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Change Mapping of Models to Diversify STEM Faculty as Practiced by Alliances for Graduate Education and the Professoriate

Jue Wu¹, Sarah Chobot Hokanson², and Bennett B. Goldberg³

¹ Mathematical and Physical Sciences Dean's Office, University of California, Berkeley

² Office of the Provost, Boston University

³ Department of Physics and Astronomy, Northwestern University

The dearth of historically underrepresented minorities (URMs) in science, technology, engineering, and mathematics (STEM) faculty positions is one of the most significant challenges in higher education in the U.S. Increasing underrepresented groups' success in academia through achieving and retention in tenure-track faculty roles has been the central goal of the National Science Foundation's (NSF) Alliances for Graduate Education and the Professoriate (AGEP) program. In the present study, we draw on organizational change theories in higher education reform and interpret the landscape of AGEP project alliances through mapping their theories of change, barriers to success, levels of change, and foci of change, based on semistructured interviews with 17 AGEP alliances' core teams. Our mapping reveals local structures as well as interesting patterns across AGEP alliances that inform national trends. We identify alignment and misalignment between our analysis frameworks and AGEP projects which amplifies contemporary questions of providing direct student support within a deficit mindset context as well as sustainability and scalability for both the AGEP community and the broader community of diversifying STEM.

Keywords: higher education, STEM education, diversity and inclusion, organizational change, NSF AGEP

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The Alliances for Graduate Education and the Professoriate (AGEP) is a National Science Foundation (NSF) program that seeks to advance knowledge about models to improve pathways to the professoriate and success for underrepresented doctoral students, postdoctoral scholars, and faculty in science, technology,

engineering, and mathematics (STEM) disciplines and/or STEM education research fields. NSF AGEP programs focus on STEM PhD and postdoc success among racial and ethnic underrepresented minorities (URMs), including African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians,

Jue Wu  <https://orcid.org/0000-0002-2931-7146>

Sarah Chobot Hokanson  <https://orcid.org/0000-0002-7348-4312>

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of Underrepresented Doctoral Students in Engineering. (i) The Hispanic AGEP Alliance for the Environmental Science and Engineering Professoriate in Community Colleges and Associate Degree Programs. (j) The Committee on Institutional Cooperation (CIC) Professorial Advancement Initiative. (k) AGEP Transformation Alliance: Center for the Integration of Research, Teaching and Learning (CIRTL) AGEP—Improved Academic Climate for STEM Dissertators and Postdocs to Increase Interest in Faculty Careers. (l) California AGEP Model to Increase the Success of Underrepresented Minority Postdoctoral Fellows Becoming Faculty in Mathematics, Engineering and Physical and Computer Sciences. (m) AGEP Transformation Alliance: Bridging the PhD to Postdoc to Faculty Transitions for Women of Color in STEM. (n) The AGEP Engineering Alliance: A Model to Advance Historically Underrepresented Minority Postdoctoral Scholars and Early Career Faculty in Engineering. (o) The AGEP Alliance State System Model to Transform the Hiring Practices and Career Success of Tenure Track Historically Underrepresented Minority Faculty in Biomedical Sciences. (p) The Michigan AGEP Alliance for Transformation (MAA): Mentoring and Community Building to Accelerate Successful Progression into the Professoriate. (q) An AGEP Alliance Model to Advance Underrepresented Minority STEM Faculty at Predominately Undergraduate Institutions.

Correspondence concerning this article should be addressed to Jue Wu, Mathematical and Physical Sciences Dean's Office, University of California, Berkeley, 101 Durant Hall, Berkeley, CA 94720, United States. Email: juewu@berkeley.edu

and Native Pacific Islanders.¹ The purpose of this article is to present and interpret the current AGEP landscape by describing, organizing, and analyzing what AGEP alliances do and how they work in the context of their chosen models. We term our approach change mapping, taking a perspective that prioritizes a theory of change approach (e.g., Anderson, 2004; Connell & Kubisch, 1998; Kezar, 2013), where we describe the change models and interventions utilized by current AGEP alliances, examine barriers to their success, and discuss their strategies for scalability and sustainability.

We were motivated in this work to provide a guide for both current AGEP alliances and those who are interested in starting an AGEP alliance, as we (the authors) were the organizers of the 2020–2021 AGEP National Research Conference that brought together the entire AGEP community to communicate practices related to the dissemination, institutionalization, sustaining, and scaling of AGEP models. Further, understanding what the practices of AGEP alliances are and how alliances operate also provides insights on the many projects and programs seeking to diversify STEM and create institutional change work in the broader higher education reform context. For example, reformers in diversity work may find it helpful to connect specific practices and implementations to institutional change theories. The change mapping approach we introduce in this article can help them create more meaningful theories of change to support their projects' success. Our change mapping may also potentially become a novel tool for analyzing complex diversity, equity, and inclusion programs funded by NSF and many other agencies, connecting the focus of individual projects and the landscape of the entire funded program. Finally, higher education institutions might benefit from learning about funding opportunities such as AGEP and others that support diversifying and making more inclusive STEM higher education and pathways.

Background

One of the most significant and intransigent sociopolitical challenges facing higher education and workforce development broadly is the dearth of historically URMs in STEM faculty positions in the United States, partly because of the “leak” of minority graduate students from the STEM pipeline (National Research Council, 1986) persists. Based on a recently published report from the NSF, the share of academic positions held by racial and ethnic URMs in STEM has increased from 5.8% in 1997 to 8.9% in 2017 (National Science Foundation, 2019), but the representation of African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders is still very low compared to their respective population sizes in the United States, with the total share under 10% (NSF, 2019). The persistently White and Asian majority racial makeup of STEM graduate programs in universities relative to the United States population suggests that higher education has much progress to make in order to become equitable in STEM education. Moreover, among STEM doctorate degree holders in academia, historically URMs also have a lower rate of tenure compared to their White counterparts (NSF, 2019).

To address underrepresentation in STEM education and the professoriate in the United States, NSF has created a variety of funding opportunities for research and intervention in the STEM reform space. For example, the inclusion across the nation of communities of learners of underrepresented discoverers in

engineering and science (INCLUDES) is a comprehensive national initiative designed to enhance leadership in STEM discoveries and innovations by focusing on broadening participation in these fields at scale and across multiple communities. Another program, ADVANCE: Organizational change for gender equity in STEM academic professions (ADVANCE), works toward broadening the implementation of evidence-based systemic change strategies that promote gender equity for STEM faculty in academic workplaces and the academic profession (Laursen & Austin, 2020). The focus of this article, AGEP, is similarly a program that serves the goal of increasing underrepresented groups' success in academia through supporting their pathways into and retention in tenure-track faculty roles.

AGEP projects employ an alliance model, where multiple institutions collaborate on a single proposal and jointly apply for funding support. Funded alliances work collaboratively to develop and implement interventions and strategies. From its inception in 1998 as the minority graduate education (MGE) program, the AGEP program has evolved significantly.² Initial programs supported students directly by providing tuition and stipends and focused on developing strategies and models for recruiting, mentoring, and retaining marginalized students in STEM disciplines. Newer programs seek to advance knowledge by developing new models or reproducing/replicating existing models that succeed at diversifying tenure-line STEM faculty and have expanded to include social science research as well. The evolution of AGEP solicitations and the design of the corresponding funded AGEP alliances has displayed a collective understanding of the need for more systematic, institutional, and sustainable changes, as well as a need for better understanding such change models (e.g., Eckel & Kezar, 2003; Harper & Hurtado, 2007; Kezar, 2013; Loomis & Rodriguez, 2009).

We conducted the current research to create a change mapping system with the goal of understanding AGEP alliances' change models in the current national landscape. We structure our article by first reviewing the theoretical framework that guided our research design and analysis, then presenting a few case studies of individual AGEP alliances, followed by a comprehensive landscape analysis of the whole AGEP alliances collection, and finally interpreting our results and discussing the implications.

Theoretical Framework

Kezar's work on change and reforms in higher education (e.g., Kezar, 2011, 2013) has made a significant impact on our understanding and how transformation processes are conceptualized at colleges and universities. Since AGEP projects develop, implement, self-study, evaluate, and disseminate alliance models that are focused on achieving change across multiple participating institutions, it is important to employ a systematic view that examines models and interventions from a multifaceted and multitheory approach, examining multiple levels and several foci of change. Kezar (2013) proposed six theories and models in terms of

¹ The use of the term “historically underrepresented minority” or “URM” reflects language from Congress. The specific racial and ethnic populations referred to here are defined by the NSF AGEP program and are derived from the U.S. government's guidance for federal statistics reporting.

² From 1998 until 2019, there were six revisions of the program funding opportunity, listed as NSF 01-138; 04-575; 10-605; 12-554; 14-505; 16-552.

organizational change in higher education—scientific management, evolutionary, cultural, political, social cognition, and institutional. Extrapolating from the theories proposed by Kezar (2013), we identified three main theories of change from the literature that are most relevant to the context of AGEP alliances for its flexibility in application to multi-institution initiatives: social cognition, cultural, and institutional.

Social Cognition Theory of Change

Social cognition theory highlights the role of individual learning and development and assumes that change can be best understood and enacted through individuals (Harris, 1994; Kezar, 2001; Martin, 1992). Change occurs because individuals see a need to grow, learn, and change their behavior. In the context of AGEP, alliances that focus on this type of change have interventions that seek to shape individuals' thinking and interpretation within their organization(s). For instance, AGEP alliances might have interventions such as providing academic and research support (teaching training, grant writing workshop, etc.) to minoritized STEM graduate students, postdocs, or junior faculty members at their respective institutions.

Cultural Theory of Change

Cultural theory of change suggests that cultures are always changing, and change occurs naturally in the form of shifting values and beliefs (Kezar, 2013; Morgan, 1986; Schein, 1985; Shaw, 1996). In the context of AGEP, this type of approach often involves change at multiple levels and in different forms because values and beliefs held by various communities are embedded in the policies and practices of a particular system housing that community. For example, AGEP alliances might develop mentoring programs that provide opportunities for mentors and advisors of URM students to better understand students' communities or learn about their cultures and beliefs (González et al., 2006) that students bring to their graduate studies and research.

Institutional Theory of Change

Institutional theory of change examines change at a broader context, such as institution-wide or alliance-wide, and also often relates to change at multiple levels. It takes into consideration both internal organizational features as well as external conditions that may encourage or inhibit change. In the context of AGEP, alliances that focus on this type of change often involve working closely with university leadership to drive institutional change. For instance, there might be changes in institutional policies, practices, and career pathways, or institutional, departmental, and laboratory climates, driven by AGEP alliances' work with institutional and departmental leadership.

Barriers to Success, Levels of Change, and Foci of Change

In addition to the frameworks based on social cognition, cultural and institutional theories of change, various barriers to success, multiple levels of change, and various foci of change are also key concepts that motivate, organize, and help analyze our work. Specifically, barriers to success (e.g., Kezar, 2013; Kezar &

Holcombe, 2020) in the context of AGEP are factors that inhibit URM's success in STEM identified for intervention by alliances. Categories of barriers include social cognitive barriers, cultural barriers, and scientific barriers. Social cognitive barriers refer to personal and professional identity, understanding, and abilities (e.g., self-efficacy, mindset). Cultural barriers relate to attitudes, values, and beliefs about diversity (e.g., faculty perception and bias). Scientific barriers are about lack of effective policies and procedures (e.g., lack of holistic admission or unbiased faculty hiring policy). Foci of change (see Kezar, 2013) are phenomena or outcomes that AGEP alliances are working towards, which can be structures, processes, and attitudes. Structures refer to policies and or procedures (e.g., admission and hiring process), processes relate to approaches to enacting certain operations (e.g., diversity plans), and attitudes are the ways people feel about themselves and their work and are often closely related to culture (e.g., perception and awareness). Moreover, based on alliances' strategies and interventions, levels of change can be distinguished into individual and organizational.

The elements discussed above are not independent of one another. For example, adoption of a particular theory of change might depend on the identified barriers to success of URM individuals. Theories of change may also affect strategies and interventions of AGEP alliances, which are then related to barriers to success and foci of change. In general, alliances make choices among theories of change, barriers to success, and level of change that support their goals within their local contexts. Some alliances might have identified different types of barriers but decided to focus on a single change model to begin to make a difference and determined foci of change accordingly. Our research sought to uncover AGEP projects' alignments of theories of change and other key factors by mapping all these axes onto a single figure.

By applying these theoretical frameworks as lenses and filters to organize and interpret AGEP approaches and practices, we hoped to examine AGEP alliances' functioning and sustainability from a multifaceted approach. Specifically, we tried to answer the following questions from this work: (a) What do typical AGEP alliances look like and how do they function? (b) Across the existing AGEP alliances, what does the landscape look like with regard to their theories of change, barriers to success, levels of change, and foci of change? (c) How can institutions initiate and/or sustain an AGEP alliance? (d) What are the implications of AGEP alliances for the broader community involved in work that supports the diversification of STEM in higher education?

Method

There were 15 AGEP alliances funded in fiscal years 2016–2019 under AGEP Solicitation NSF 16-552, which was released in 2016 and was the most recent solicitation when we conducted this research. However, in order to also investigate the issue of sustainability, we included alliances that span different funding years in our recruitment process. Including currently funded AGEPs from prior solicitations, there are 28 total AGEP alliances that are active in operation at the time of writing this article.

To note, this work did not evaluate the alliances, as all alliances have built-in funded structures for evaluation. We did not collect evaluation summaries nor data, nor did we request evidence of outcomes from the alliances. In addition, we did not have access to

NSF annual or site visit reports. Our goal was to review and report on alliance structures, approaches, and models to describe and interpret the current AGEP landscape without asking or answering whether and how the chosen approaches and models reach their desired outcomes. Our nonevaluative approach was intentional—we are not reviewers and we sought to position our work as conference designers in supporting the current alliances where they are now. This would allow them to use our conference sessions to better articulate and reflect on their models, in order to examine and improve approaches and practices.

We emailed all the lead principal investigators (PIs) of the lead institutions of each AGEP alliance (who are listed as the main point of contact on publicly available NSF websites) our request to conduct an 1-hr, semistructured interview with the leadership team of the alliance. The decision to interview the leadership team of the alliance was made because the leadership team often involves not only PIs/co-PIs of the AGEP grant, but also social science researchers and evaluators who are familiar with the development and implementation of AGEP alliances' models. We received responses and successfully conducted interviews with 16 current (of the 28) and 1 previous AGEP alliances during the fall of 2019.

Our interview discussion protocol was semistructured and was developed based on the theoretical framework of organizational change theories in higher education that we described previously. We began with general questions on how the alliance began, and then we asked questions relating to their models of change, which is core to the NSF Solicitation (NSF 16-552) that funded their work. We asked about alliances' participants and change agents, as well as interventions and practices developed to drive change. We also included questions on sustainability and scalability. The interview protocol is available in Supplemental Materials.

Upon conducting interviews, we organized our interview notes and performed coding and analysis based on the preidentified axes developed from our theoretical framework with regard to theories of change, barriers to success, levels of change, and foci of change. This approach of coding is deductive, as our set of codes was predefined by the theoretical framework, and we went through our

qualitative data to assign these codes (Miles et al., 2018). In addition to using the previously discussed framework derived from Kezar's work (e.g., Kezar, 2011, 2013) to categorize theories of change, barriers to success, levels of change, foci of change for each of the AGEP alliances we interviewed, we also adopted a change mapping approach (Turner, 2015) to understand, at a glance how these elements relate to each other in a complex system that involves multiple changes. Specifically, our attempt to map changes is based on our creation of a color-block template that places theory of change, barrier to success, level of change, and focus of change on each individual row. Whenever an element is identified as present in the alliance based on our coding, we fill it with a color. Otherwise, blocks remain transparent. The coding is binary and does not indicate gradation by intensity of color. The idea behind such a template is to allow us to quickly examine the alignment of elements within each row and to see patterns across multiple AGEP alliances. Figure 1 is an example of our change mapping template. We use this template to map theories of change, barriers of success, level of change, and foci of change for all 17 alliances that we interviewed.

Results

Our analysis demonstrates both a high-level understanding of individual AGEP alliances and also a collective picture of the AGEP landscape, discovering that a majority of alliances act through social cognition in support of individuals, yet many describe institutional and cultural theories leading to a surprisingly large misalignment of theories and actions. We present our findings by first narrating four case studies of existing alliances to provide a contextualized view of the different aspects we examined, and then visualizing spatially and chromatically with a change mapping template we created to characterize the relationships among different axes.

Case Studies of Existing AGEP Alliances

In this section, we present four case studies of existing alliances to convey a sample of how different types of alliances are structured and how they function. This level of detail was collected on all measured alliances. Our selection of examples is based on alliances'

Figure 1
Color-Block Change Mapping Template

	Alliance Alpha		
Theory of Change	Social Cognition	Cultural	Institutional
Barriers to Success	Social Cognition	Cultural	Scientific
Level of Change	Individual		Organizational
Focus of Change	Structure	Process	Attitude

Note. See the online article for the color version of this figure.

theories of change as the primary criteria, to cover social cognition, cultural, and institutional change models. Note that there are few alliances focused on cultural theories of change. The case studies also contain alliances that chose different target participants, areas of focus, and interventions. Our goal is to display the self-reported priorities of a representative set of alliances together with the way they describe their theories of change, barriers, loci of action, and interventions. By doing so, we seek to add context to our process of change mapping, making richer and more nuanced the relationships among change processes within and across alliances. In addition, this approach would also allow us to connect AGEp models to other STEM broadening participation initiatives.

Alliance Alpha: A Professional Identity and Individual Development Plan for Dissertating STEM Doctoral Candidates

Alliance Alpha started in 2017 and formed a leadership team based on an existing state-level university system and an existing collaboration within a previous AGEp project. Alliance Alpha's model seeks for a systematic understanding of URM students' needs and aims to effectively address the barriers that prevent success of URM students in academia through focusing on professional identity and a written individual development plan for dissertating STEM doctoral candidates. Alliance Alpha is applying a prototypical social-cognition change model, which highlights the role of individual learning and development and assumes that change can be best understood and enacted through individuals (Harris, 1994; Kezar, 2001; Martin, 1992). Alliance Alpha developed this model based on experiences from their previous AGEp project and also drew upon theories related to learning communities (Cox, 2004). The model addresses social cognitive barriers, such as personal and professional identity and self-efficacy, so that their participants are more likely to succeed. The level of change is at the individual level, as they work on the professional identity and individual development plan for their doctoral student participants. The foci of change are attitude and process, as the alliance works toward shaping individuals' thinking and interpretation of the STEM work environment as well as crafting professional development approaches that can be shared across multiple institutions.

Alliance Alpha's interventions focus on creating experiences for skill development and degree completion. Their 26 interventions and practices range from academic and research (e.g., degree completion support), mentoring (through grad school to postdoc to junior faculty), professional development (e.g., exposure to international institutions, job planning strategies), and community building (e.g., scholarly learning community). The participants of Alliance Alpha are direct participants: URM STEM doctoral candidates in the dissertation phase. The first and the only cohort of participants started off with 12 doctoral candidates across four participating campuses. Because Alliance Alpha started in 2017 and participants have been in the alliance for several years, a small number of the participants have become postdocs. The reason for a single cohort is that Alliance Alpha wanted to follow along with their participants as they advance from doctoral students to postdocs to junior faculty and learn and understand their successes and challenges through the tool and artifact of an individual development plan.

Alliance Beta: An Institutional and Faculty Transformation Model

Alliance Beta started in 2018 as an expansion of a pilot project in mentoring URM doctoral fellows at one of the participating institutions. The goal of Alliance Beta is to decrease the gap between the numbers of underrepresented students earning PhDs in STEM disciplines versus the number of majority students. Their change model is based on the theory that reducing the gap in PhD degree recipients is one approach toward eliminating the gap in faculty representation. The leadership team of Alliance Beta had worked with one another on previous NSF projects seeking to increase women and URM representation in academia, and began this alliance based on an existing collaboration and an established common interest among members of advancing access to and success in the professoriate of minoritized groups.

Alliance Beta's model draws upon Kezar and Eckel's work on institutional transformation (Kezar & Eckel, 2002) and is an institutional and faculty change model that promotes diversity, equity, and inclusion at an organizational level with the intention to shift faculty attitudes that will indirectly and over time support URM PhDs to the professoriate. Alliance Beta recognizes that changes require developing new institutional policies and practices and therefore need support and engagement at all levels in the university. One aspect of their approach to structural change includes the creation of departmental and university-level diversity plans. They also have faculty studying the challenges and barriers of URM students, which is a key component in Alliance Beta's interventions because all faculty participants need to understand what students are experiencing first before they can commit to driving institutional changes. Their overall goal is to shift faculty's attitudes and engagement on diversity-related issues, promoting institutional changes over time.

The participants of Alliance Beta are termed indirect participants in our study; by this, we mean that the targets of the interventions are not directly the URM graduate students whose outcomes the overall program seeks to impact. Instead, their participants are faculty fellows from STEM departments who work with and impact URM STEM students in their everyday teaching and advising roles. Faculty fellows are accepted into the program on a cohort basis, and they commit for 2 years as participants of Alliance Beta. Faculty fellows gather together monthly to learn about the experiences of URM students at their own and across other alliance institutions, share findings with other faculty in their department, design initiatives to spread best practices about working with URM students, and thereby eventually promote institutional change. The leadership team also holds semiannual cross-alliance meetings with department heads, directors of graduate programs, and provosts, to transmit the learning and initiative design from faculty fellows to influence higher level change policies. Alliance Beta chose to focus on this particular group of participants because they wanted to change the institution rather than placing the burden of change directly on their URM students. Alliance Beta's goal is to address a social cognitive barrier that URM students often feel isolated when interacting with faculty members and other students by developing a set of faculty and staff that are change agents in their department, creating inclusive and welcoming environments.

Alliance Gamma: A Cultural Appropriateness Model

Alliance Gamma's model is a culturally appropriate model that draws upon indigenous research and grounds their work in cultural knowledge, traditions, and core values. The model aims to provide support for the professional success of faculty and instructional staff in STEM who are members of, and/or descendants of, Native American tribes.

Alliance Gamma started in 2017 with three participating institutions: A state university and two tribal colleges. The three participating institutions had partnered before and therefore had built existing relationships. The collaboration between a research institution and tribal colleges highlights Alliance Gamma's mission to address the issue through partnering with other stakeholders within the STEM pipeline. Alliance Gamma originally was designed to support the professional development of Native American women in STEM, but the target participants were expanded to all Native American STEM faculty and staff in the three institutions. Alliance Gamma seeks to address the underrepresented and underserved population of Native American STEM faculty because there are only about 700 Native American STEM faculty across the entire nation, or 0.05%.

Alliance Gamma's model is a cultural change model in which changes occur through shifted values and beliefs that define the cultural system. The goals include academic and professional support toward social cognitive change, as well as cultural change. Cultural change is enacted through awareness and understanding of Native ways of the majority population, rather than supporting the existing dominant culture. The level of change is at both the individual level and the organizational level. At the individual level, Alliance Gamma provides academic and professional development support for their participants through indigenous mentoring. At the institutional level, Alliance Gamma seeks for opportunities to build relationships with university administrators and hopes to inform policy-making decisions related to recruitment and retention of Native Americans in STEM. The foci of change are both process and attitude. Alliance Gamma supports Native American STEM faculty and staff as they engage in academic activities with six Rs: respect, relevance, responsibility, reciprocity, representation, and relationship (Baskin, 2005; Kirkness & Barnhardt, 1991; Restoule, 2006).

The development of Alliance Gamma builds on indigenous research methodology (Denzin et al., 2008) and community-based participatory research (Sohng, 1996; Strand et al., 2003) and adopts an indigenous evaluation framework in their evaluation plan. Their interventions range from academic and research training (e.g., grant writing workshop), mentoring (e.g., indigenous mentoring program), to community building and institutional climate change (e.g., institutional support program that seeks for changing existing policies).

The participants of Alliance Gamma are direct participants, Native American STEM faculty and instructional staff. The participants are on a single cohort basis, with the same cohort advancing through the programs and processes over 4 years. Alliance Gamma chose this particular group of participants because there are existing alliances for other populations and there is a need for an AGEP alliance for Native Americans in STEM. Alliance Gamma tries to ensure the success of Native American STEM faculty and staff by addressing a social cognitive barrier resulting from the mismatch of Native Americans' desire to leave academia and colleges' desire to retain them in this particular alliance.

Alliance Delta: An Adoption and Adaptation Model

Alliance Delta started in 2015 as an AGEP-knowledge adoption and translation (AGEP-KAT) project, focused on translating an existing model developed by another AGEP alliance into a new collaboration. Although the AGEP-KAT track has since been discontinued by NSF, the current AGEP solicitation funds alliances that reproduce and/or replicate existing models to understand how effectively these models can be adopted and/or adapted by other institutions. Alliance Delta proposed to test one of the existing models that had been widely recognized as successful (Maryland's PROMISE AGEP). This Alliance formed out of an existing collaboration between members of the leadership team of Alliance Delta.

Alliance Delta decided to adopt and adapt a portion of the prior alliance's strategies and interventions and apply them to a different population. They chose to focus on engineering doctoral students because they have a highly ranked engineering school and that is where the highest number of URMs are enrolled in their institution. Alliance Delta is a model that supports URM engineering doctoral students through interventions that increase faculty engagement and address departmental climate change. Their change theory is both social-cognition and institutional, because their interventions target both the individual learning and development of URM doctoral students as well as how faculty view and interact with those students. Therefore, the focus of change is students' and faculty's attitude, and the change involves both the individual level and the organizational level.

Alliance Delta's interventions include academic and research training (e.g., dissertation house), mentoring (e.g., monthly faculty-student engagement), professional development, community building (to address students' feeling of isolation), and institutional climate change (e.g., institutional-wide adoption of diversity and inclusion statement). Alliance Delta addresses a social cognitive barrier of faculty's perception of and communication with URM students as well as a cultural barrier of university leadership and administrators' receptivity toward URM students.

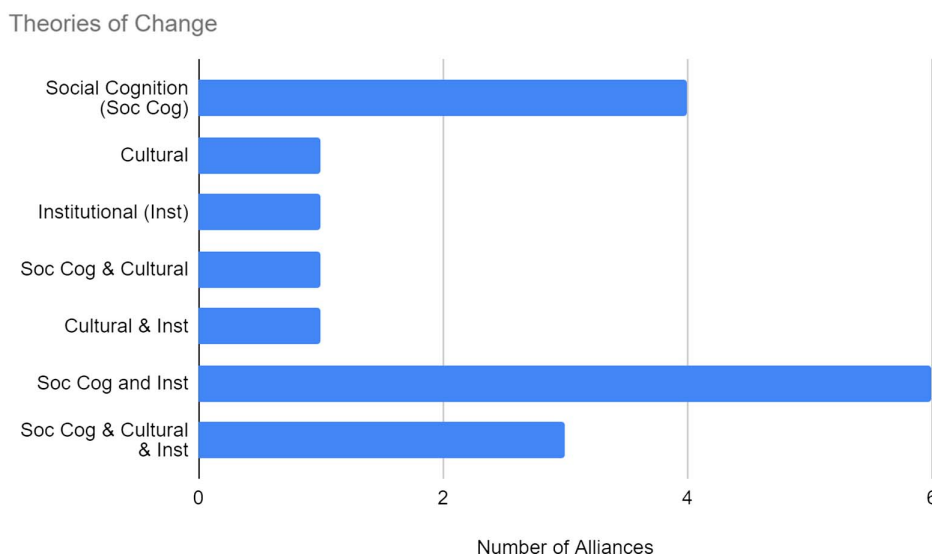
Landscape Analysis of AGEP Alliances

This section interprets the current AGEP landscape by analyzing, organizing, and describing what AGEP alliances do and how they work within the context of their models based on our interviews with the 17 alliances. We applied a change mapping lens that prioritizes a theory of change approach, as well as identifying an alliance's self-reported barriers, foci of action, and interventions. In our initial analysis, we simply present the frequency of occurrence across the alliances for each of these four axes of change. In our secondary analysis, which we report and interpret in the Discussion section, we develop and present a change mapping visualization that spatially and chromatically characterizes the relationships of these four axes allowing us to identify several interesting patterns that raise compelling questions for the national AGEP community.

Theories of and Approaches to Change

We identified three main theories of change among the existing AGEP alliances: social cognition, cultural, and institutional. Many of the AGEP alliances draw upon more than one theory of or approach to change, although there is often only one dominant theory. Figure 2

Figure 2
Categorization of Theories of Change Among AGEP Alliances



Note. AGEP = Alliances for Graduate Education and the Professoriate. See the online article for the color version of this figure.

illustrates the categorization of frequencies of theories of change, summarized from our interviews.

Almost all of the alliances draw upon social cognition theory of change, as only three alliances do not involve social cognition theory of change. This indicates that the learning and development of URMs in STEM remains at the core of AGEP programs. However, this approach, if not fully articulated and understood by the URM population, could place the burden and expectation of change on this vulnerable group, an issue we discuss in detail below. We also see that cultural theory of change and institutional theory of change often do not act alone—they are more commonly used in combination with other theories of change. The reason for this may be because these two theories often involve multiple levels of change and could be more beneficial when combining with other theories, or perhaps the reason they are often used in tandem is because when an alliance takes a broader approach, they may end up missing cultural and organizational change approaches. Moreover, we see a majority of alliances involve institutional approaches to change. Although not visible in the bar chart, many of the alliances that draw upon institutional theory of change are the newer awardees, with newer alliances following the growth of literature emphasizing the importance of institutional change (e.g., Gehrke & Kezar, 2017; Micelotta et al., 2017) and NSF solicitation revisions³ and might be a key for sustainability when thinking about the long-term impact of AGEP.

Barriers to Success

AGEP alliances develop and disseminate models that seek to overcome barriers that prevent URMs from succeeding in STEM, and those barriers can be social cognitive, cultural, or scientific (see above, for additional explanation). Figure 3 illustrates the categorization of barriers to success.

As we can see from Figure 3, 12 of the 17 alliances identify a single barrier to success. In comparison, only six of 17 alliances identify a single theory of change (see Figure 2), implying that alliances are seeking to employ multiple change models and strategies to address an individual barrier. We also note that some alliances’ identified barriers are not strictly within their change models, which we address in greater detail below.

Levels of Change and Foci of Change

Although alliances differ in their theories of change, 65% of the alliances involve both the individual and the organizational level of change. Only one out of the 17 alliances involve change at the organizational level solely. Also, more than half of the alliances involve more than one focus of change—there are often multiple phenomena that alliances want to address as end goals in one award cycle. Information on the breakdown can be found in Supplemental Materials.

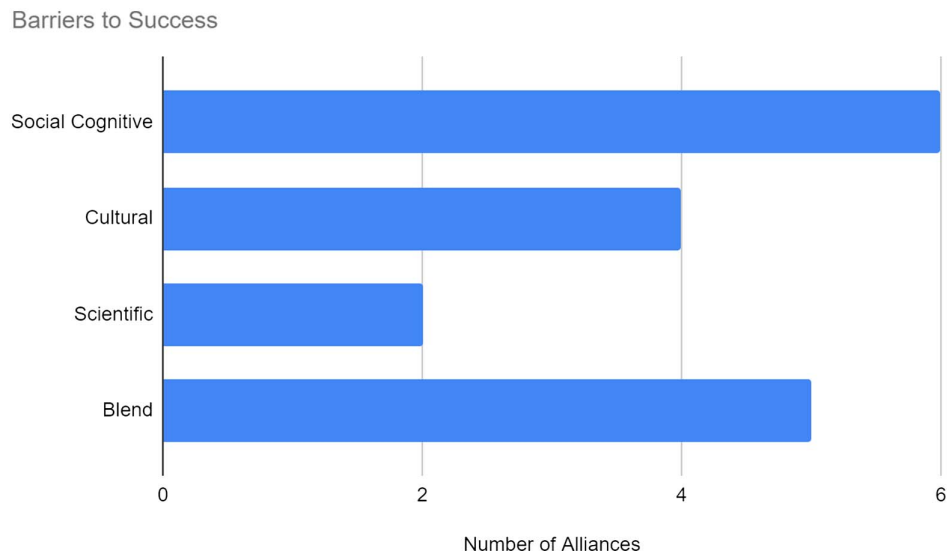
Direct and Indirect AGEP Participants

One way to categorize AGEP alliances’ participants is to differentiate direct and indirect participants. As mentioned above, we define direct participants as those individuals whose cognitive, attitudinal, and behavioral changes are goals of the interventions, and that those goals and the advancement of those individuals represent the desired final outcome. In the context of AGEP, this often means URM students, postdocs, or junior faculty in STEM and/or STEM education research disciplines. Indirect participants, on the other hand, are those individuals whose cognitive, attitudinal, and behavioral changes are the targets of the interventions, but whose are not implicated in the desired final outcome, rather in the

³ NSF 01-138; 04-575; 10-605; 12-554; 14-505; 16-552.

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Figure 3
Categorization of Barriers to Success Among AGEP Alliances



Note. AGEP = Alliances for Graduate Education and the Professoriate. See the online article for the color version of this figure.

steps along the way toward it. Typically, in AGEP projects, indirect participants are STEM faculty advisors or other university personnel who work with URM PhD students and postdocs. Instead of developing interventions that directly support URMs learning and research, alliances with indirect participants develop interventions that engage with STEM faculty and other related personnel so that they become the change agents and create a better environment for URM students, postdocs, and junior faculty toward achieving the ultimate goal of retaining greater URM percentages in STEM toward their recruitment into faculty positions. The majority (15 of 17) of the AGEP alliances work with direct participants. Among the alliances we gathered information from, only two alliances have interventions designed to focus on indirect participants. This is linked to alliances' theory, level, and focus of change.

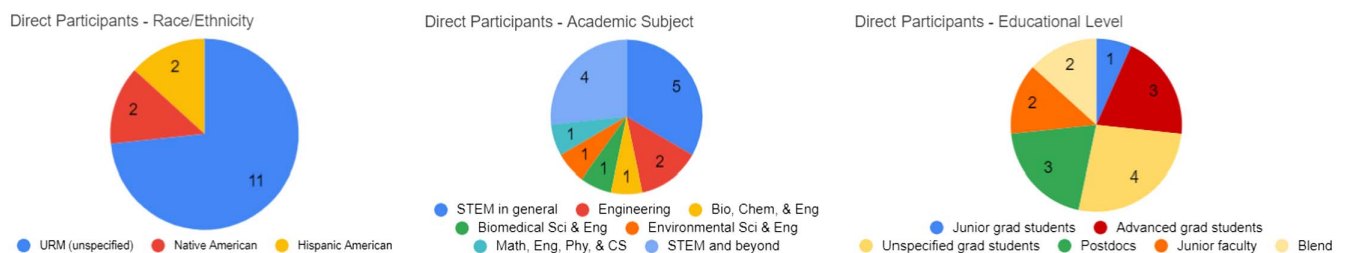
There are also several ways to categorize direct AGEP participants, including identity, discipline, and career status. Among the 15 alliances that work with direct participants, 73% work across all URM identities while others focus on a particular racial or ethnic group. This same is true for disciplinary focus, with some alliances

focusing on participants from all STEM fields while others target participants from a specific STEM discipline. Some alliances focus on participants who are graduate students, postdocs, or junior faculty. Figure 4 summarizes categorization among direct participants.

Types of Interventions

We have identified five main categories of interventions among AGEP alliances: (a) academic/research: interventions that provide academic and research support (e.g., teaching experience, grant writing, etc.) for direct AGEP participants such as URM students, postdocs, and faculty; (b) mentoring: interventions that provide coaching and mentoring outside and independent of participants' academic program; (c) professional development: interventions that offer professional development workshops or networking opportunities for direct participants; (d) community building: interventions that create and support learning communities for either direct or indirect participants; (e) institutional climate: interventions for indirect participants that change institution policies, practices,

Figure 4
Categorization of Direct AGEP Participants



Note. AGEP = Alliances for Graduate Education and the Professoriate. Left: categorization of direct participants based on race/ethnicity. Middle: categorization of direct participants based on academic subject. Right: categorization of direct participants based on educational level. See the online article for the color version of this figure.

and career pathways, or institutional, departmental, and laboratory climates. Almost all of the alliances involve interventions for the first four categories, with fewer alliances implementing interventions for institutional climate change. Below, we present examples of interventions for each of the categories with representative examples from the alliances we interviewed.

Academic/Research. Almost all of the alliances involve academic and/or research interventions. Examples of academic and/or research interventions include grant writing workshops, dissertation workshops, academic bridge programs, research exchange programs, or teaching professional development.

Mentoring. Similarly, almost all of the alliances involve creating or promoting mentoring programs that provide mentoring, coaching, advising and advocacy to participants outside of their formal academic or research program structures. Approaches to mentoring include matching people with similar racial, ethnic or research backgrounds or pairing graduate students with faculty at community colleges. The goal of such mentoring programs is often to support URMs psychologically and help them build confidence as they develop trusted relationships with mentors who share similar backgrounds with URM participants.

Professional Development. Professional development is a common component across almost all of the alliances. Interventions for professional development include providing conference travel grants so that participants can present their research work and involve in networking events, maintaining a Curriculum Vitae (CV) database so that participants have a higher chance to be hired as their resumes are available for potential employers, interview preparation and job material workshops for participants who are ready to be on the job market, and so forth. These programs are designed to build professional skills to ensure greater preparation to enter the academic workforce.

Community Building. Community building interventions are provided by almost all of the alliances. It is recognized that many URMs experience a feeling of isolation during their graduate education, postdoctoral training, or even beyond (Curry & DeBoer, 2020). The idea behind community building activities is to create a safe space (e.g., third space) for URMs to feel that they belong (Gutiérrez, 2008; O'Meara et al., 2019). What URMs are experiencing is often shared by other peers who hold similar identities (Gutiérrez, 2008); therefore, the issues can be overcome if peers relate to one another. Examples of community building interventions include an alliance-wide community retreat, third space, where participants bring their knowledge and experience from first space—home—together with knowledge from their second space—academic and work—to achieve academic equity (Gutiérrez, 2008), or reading and learning groups. Many of these community building interventions have moved to virtual online spaces since the emergence of the COVID-19 pandemic.

Institutional Climate Change. Few alliances utilize interventions for institutional climate change. Examples of institutional climate change interventions include new policies for admission and retention, diversity and inclusion training for faculty and staff, and so forth.

Discussion

Change Mapping Visualization

In order to better represent each alliance's theory of change, barriers to success, level of change, focus of change, and the

relationship between all these elements, we use color-block visualizations to map out the 17 alliances we interviewed. Figure 5 on the next page shows a collection of the 17 alliances.

This approach draws on prior work of change mapping (Turner, 2015), which is distinct from approaches like logic models that seek to align goals, activities, assessments, and outcomes (Knowlton & Phillips, 2012). Change mapping seeks to understand the intentions, barriers to overcome, interventions, and mechanisms of change, which may in part be represented in logic models, but more explicitly and holistically centers the notion of change across a complex program. On the first row, we have six alliances who draw upon a single theory of change. Among these six alliances, most of them draw upon social cognition theory of change, and this includes Alliance Alpha.

Alliance Alpha has its theory of change, barriers to success, and level of change aligned, meaning that their program seeks to address the barriers they identified by drawing upon the corresponding theory of change for those barriers. Specifically, their barriers to success are an URM individual's identity, confidence, and self-efficacy, and they developed an individual-level development plan to address these barriers based on a social cognition change model. Nevertheless, not all alliances have their theory of change, barriers to success, and level of change aligned. Some alliances might have identified all different types of barriers but decided during this award period just focusing on a single change model to start to make a difference.

It is noteworthy that a large number of the alliances focus on social cognition theory of change, which implies that they believe that individuals, especially URM AGEP participants, need to change in order to be successful in academia. Such an approach needs to take care to avoid projecting a deficit mindset (Smit, 2012), or implying that URM AGEP participants have, as a group, "learning needs" or that they are not fully prepared for the R1 research and faculty environment. We posit that this is evidence that the academe remains heavily influenced by the illusion of a system of meritocracy (Liu, 2011), which places the burden of academic advancement on the individual, rather than systems of education. Such an implicit view of the deficits of individuals has in fact proved to be a barrier to implementation and success of changes (Kezar et al., 2015). Further, there is ample evidence that interventions that support an individual's belonging (e.g., Hausmann et al., 2007; Meeuwisse et al., 2010), high expectations of performance (e.g., Byars-Winston et al., 2010), and commonality of struggle (e.g., McGill et al., 2021) significantly improves academic outcomes for marginalized students in STEM. We therefore strongly encourage AGEP leaders to reexamine their approach to social cognitive interventions. Research on diversity and inclusion in higher education has proposed that community cultural wealth (Yosso, 2005) or cultural competence (Hammer et al., 2003), rather than deficit-based approaches, provide promising methods to increase URM individuals' enrollment and retention in STEM higher education (Miriti, 2019; Winkle-Wagner et al., 2020). We also note that almost all of the alliances have developed some academic and/or research interventions, as we discussed in the previous section. One of the reasons behind such an observation might be that many of the AGEP awardee institutions are research-intensive universities. Therefore, they have the expertise and resources to provide academic/research training and support, and also highly value academic and research outcomes. Moreover, the intention behind social cognition change models and

Sometimes, alignment might not even be possible. Our goal is to capture the differences in how AGEP alliances develop their models and implement them, driving toward changes that advance URMs to the academe.

The categorizations in the landscape analysis show the distributions for all the components we looked at across all the alliances we interviewed, while the visualization in this section allows us to quickly grasp relationships among the axes and reflect on the connections. This type of visualization could be particularly useful when the context of examination tends to be complex systems (e.g., a collection of programs) because the color-blocked tool itself makes the connections visible and accessible, and easy to process. If we zoom out and step back to think about the community of diversifying STEM or higher education reform as a whole, many of the initiatives involve complex systems to counteract systemic inequities in STEM, which could potentially be a great place to utilize such a change mapping visualization tool.

Initiating and Sustaining Alliances

Initiating and sustaining change are important transitional stages for any large-scale project, especially for systemic and structural changes in broadening participation that the AGEP alliances seek to make—to improve pathways to the professoriate and success for doctoral students, postdoctoral scholars, and faculty that hold historically marginalized racial and ethnical identities.

Based on our review and analysis of funded AGEP projects, we observed these common ways of starting an AGEP alliance: (a) Existing collaboration: This is perhaps the most intuitive way to extend working relationships. Starting from an existing collaboration means that institutions can leverage prior relationships and committed resources toward a new initiative. This approach might be even more successful if the existing collaboration is also related to initiatives on broadening participation in STEM. (b) Personal connection: Even if institutions are not currently collaborating, taking advantage of personal connections and networks also informs the development of alliances. (c) State university system: Though similar to existing collaborations, it is also different and special in that a state university system often means that institutions have a formal relationship, are controlled by the same policies, and can potentially share personnel information within the system. (d) Geographic proximity: Institutions in a close geographic distance report finding it easier to plan alliance-wide programs and create a locally based community for their participants. Detailed distribution of strategies AGEP alliances used to form their collaborations can be found in Supplemental Materials.

The process of initiating new alliances identifies several questions that may inform the alliance's choices of model, interventions, and structure. Specifically, alliances that are forming can reflect on the following three aspects as part of their development: (a) The participant groups the alliance is trying to impact; (b) The benefits of a multi-institutional collaboration; (c) Their change model and their partners that can support their work.

First, alliances need to decide what population that they want to work with and whether or not their work will directly impact URM graduate students, postdocs, and junior faculty or involve indirect interventions (e.g., faculty mentors, institutional leaders). Focusing on direct participation means engaging directly with those who hold historically marginalized identities to achieve AGEP's goals.

Potential AGEPS should proceed with this work based on the demographic characteristics of the particular institutions collaborating and the greatest potential to achieve impact. For example, participants may encompass all URMs at a set of institutions or focus on a specific group. Participants may also represent all STEM disciplines or a specific subset. Also, in a model that focuses on direct participation, the training stage of the participants will need to be identified—is it a broad engagement of URM scholars across all stages (e.g., graduate students, postdoctoral scholars, junior faculty), or targeting a specific training stage or transition moment? Choosing a model focused on indirect participation focuses on a different set of levers within higher education. Indirect participants of AGEP alliances are usually those in positions to influence policies or structural inequities that create barriers to retain URMs in the professoriate. These participants could include STEM faculty or other university personnel who work with URMs.

A critical component of the AGEP alliance model is achieving impact and institutional change through partnering with other institutions, rather than being limited to a single institution. This alliance-based approach to change alleviates one common, and perhaps the biggest, challenge for promoting changes at an individual institution—resources. Institutional budgets, particularly in a post-COVID-19 era, are constrained in how they can support diversifying STEM disciplines. Sharing resources within an alliance allows all institutions to benefit from their efforts. Also, the available resources at a single institution may differ, and cross-institutional partnerships can leverage the collective strengths across the alliance. For example, partnering a teaching-oriented institution like a community college or predominantly undergraduate institution with a research-intensive institution would allow sharing both scholarship-based training to students (e.g., grant writing), and teaching professional development or teaching experience among AGEP participants, efficiently utilizing resources and expertise, as well as providing a range of faculty role models and careers. According to alliances that we interviewed, the sharing of resources within an alliance is often reciprocal, which in turn can make the alliance long lasting. Other benefits of such multi-institutional participation include mutual accountability and greater diversity of perspectives. Changes that alliances are seeking often involve many partners within and beyond individual institutions. At local institutions, many alliances partner with offices that support their participants (e.g., career development center, diversity office, office of institutional research, office of student affairs, office of postdoctoral affairs, office of faculty affairs, center of health, and psychological wellness).

Leadership teams for AGEP alliances often consist of university leaders, in order to position them directly to support institutional change. These types of personnel could include department chairs, graduate school deans, or even provosts. Beyond local institutions, alliances also often partner with external stakeholder groups, including local leaders within organizations like state university systems, community colleges, and tribal colleges, to ensure that the model is directly applicable to students that may enter the institution from those prior training environments. One of the challenges some alliances face in implementing interventions across institutional contexts is the varying positionalities of their team. Some alliances implement local mapping exercises to better understand the context and positionality of their project teams and account for those similarities and differences when planning interventions.

Indeed, reflecting on these issues and questions could potentially give new alliances a good starting point. From there, alliances will decide on their theories of change, defining their barriers to success, levels of change, and foci of change, and creating their models. Then, in the next step, the funded alliances will and should begin to think about what the future of AGEP might look like.

AGEP awards are not currently renewable, though some alliances have been able to sustain funding by expanding or pivoting their program (e.g., PROMISE is in its third generation and has switched focus from graduate enrollment to system-wide postdoc advancement to creating pathways to faculty positions). Therefore, one of the biggest challenges AGEP alliances have is how to sustain and institutionalize their accomplishments in the absence of federal funding support, as is explicitly required under the most recent call for proposals. Alliances must consider sustainability at the start of their project, though most commonly these considerations come into practice later in the work, and as expected, have evolved throughout. Many alliances have found early and frequent communication with senior leaders at their institutions is critical for those programs that require financial support to sustain. Moreover, some alliances are sustaining their programs through scaling at other institutions, encouraging them to adopt or adapt interventions or strategies. Even models that are not entirely successful can be broken down into specific strategies and interventions that are successful and sustained, translating to praxis in other and even broader contexts.

Moreover, an idea of an alliance of alliances has emerged, with the hope to start some homogeneous and/or heterogeneous mega-alliances. For instance, alliances that rely on the same theory of change can potentially become a mega alliance, to better share and collaborate on their respective interventions. This type of mega alliance will be in the form of a homogeneous mega alliance. Heterogeneous mega alliances can also be valuable. For example, alliances with different change models that coalesce as a mega alliance based on geographical proximity, could improve or institute new interventions fostered through exchange of ideas. As we have discussed in previous sections, many of the AGEP alliances are formed by institutions that are geographically close to each other. During the era of COVID-19 when travel is very much limited and most of academia is reliant upon virtual meetings, a mega alliance of alliances that are relatively closer to each other could potentially solve the issue of difficulty in communication caused by multiple time zones.

End of federal funding does not necessarily mean the end of an alliance, and established funding does not mean alliances stop seeking partners. In fact, most AGEP alliances are actively looking for existing and new partnerships beyond their program to maximize their impact. Members of the AGEP community have expressed desire through our conference sessions, polls, and evaluation data to collaborate with other NSF broadening participation initiatives and professional societies. These partnerships may generate additional resources not possible without collaboration or could be a way of maximizing impact while distributing overall workloads.

Implications

Meanings of Analyses and Categorizations

We recognize that our analysis framework was developed based on the AGEP community. However, the change mapping approach

that we employ in this article represents a multilevel, multifaceted way of understanding and examining large-scale initiatives that involve various change agents and interventions. Such categorizations and mapping, depending on the context of what needs to be examined, might be adapted or adopted to look at other programs or projects as well.

Connecting AGEP Models to Broadening Participation Initiatives Generally

AGEP alliances develop different change models based on their participants and barriers to success and draw on different change theories to enact change. In fact, when alliances draw on social-cognition theory of change and institutional theory of change, many of their interventions share the same goals with the NSF INCLUDES (and other NSF programs). In particular, interventions focusing on individual development aligns with INCLUDES' first primary tenet—broadening participation in STEM; and interventions focusing on institutional structure and process aligns with INCLUDES' second primary tenet—collaborative infrastructure (National Science Foundation, 2020). Moreover, when alliances draw on cultural change theory and ground their work in cultural awareness, their interventions such as the indigenous mentoring program could raise awareness of inclusive teaching and learning for mentors and advisors, which to some extent shares the goal of building inclusive learning environment as other NSF sponsored initiatives such as the Inclusive STEM Teaching Project (<https://www.inclusivestemteaching.org/>). Therefore, learnings from AGEP alliances can benefit not only the AGEP community, but also the broader broadening participation community as well.

Limitations

Although we reached out to all alliances, our landscape analysis is still based on a sample of 17 (of a total 28) alliances. Further, we acknowledge that there are many programs seeking to diversify and make more inclusive STEM higher education, and our article is limited to a specific (NSF AGEP) program. However, as we discussed previously, the change mapping tool we developed can be used beyond the AGEP community, as an empirical mapping system for creating meta-analyses for similar initiatives for broadening participation in STEM. As noted previously, our funding was limited to conference design and planning, and therefore our analysis reflects program design and implementation rather than assessing program outcomes. In addition, we recognize that our analysis relies heavily on organizational change theories (e.g., Kezar, 2013) and therefore overlooks some of the important constructs in the literature body. For instance, because the AGEP program exclusively focuses on advancing focuses on racial and ethnic minorities, we did not in this research take into account intersectional identities, such as gender. Nevertheless, intersectionality (e.g., gender and race/ethnicity) is an important framework to critically examine individuals' experiences in STEM (Ireland et al., 2018). Social capital and cultural capital (Bourdieu, 1977, 1986) are also critical concepts in evaluating work related to race and ethnicity in education that we did not discuss in this article. Research has suggested that social and cultural capital are significant for persistence in higher education across all racial and ethnic groups (Wells, 2008). Despite this, we have chosen to develop our analytical tool

based on organizational change theories, and we invite readers to consider these other critical frameworks in STEM diversity work as they are also important and valuable.

Conclusion

The stated purpose of AGEP is to test and implement change models and disseminate successful practices that change institutions and by default, the structures of higher education, that inhibit the advancement of traditionally URMs to the professoriate. This study of mapping theories of change, barriers to success, levels of change, and foci of change has revealed interesting patterns across AGEP alliances past and current. Change mapping has revealed alignments and misalignments in AGEP alliances that would not necessarily have been obvious from a logic model analysis, since such models do not intentionally reveal how changes manifest at each step. All AGEP alliances are limited by funding resources, personnel support, power and positionality, and time. Our hope is that this change mapping perspective opens a new window into how AGEP alliances see their own designs and efforts, and may better focus their models toward greater outcomes. Moreover, change mapping brings such a multifaceted, multilevel approach that has the potential to become a powerful tool in understanding and examining general broadening participation, diversifying STEM initiatives, or even the broader higher education reform practices.

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