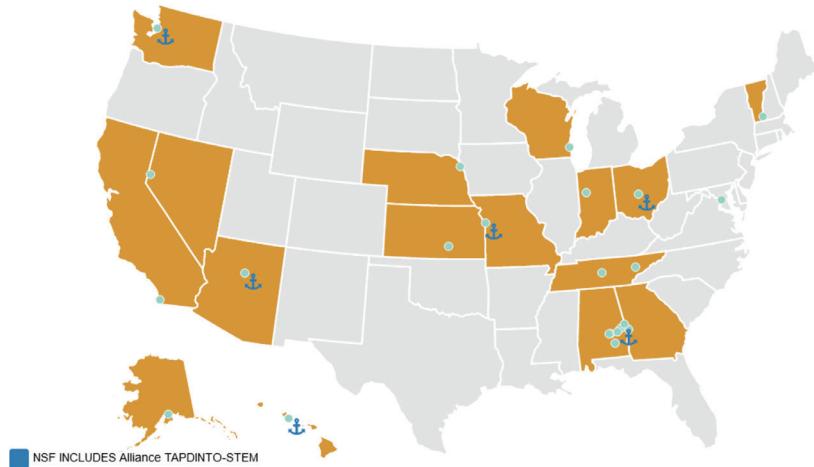


Fig. 2. TAPDINTO-STEM Alliance Map (anchors represent hub lead institutions).

- **Islands:** This study focuses on students with disabilities (SWD) and the unique issues of culturally and linguistically diverse (CLD) SWD (i.e., Native Hawaiian, Pacific Island, and Asian American students) as there is a continued issue of access for these subset of students [15, 16]. The study will be conducted in stages. Stage 1 is designed to investigate factors (e.g., historical, social, cultural, disability, and other personal factors) that facilitate or impede students' attitude toward and access to postsecondary education and STEM, identity development in STEM, and persistence towards and graduation with a STEM degree to understand the students' needs, conditions, and circumstances. Then, in considering those factors and different educational stages students are in, we will identify effective strategies to develop a tailored bridge and mentoring activities (e.g., e-mentoring, internship, course guidance, research support, student-family activities) appropriate to individual students' needs, conditions, and circumstances. Subsequently, stage 2 will provide a personalized menu of mentoring activities tailored to specific SWD to support their retention and graduation.
- **Midwest:** Academic student success from college choice toward graduation is often dependent on how well students can navigate institutional policies and procedures. While some of the supports that institutions create generate helpful momentum for students, far too many rules create pain points. Consequently, many students prematurely leave without knowing if they have what it takes to succeed in college [4]. This scenario is magnified for students with disabilities [5], especially in difficult degree programs like STEM [6]. Therefore, the Midwest Hub is investigating to what extent and how TAPDINTO-STEM students experience their institutions' requirements and support for matriculation toward graduation as assisting or delaying their academic success [7]. More specifically, this examination uses the Completion by Design loss/momentum framework [4] that defines five phases where students experience their campus as providing loss or momentum through: access, entry, progress, completion, and transition. The overarching objective is to identify patterns in momentum or loss points across the institution in hopes of enhancing

supportive factors and mitigating adverse ones for students with disabilities in STEM degree programs.

The Midwest Hub research team is using a mixed-method design where Alliance STEM faculty mentors and student mentees were surveyed about their experiences corresponding with the five loss/momentum framework phases. Alliance faculty mentors were surveyed about adequacy of institutional resources, services, and responsiveness in supporting SWD in STEM degree programs. Meanwhile, Alliance students were asked general questions about their experiences with their institutions' academic and disability support services as well as questions related to the loss/momentum phases. The "access" questions ask students about their experiences with the institution while they were in high school; "entry" questions ask about their experiences transitioning to college; "progress" questions ask about students' current semester; and "completion" and "transition" questions ask students who have advanced to their final year about completing their degree and their confidence in transitioning to the STEM workforce. This research project will continue with two additional survey administrations and follow-up qualitative interviews with Alliance faculty mentors and student mentees.

Another aspect of this study is to include a control group of students with disabilities in STEM degree programs and staff who support those students from non-Alliance institutions. The Midwest hub research team selected 33 comparison institutions using propensity-score matching, a procedure in which logistic regression predicts the probability that a case will belong to one of two groups. In our case, we used it to predict whether any institutions in the IPEDS database would belong to the same group as our target sample of the original 27 Alliance institutions. Institutions having the closest probability to each of the target institutions were selected as matches. More matches were selected than target institutions because some schools had the same predicted probabilities. The advantage of using logistic regression for matching is that logistic regression models can easily incorporate many different variables, whereas it is difficult to conduct matching by eye using more than a few variables. Currently, the Midwest hub research team is contacting target institutions for their participation in the comparison group.

- **Mountain:** The Mountain Hub is conducting research focused on bias, discrimination, and stigma experienced by college students with disabilities pursuing STEM degrees. The overarching research question is "Using an intersectionality lens, what are the disconnections and gaps between (a) the experiences of post-secondary STEM students with disabilities related to bias, discrimination, and stigma, (b) information and messaging available to IHE faculty and staff pertaining to inclusion and recognizing intersectionality, and (c) IHE faculty and staff perceptions that perpetuate bias, discrimination, and stigma?" To address this question, a mixed methods approach including PhotoVoice and surveys is being used.

To date, a pilot of the PhotoVoice approach has been completed. PhotoVoice was introduced as a qualitative approach in the mid-1990's [8]. In the social sciences, PhotoVoice has been an effective approach for collecting data about lived experiences and personal perceptions [9]. As a pilot, six students took photos of the college environment representing situations in which they feel included, excluded, or empowered. Students were then interviewed about their photos, the situations depicted, and their perceptions.

The pilot results showed examples of inaccessible spaces and interactions with faculty and instructors that assumed that disability equates to incompetence.

- **Northeast:** This study aligns with the Alliance goal of increasing STEM degree completion for students with ASD by examining students' use and perceptions of support services provided by either the STEM department or disability services. College SWD who use a variety of support services are significantly more successful in completing college [17]. This research study examines the use and value of support services aimed at improving SWD academic and employment outcomes. Services focused on academic outcomes include tutoring services provided by STEM departments and private tutors, disability support accommodations (extended time, distraction free environment for testing, notetakers, etc.) and assistive technology (speech-to-text; text-to-speech; electronic notetaker pens; etc.). Support related to social outcomes include peer mentoring and mentoring by teacher/faculty member, social skills instruction, and life coaching with a trained facilitator. Employment focused support services include career services (career fairs, stipends, job placement services, job coaching services etc.) and services provided by disability services/organizations (campus disability office, VR – job placement services, job coaching services). All support services are examined to identify those most valued by SWD and the extent to which such services should be tailored to students with different types of disability. Finally, use of these services is examined in relation to academic, social and employment outcomes.
- **Southeast:** The purpose of the Southeast Hub research is to examine key constructs in relation to students with disabilities (SWD) institutional commitment, persistence, and retention. This research study is focused on SWD persistence and is based on decades of research on student persistence [10] and research using social cognitive career theory (SCCT) to examine persistence among students with disabilities [11].

Thus far, data have been gathered from TAPDINTO-STEM students over three semesters (Fall 2022 to Fall 2023). Researchers have drawn from several survey scales they have used as part of a prior RDE project and current INCLUDES project [3, 12]. These surveys include measurement scales constructed to represent the constructs of interest in STEM careers, issues and challenges faced in college, self-advocacy knowledge and behaviors, academic efficacy, and intention to persist in their degree program with all scale reliability estimates exceeding .70. Finally, the researchers are further examining more specific aspects of persistence using the College Persistence Questionnaire [13, 14].

Initial findings include descriptions of sample characteristics, disability conditions, accommodations and services used by SWD, these findings also include a summary of variables in relation to persistence. More specifically, students who have reported greater persistence have also reported being more confident in facing academic, social and time management issues and challenges, more confidence to face issues related to their disability and be self-advocates, greater academic focus and academic efficacy and a greater sense of belongingness associated with TAPDINTO-STEM and their university.

- **West Coast:** The West Coast Hub has worked with Alliance students to solicit formative input and pilot a campus accessibility tool called "Equal Access: A Checklist

for Making Science Labs Accessible.” These activities took place in April 2023 at the TAPDINTO-STEM Alliance Convening which was held on the University of Missouri Kansas City campus. The West Coast Hub has refined the tool, originally developed with NSF funding as part of an Alliance called AccessSTEM (NSF# #HRD-0833504) and will develop a process for TAPDINTO-STEM students across the country to work in small teams with a faculty mentor’s support to evaluate a science lab or science building on their campus. Students will participate in the development of a summary report for their campus that suggests different ways accessibility can be increased. West Coast Hub staff will follow up with each campus and faculty member at 3- and 6-month intervals to determine which, if any, recommendations were implemented. The study seeks to demonstrate that:

- students with disabilities, through their lived experiences and guidance from the accessibility checklist tool, can improve skills at identifying access barriers on their campus,
- improve skills at collaborating with and communicating with campus faculty and administrators about access barriers, and
- directly influence institutional change on their campus.

The study will also explore and share reasons why certain recommendations were not implemented.

4 Conclusions and Future Work

Over 200 scholars have participated to date in Alliance mentoring activities to date, and students have reported improvements in persistence in college, behaviors/skills, academic efficacy, research interests, and satisfaction with mentoring. The evaluation plan for the Alliance includes internal and external components and encompasses both formative/ongoing evaluation and summative/impact evaluation. Common metrics collected from all participating institutions include student participation and progress data, institutional data related to capacity to support SWD and project engagement, and measures related to the Collective Impact framework.

At the conclusion of the project’s second year, findings show that the Alliance has made significant progress in several areas and has had a positive impact on students and alliance members. Students reported being positively impacted by their participation in a TAPDINTO-STEM convening held at the University of Missouri-Kansas City in March 2023 and in the Alliance mentoring program. Positive impacts include increased sense of belonging, intent to persist, and academic efficacy, and key findings are described below. All items mentioned used a five-point response scale.

4.1 Key Findings: Students’ Perceptions of Impact

Overall Bridge Model Perceptions and Perceived Outcomes. Sixty (60) students responded to items in relation to their involvement in and perceived benefits of TAPDINTO-STEM bridge and cluster meetings. Students reported the greatest benefits related to commitment and confidence to complete their degree ($M = 3.77$), learning

about valuable resources at their institution ($M = 3.5$), being better prepared for internships ($M = 3.47$) and developing closer relationships with faculty ($M = 3.42$). Students described having great confidence in their ability to succeed academically, having a goal to learn as much as they could ($M = 4.55$), being important learn a lot of new things ($M = 4.53$) and believing they could do all the work in the classes if they didn't give up ($M = 4.27$).

Mentoring Perceptions and Satisfaction. Students also reported being satisfied with the mentoring experience, with the highest levels of satisfaction related to the length of the session ($M = 3.23$), their mentor's ability to help them ($M = 3.21$), their relationship with their mentor ($M = 3.20$) and the overall experiences ($M = 3.20$). In addition, students strongly agreed that they were able to talk about career and life goals ($M = 3.57$), they felt respected and supported ($M = 3.55$), were encouraged to share their feelings ($M = 3.48$), felt comfortable approaching their mentor with questions ($M = 3.46$), and were satisfied with the mentoring experience ($M = 3.45$). Finally, in response to open-ended questions, students described the mentoring process as helping them build knowledge and skills (and their vita), prepare for internships, jobs, graduate school and other career opportunities.

Persistence and Career Preparation. Students expressed a strong intention to persist. They most strongly agreed that they intended to get their degree in their current major ($M = 4.65$), would continue their education in the same field ($M = 4.62$), get a job in the field ($M = 4.60$) and could see themselves working in the field for quite a while ($M = 4.49$). TAPDINTO-STEM students also had confidence in their skills as they prepared for internships and careers. They expressed the most confidence in their abilities to receive and give feedback ($M = 3.91$), learn about sources for potential internships ($M = 3.70$), talk with faculty and others about potential internship opportunities ($M = 3.65$), meet and engage with professionals in the field ($M = 3.63$), and apply for internship or job opportunities ($M = 3.61$).

Self-advocacy and Belongingness. At the Convening in March, TAPDINTO-STEM students (and others) described a sense of belongingness on their campus and the importance of self-advocacy. In spring 2023, students were asked about the sense of belonging and self-advocacy.

University Belongingness. Based on the initial examination in spring 2023, TAPDINTO-STEM students do perceive a sense of belongingness. They feel a strong affiliation with their university in that they have found it easy to establish relationships at my university ($M = 3.81$), they were proud to be a student at their university ($M = 3.7$) and feel a sense of pride when they meet someone from my university off campus ($M = 3.67$). They also indicate that there were supportive resources available to them on campus ($M = 3.86$), the university environment provides an opportunity to grow ($M = 3.81$), and their cultural customs are accepted ($M = 3.81$). Finally, TAPDINTO-STEM students held positive perceptions of faculty and staff, believing strongly that faculty/staff members care about them ($M = 3.86$), faculty/staff appreciate them ($M = 3.77$), and they feel like faculty value their contributions in class ($M = 3.60$).

Self-advocacy Behaviors. Our initial examination of self-advocacy reveals that TAPDINTO-STEM students are engaged in many effective behaviors, but there is room

for improvement. That is, students indicated that they can explain their disability to their teachers ($M = 3.91$), they meet with teachers at the beginning of the semester to discuss accommodations ($M = 3.80$), they talk with someone when frustrated about problems related to my disability ($M = 3.64$), they ask the appropriate office to assist them in resolving problems ($M = 3.57$) and they let teachers know immediately about the specific accommodations they need ($M = 3.52$). On the other hand, other behaviors have more room for improvement. These pertain to apologizing when requesting approved accommodations, telling teachers over and over how to meet my needs and just accept it and do their best if a teacher forgets or refuses accommodations.

4.2 SOAR Data Portal

A data portal has also been developed for the uploading of data and allows for continuous feedback for project improvement. The SOAR Portal (Surmounting Obstacles for Academic Resilience) [18] was developed by a team of computer science faculty and doctoral students at UMKC as the Shared Measurement System for the alliance. The portal serves as the data collection system and repository for student, mentor, and leadership contact information, agreements, and data. In collaboration with the evaluation team, data collection measures were developed and include surveys and questionnaires which are presented to participants as forms for answering questions related to alliance objectives and reporting activities at established time intervals throughout the academic year. In addition, a data visualization dashboard has been initiated which generates dynamic charts based on data in the warehouse. Both Android and iOS mobile apps have been deployed for the SOAR portal.

Upcoming developments and significant improvements for SOAR include further developing the data visualization dashboard to comprise static, manually generated, and AI generated charts; the ability to upload externally collected data, including institutional data and the internal evaluation; and improved chatbot functionality. There is also anticipation of American Sign Language integration as a sign-to-text function, similar to talk-to-text. Additionally, we will add short instructional videos to help all users understand that the AI is used only for automatically aggregating the data into dynamic visualization and generating interpretations based on the dynamic visualization. This will enable individual users to see progress, momentum, and areas where additional uplift is required.

4.3 Hub-Level Research

The **Islands Hub** study on the unique issues of culturally and linguistically diverse students with disability has been pilot-tested among students with disabilities to examine the usability, accessibility, and content of the research instrument. Data collection will continue on a larger scale across all Islands Hub institutions, and once students have provided information, work will begin on developing a personalized menu of mentoring activities tailored to specific students to assist them in their STEM studies and help keep them on track for graduation.

The **Midwest Hub** research team is investigating the extent to which momentum or loss points within five phases of entry into college toward graduation impact Alliance students' academic journey from their first institutional contact through graduation. Currently, the researchers have secured IRB exemption and completed the first round of survey data collection from with the Alliance STEM faculty mentors and STEM SWD mentees. These groups will be surveyed twice more and be invited to participate in semi-structured interviews. Additionally, this project seeks to include comparison groups of SWD in STEM degree programs and staff who work with SWD in STEM degree programs from non-Alliance institutions through an analytical matching process that has yielded several similar institutions that will be contacted to participate. Prior to the final administration of the Alliance mentor and mentee surveys, provisional results will be disseminated to Alliance campuses so they can consider implementing any measures they believe may help their students move through the Completion by Design milestones.

The **Mountain Hub** will scale-up the PhotoVoice portion of the research by recruiting student participants across the Alliance and across undergraduate and graduate students. The resulting data will be used to inform the development of a survey to be distributed across TAPDINTO STEM and nationally.

The **Northeast Hub** is currently recruiting and conducting structured interviews with Autistic STEM undergraduates at partner institutions to learn more about academic, employment, and social supports and services that are valued by individuals in this community and promote their success in higher education. Preliminary findings were presented by the research team and two TAPDINTO-STEM scholars from The Ohio State University (OSU) at the 25th International Conference on Autism, Intellectual Disability & Developmental Disabilities in January 2024. The concurrent breakout session, entitled Cultivating Neurodiverse STEM Cultures on Campus, described how the project's mentorship model led to the development of a funded student organization at the school, which aims to build community and advance sustainable, systemic change by empowering students and promoting accessible and inclusive STEM programs. Facilitators include: (i) connecting students to support staff and programs; (ii) leveraging technology to promote access and engagement; (iii) building community and peer networks; (iv) promoting friendly and flexible pedagogy; and (v) utilizing academic accommodations. Barriers include: (i) rigid and strict approaches to teaching and learning; (ii) difficulty accessing accommodations; (iii) inaccessible course materials; (iv) exclusionary assessments and expectations; and (v) time and resources required to address complex needs. The research team will expand the pool of study participants to additional partner schools across the Alliance and disseminate findings to inform faculty and empower students with key strategies that support the inclusion, persistence, and transition of neurodivergent STEM students.

In the **Southeast Hub**, data collection is ongoing and will continue each semester throughout the duration of the TAPDINTO-STEM alliance. Data collection is also expanding beyond the southeast region to include students throughout the national TAPDINTO-STEM alliance. Findings from this research will identify key variables related to persistence and be shared with campus leads to help students persist and earn degrees in STEM fields.

Project staff at the **West Coast Hub** have observed that students appreciate learning about best practices to increase access to postsecondary STEM programs. Students involved in piloting and refining the new science labs checklist tool were enthusiastic about advocating for change and learning new skills in this area. Activities to scale up the pilot project to include campuses at each Hub of the Alliance are currently underway. Completion of the study will inform the direction of future work. Such work could include broadening the scope of tools for students interested in accessibility auditing, further assessment of changes in student skills and confidence in impacting postsecondary campus accessibility and exploring the perceptions of postsecondary administrators who interface with students conducting such activities (Fig. 3).



Fig. 3. Group photo from Spring 2023 TAPDINTO-STEM convening held in Kansas City, MO

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