A NASA/University Faculty Development Partnership: Equipping Educators to Promote Equity in STEM Education

Abstract

As the call for reform in STEM education has continued to increase over the past twenty-five years, new challenges arise for colleges and universities to seek high-quality professional development strategies and opportunities for faculty to upgrade and enhance their STEM teaching methodologies. Against this backdrop, the authors discuss what constitutes high-quality professional development and examine a large-scale three-year case study, involving a collaborative effort among NASA MUREP Educator Institutes for preservice-teachers and STEM education faculty from minority serving institutions. The authors analyze the resulting impacts of this professional development on various aspects of the professional practices of participating university faculty.

Introduction

In 2015 NASA's Minority University Research Enhancement Project (MUREP) launched a partnership with universities targeted at promoting equity in STEM education for learners of all ages. The link between NASA and closing the parity gap in STEM is straight-forward. Motivated by their need for a larger and more diverse STEM workforce, NASA MUREP is attempting to prepare educators who will inspire students through engaging and challenging STEM experiences that will propel them to pursue continued STEM studies and ultimately expand their career options in the STEM field. By investing in the development of STEM faculty at Minority Serving Institutions (MSIs) who prepare the next generation of STEM teachers, NASA aspires to develop the capacity of future teachers of color who research indicates are the most likely to teach in economically disadvantaged areas (Ingersoll, Merrill, Stuckey, and Collins, 2018) and to reach underserved students from groups that have been traditionally under-represented in STEM fields. In order to ultimately impact the education of all K-12 students, and especially those from underserved populations, it is necessary to enhance the preparation of their future teachers, and to do so necessitates impacting the educators who are tasked with preparing these future teachers. It is with these goals in mind, that NASA began to tackle this complex and long-range challenge.

In this article, the questions of quality and impact of a faculty development programs will be examined and a specific STEM PD case study involving the NASA MUREP Educator Institutes (MEI) will be utilized to investigate these issues. The article will conclude by discussing findings and implications from this work and how the study insights can be utilized to guide future decision-making and strategic planning related to STEM faculty development.

The Need for Professional Development for STEM Faculty

There is general consensus among university administrators and policymakers that it is important for university faculty to participate in ongoing professional development (PD) in their content fields, in emerging technologies, and in current teaching practices (Van der Klink, Kools, Avissar, White, and Sakata, (2017). Vermunt and Endedijk (2011) reflect on this simple understanding, "For education to fulfill its mission, it needs to keep up with developments in society, students, and science." STEM teacher preparation is a joint endeavor of content faculty (typically from the College of Science) and science pedagogy and methods faculty (often from Colleges of Education). In the case of STEM, professional development is especially important because of the rapid advances occurring in all aspects of science, many of which are driven by the use of new technologies that are radically more powerful than in previous years. In the field of STEM, professional development targeted at STEM pedagogy is also especially important, because some university STEM faculty in the content fields typically have had limited preparation in designing and teaching courses" (Clapp, 2018; Brownell and Tanner 2012; Felder 2012; Stains**,** Pilarz, and Chakraverty 2015; Ebert-May, Derting, Hodder, Momsen, and Log. 2011).

"Transforming instruction in undergraduate science, technology, engineering, and mathematics (STEM) classrooms from a dominantly lecture-based, content-focused format to one in which students engage in learning concepts and processes of science is regarded as critical to the economic and cultural health of our nation" (Manduca, Iverson, Luxemberg, Macdonald, McConnell, Mogk, and Tewksbury, (2017). Henderson, Finkelstein and Beach (2010) echo the need for professional development in their discussions of STEM education, "There are repeated calls for the reform of undergraduate teaching. Resulting change efforts often focus on developing and disseminating specific instructional ideas and practices to individual faculty." Similarly, McNeil and Ohland (2015) contend that "Faculty developers should address the specific needs of faculty by explaining the research on how students learn and the best teaching practices from the research." Wieman in his book titled *Improving How Universities Teach Science (2017)* discusses the value of professional development in the Science Education Initiative (SEI), a program implemented across thirteen science departments at the universities of Colorado and British Columbia, to support the widespread adoption of the best research-based approaches to science teaching.

STEM faculty who have had the benefit of professional development devoted to STEM pedagogy reflect on becoming familiar with the learning sciences and report becoming better teachers themselves. Manduca et al. (2017) concluded from analysis of three national surveys of science faculty conducted in 2004, 2009 and 2012, (n = 7,547), "Faculty who invest time in learning about teaching report the strongest teaching practices. Although more research is needed to understand the relationship between learning about teaching and improving teaching practice, it is clear that opportunities to learn have an impact." The authors reflected on the contribution of this research, "Our study adds to the growing body of evidence that investments that support faculty learning about teaching lead to improvements in teaching practice."   Zhang, McInerney and Frechtling (2010) in working with such faculty quoted one STEM professor as saying "A major personal 'a hah' was the discovery of best practices in teaching". Another faculty member remarked, 'I never used hands-on methods or group work before, but I found it really gets the concepts across to my college students." One senior STEM faculty with whom they worked summed up the situation best, "This is the methods class that I've never had before."

Given these well-documented needs and the reported experiences of STEM faculty who have had the benefit of valuable professional development, it becomes clear that high quality professional development for STEM education faculty is a necessary ingredient if needed reforms are to be implemented. At the same time, it is also reasonable for administrators and policymakers to question whether the investments in PD translate into changes in professional practices among participating faculty but there have been few studies to investigate this question. With regard to quality attributes of faculty development there is a considerable body of literature providing guidance related to professional development for PK-12 educators, but less is available concerning desirable attributes of faculty development for university educators. In addition, the specific attributes that constitute high quality faculty development are a matter of some debate.

Theoretical Background

What constitutes quality professional development?

In a landmark study conducted by Darling-Hammond, Hyler and Gardner (2017), the researchers analyzed 35 methodologically rigorous studies that have demonstrated a positive link between teacher professional development, teaching practices, and student outcomes in order to determine criteria of effective PD. They defined effective professional development as structured professional learning that results in changes teacher practices and improvements in student learning outcomes and found that effective professional development incorporates most, if not all, of the following elements:

- ***Is content focused***. PD that focuses on teaching strategies associated with specific curriculum content supports teacher learning within teachers' classroom contexts. This element includes an intentional focus on discipline-specific curriculum development and pedagogies in areas such as mathematics, science, or literacy.

- ***Incorporates active learning.*** Active learning engages teachers directly in designing and trying out teaching strategies, providing them an opportunity to engage in the same style of learning they are designing for their students. Such PD uses authentic artifacts, interactive activities, and other strategies to provide deeply embedded, highly contextualized professional learning. This approach moves away from traditional learning models and environments that are lecture based and have no direct connection to teachers' classrooms and students.

- ***Supports collaboration*.** High-quality PD creates space for teachers to share ideas and collaborate in their learning, often in job-embedded contexts. By working collaboratively, teachers can create communities that positively change the culture and instruction of their entire grade level, department, school and/or district.

- ***Uses models of effective practice*.** Curricular models and modeling of instruction provide teachers with a clear vision of what best practices look like. Teachers may view models that include lesson plans, unit plans, sample student work, observations of peer teachers, and video or written cases of teaching.

- ***Provides coaching and expert support.*** Coaching and expert support involve the sharing of expertise about content and evidence-based practices, focused directly on teachers' individual needs.

- ***Offers feedback and reflection*.** High-quality professional learning frequently provides built-in time for teachers to think about, receive input on, and make changes to their practice by facilitating reflection and soliciting feedback. Feedback and reflection both help teachers to thoughtfully move toward the expert visions of practice.

- ***Is of sustained duration*.** Effective PD provides teachers with adequate time to learn, practice, implement, and reflect upon new strategies for changing their practice.

Does PD impact practice?

It is assumed, and there is evidence to support the claim, that the resources devoted to faculty development impact the classroom and professional practices of participating faculty, though the number of investigations to explore the extent to which this is the case are been somewhat limited (Ebert-May et al. (2011). One of the studies that attempted to measure changes in instructional practices linked to participation in professional development was a large-scale study sponsored by the Council of Chief State School Officers and funded by the National Science Foundation (Smithson and Blank, 2006). Study researchers compared the teaching practices of grade 6-8 teachers who participated in the Mathematics–Science Partnership (MSP) to the performance of a comparison group of non-participating teachers. For the mathematics teachers, MSP teachers show a significantly greater instructional time and emphasis on demonstrating understanding of mathematics, analysis of information, and active learning by students as compared to the practices of comparison teachers. For science teachers there were not significant differences between in the instructional practices in MSP teachers and comparison teachers, but over the course of the two-year study, the science teachers participating in MSP programs increased the alignment of instruction with standards, and as a group became more consistent in the science content they taught. A second study (Zhang et al. 2010) looked at the impact of MSP participation on the university STEM faculty who participated in a variety of MSP activities, such as developing the summer institute's curriculum, instructing pre-service and in-service teachers, and conducting research on STEM education. In surveys and interviews with participating university faculty, the researchers report that faculty indicated through self-reports increased learning for the MSP experience in three areas: 1) becoming better teachers themselves, 2) acquiring a deeper understanding of current and future school-teachers, and 3) becoming familiar with the learning sciences.

Research Design.

The following case study is intended to extend this line of research through documenting instructional practices of participating university faculty by collecting the specific data that substantiates these practices, and in turn, to address the question of 'Does PD impact practice among university faculty?' This study focused on investigating the impacts of a particular professional development initiative, designed in partnership with NASA, for prospective STEM teachers and their faculty sponsors.

A specific STEM PD case study: The NASA MUREP Educator Institutes

For the past three years, the National Aeronautics and Space Administration (NASA) has made a unique professional development opportunity available to university students enrolled in teacher preparation programs and their faculty sponsors at Minority Serving Institutions (MSIs) across the nation. Given that prospective STEM teachers are university students who typically take their science content courses through the College of Science/Engineering and their teacher preparation coursework from science educators working in the College of Education, faculty sponsors from both Education and Science/Engineering were eligible to participate. By impacting future STEM teachers and the educators who prepare them, NASA has leveraged their investment in a way that can impact both K-12 and university students and faculty for many years to come. By concentrating their investment in Minority Serving Institutions (MSIs), NASA has ensured that they are making these opportunities available to a diverse group of students and faculty who are representative of populations that have traditionally been under-represented in the STEM fields.

MSIs are designated by the U.S. Department of Education and typically serve a student population that is comprised of at least 25% of a specific underserved population. Among the types of MSI classifications are Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), Tribal Colleges and Native-American Serving Non-Tribal Colleges, and various other classifications involving Asian American and Pacific Islander student populations. Table 1 shows the numbers of Institutes and participants, and participating MSIs for 2016, 2017 and 2018.

[Insert Table 1]

The MEI program was funded through NASA Minority University Research Enhancement Program (MUREP) through a cooperative agreement with the LBJ Institute for STEM Education and Research at Texas State University, the host university for the NASA STEM Educator Professional Development (EPDC). MEI leverages existing resources in place through the NASA Centers and the NASA EPDC and capitalizes upon the existing infrastructure to ensure that the resources invested in the Institutes generate the greatest benefits possible for the professional learning of preservice teachers and their faculty sponsors across the U.S.

The MUREP Educator Institute (MEI) experience consists of a one-week onsite experience at one the nation's 10 NASA Centers, coupled with 8 hours of online professional development prior to the Institute and 8 hours of post-Institute online professional development. The NASA Centers and their locations include Ames Research Center (Moffett Field, CA); Armstrong Flight Research Center (Edwards Air Force Base, CA); Glenn Research Center (Cleveland, OH); Goddard Space Flight Center (Greenbelt, MD), Jet Propulsion Laboratory (Pasadena, CA); Johnson Space Center (Houston, TX); Kennedy Space Center (Kennedy Space Center, FL) ; Langley Research Center (Hampton, VA) : Marshall Space Flight Center (Huntsville, AL) ; Stennis Space Center (Stennis, MS). Institutes are structured to accommodate 30–50 participants (depending upon Center capacity limitations) who are recruited from Minority Service Institutions (MSIs) from around the country. MSIs are encouraged to send a team of up to five participants, accompanied by a STEM Education faculty member from the institution.

The one-week Institute experience is grounded in research-based principles of teacher development and provides rich learning experiences upon which teachers can scaffold their content knowledge and further develop their content-specific pedagogical practices. The Institutes had a strong emphasis on culturally relevant teaching (CRT) approaches, a necessary ingredient for closing the parity gap in STEM. A team of STEM educators with extensive NASA EPD experience designed the learning activities that are included in each Institute. In addition, these learning experiences are fully integrated with tours of Center facilities and opportunities for participants to interact with the Center content specialists. Prior to coming to the Institute, participants are introduced via webinar to the Center, the Center's EPDC educational specialist who will help facilitate the on-site experience, and to various other NASA EPD resources. The Institute covers costs of four nights of lodging, and daily breakfasts and lunches. Upon successful completion of the Institute experiences and follow-up activities, student participants and their faculty sponsors earn a $500 stipend.

Applying the attributes that constitute quality professional development would indicate that MEI is designed, structured and operated in a manner consistent with high quality professional development. Table 2 illustrates the aspects of MEI that are consistent with the high-quality professional development criteria proposed by Darling-Hammond et al. (2017).

[Insert Table 2]

Results and Discussion

Participant evaluations of the MEI experience are also an indicator of the quality of the professional development provided. These evaluation measures included Post-Institute surveys and participants written reflections on their experiences and how they plan to utilize what they have learned and the resources they were provided in their future teaching. Table 3 shows a representative sample of the evaluation data from the twelve 2017 MEIs.

[Insert Table 3]

Qualitative data from the faculty sponsor written reflections were consistent with the high rating reflected in the quantitative survey data as is evidenced by these two examples that are representative of the qualitative data set. One faculty member from a Hispanic Serving Institution (HSI) that attended the MEI at Goddard Research Center wrote:

> *While I was at NASA MEI, I kept thinking that if only I could transmit this experience to my STEM majors, it would be so inspiring for them. It wasn't just the content, but the fact that there is so much relevance in modern science and math and that there is a place for everyone in this scientific ecosystem. I envision bringing NASA to every single class I teach (i.e. Computer Assisted Mathematical Modeling, K-12 workshops, the Math Fair for high school students, and the week-long summer camps hosted in my school).*

From the Johnson Space Center MEI, a faculty sponsor from a HSI, explained how she intended to utilize the information and resources she received at MEI in her own teaching:

> *My experience throughout the MEI gave me more tools, strategies, resources, ideas, and experiences that I'm planning on transferring to our college students with the main idea of having them become interested and excited about STEM so that they can transfer them to the real important recipients of all this, our young learners. It was amazing how day by day, trainers shared not only concepts or knowledge, but personal experiences and deep reflections, allowing, even after long hours of training, to be able to keep 'chewing' and 'digesting' those learning experiences way after the end of each day.*

As positive as the various indicators of MEI quality were, they were still insufficient to determine if the professional development would actually impact faculty practices. To address this question, an impact study was launched in 2018 to collect follow-up data from the 2016 and 2017 faculty sponsor participants. An external evaluator was contracted to independently analyze data regarding the impact of the project on participants and their practices (Macy, 2018). In the impact study, responses were collected from 65 of the 125 faculty sponsors who participated in 2016 and/or 2017 MEIs, representing a 52% response rate. 81% of the respondents were tenured or tenure-track faculty, and 19% were instructors or clinical faculty. Their teaching assignments included both undergraduate and graduate elementary and secondary education courses and STEM content courses. The respondents represented 57 MSIs and all 10 NASA Centers.

Impact Study Findings

Findings from the Impact Study indicated that faculty practices were impacted in four major areas: classroom teaching; interactions with colleagues; continued participation in NASA-related professional development; and efforts to recruit future students for NASA opportunities.

Impacts on classroom teaching.

All of the faculty sponsor respondents reported that following the Institutes, they had utilized NASA resources in their teaching. Collectively the 65 respondents had utilized these resources in 122 university classes, including both graduate and undergraduate teacher education and STEM content courses. The respondents also documented the number of students and courses impacted, as is reflected in Table 4 and Table 5.

[Insert Table 4]

[Insert Table 5]

One of the goals of MEI was to familiarize participants with the work occurring within each of NASA's four Mission Directorates (Science; Space Technology; Aeronautics; and Human Exploration). Program facilitators were curious as to which specific types of resources participants were using, the topics being addressed, and which content from which Mission Directors would be most utilized. With regard to the types of resources, 66% reported using lesson plans, 50% used NASA video clips, 42% used the Engineering Challenges; 19% utilized activities or information from NASA newsletters; 15% utilized NASA EPDC Digital Badges; and 16% utilized other miscellaneous NASA resources. Additionally, specific activities and topics being utilized (and the specific NASA Mission Directorate represented by that activity) are shown in the order of most frequent use: 1) Solar Eclipse Activities (Science); 2) Rockets & Rocketry Activities (Space Technology); 3)Engineering Design Process (Space Technology); 4) Build & Test a Paper Glider (Aeronautics): 5) BEST Engineering Design Challenge (Space Technology): 6) Solar System (Science); 7) Climate and Weather Activities (Science); 8) International Space Station (Human Exploration); and 9) GLOBE Cloud & Precipitation Activities (Science).

The 65 MEI faculty sponsor respondents also reported that they utilized the content and resources acquired through MEI in their interactions with colleagues and in their professional presentations. Respondents documented that they impacted 2,191 colleagues and they documented the amount of instructional time they devoted to NASA content and resources in their interactions with colleagues as reflected in Table 6.

[Insert Table 6]

Impacts on continued professional development.

Faculty participation in the MEI experience introduced faculty to a wealth of professional development opportunities offered by NASA, and the majority of MEI faculty participants continued to pursue other NASA-related professional development offerings. For example, 53% reported that they had participated in subsequent NASA EPDC webinars, 43% had pursued digital badges through the EPDC Digital Badging System, 20% had attended one or more additional events at a NASA Center, and 4% have pursued a NASA internship.

Impacts on efforts to recruit students for future NASA opportunities.

Universities depend upon their faculty members to mentor students and to encourage students to expand their horizons through the pursuit of professional opportunities. The MEI faculty participants reported a high degree of involvement in making students aware of future NASA-related opportunities and encouraging them to participate. MEI faculty reported using a wide variety of recruitment avenues. For example, 77% reported using a direct word of mouth recruitment strategy, 43% made announcements at faculty meetings; 29% utilized electronic bulletin boards and/or social media; 23% distributed flyers; and 17% posted bulletin board notices. In addition, a third of the faculty respondents reported utilizing other miscellaneous communication avenues to make students aware of NASA-related professional opportunities.

Conclusions and Insights Gleaned

The results of the MEI impact study would indicate that when faculty make a substantial time investment in high quality professional development, there is a high likelihood that they will utilize the content and resources gained to impact their professional practices. This study documented measurable impacts on four areas of professional practices: classroom teaching; interactions with colleagues; continued participation related professional development; and efforts to recruit future students for related opportunities. Each of these four areas have intrinsic value for the university as well as the individual faculty members and their students, suggesting that university investments in professional development do result in a good return on investment. In the case of MEI that received funding from an external partner (NASA), there is a strong indication that their investment resulted in a "multiplier effect" beyond the impact it had on direct participants. For example, following their participation in MEI faculty exposed other students and professional colleagues to NASA content and resources. Because of their positive experiences, faculty participated in other types of NASA-sponsored professional development and encouraged their students to take advantage of various other NASA-related opportunities. It is difficult to imagine how an entity such as NASA, with a similar investment, could better promote their goal of closing of the equity gap in STEM and/or accomplish such substantial long-range effects as those achieved by MEI.

New discoveries and new technologies in STEM will undoubtedly necessitate that university faculty engage in ongoing professional development throughout their careers if they are to remain current and well-equipped to provide their students with relevant and meaningful learning experiences. As policy makers and educational leaders make decisions about which PD efforts to support, it is crucial that their decisions be informed by an understanding of what constitutes quality professional development and a clear vision of the desired impacts on classroom practice that are likely to result from their PD investments. (Word Count: 3,836)

Disclosure statement: To our knowledge there is no conflict of interest.

Funding: *This article is based upon work supported by NASA cooperative agreement award number NNX15AU89A. Any opinions, findings or conclusions or recommendations expressed in this article are those of the authors and do not necessarily reflect the view of the National Aeronautics and Space Administration.*

Acknowledgements: We would like to thank the NASA personnel who made the MEI initiative possible, Michelle Berry, MEI program coordinator, and the very talented EPDC specialists without whom the initiative could not have achieved success.

References

Brownell, S., & Tanner, K., 2012. Barriers to Faculty Pedagogical Change: Lack of Training, Time, Incentives, and . . . Tensions with Professional Identity? *CBE—Life Sciences Education*, 11 (4) pp. 339-346.

Clapp, M. J. (2018). *Research-based instructional strategies: Implications for STEM faculty development*. ProQuest LLC. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED587473&site=eds-live&scope=site

Darling-Hammond, L., Hyler, M.E., & Gardner, M., 2017. *Effective teacher professional development*. Palo Alto, CA: Learning Policy Institute. Retrieved from: https://learningpolicyinstitute.org/product/teacher-prof-dev

Ebert-May, D., Derting, T.L., Hodder, J.L., Momsen, & T.M. Log. (2011). What we say is not what we do: Effective evaluation of faculty professional development programs. *BioScience*, 61(7): pp. 550-558.

Felder, R. M., 2012. New STEM faculty support: Why aren't we providing it? *Journal of STEM Education* 13 (5) pp. 5 – 6.

Henderson, C., Finkelstein, N., & Beach, A. (2010). Beyond dissemination in college science teaching: An introduction to four core changes strategies. *Journal of College Science Teaching* 39 (5) pp. 18 – 25. Retrieved at https://eric.ed.gov/?id=EJ887499

Ingersoll, R.M., Merrill, E., Stickey, D., & Collins, G. (2018). Seven Trends: The Transformation of the Teaching Force, updated October 2018. Research Report (#RR2018-2). Consortium for Policy Research in Education, University of PA.

Macy, D. J. (2018) *External Evaluation of NASA MUREP Educator Institutes*. Macy Research Associates, Wills Point, TX. Retrieved from: https://www.txstate-epdc.net/wp-content/uploads/2019/01/2018-MEI-Macy-Report-New-Title-1.15.19.pdf

Manduca, C.A., Iverson, E.R., Luxemberg, M., Macdonald, R.H., McConnell, D.A., Mogk, D.W., & Tewksbury, B.J. (2017). Improving undergraduate STEM education: The efficacy of discipline-based professional development. Science Advances. Retrieved from: Https://advances.sciencemag.org

McNeil, J. C. & Ohland, M. W. (2015). Engineering faculty perspectives on the nature of quality teaching. *Quality Approaches in Higher Education* 6 (2) pp. 20 – 30.

Smithson, J., & Blank, R. (2006). *Indicators of quality of teacher professional development and instructional change using data from surveys of enacted curriculum: Findings from NSF MSP-RETA project*. Washington, D.C: Council of Chief State School Officers.

Stains, M., Pilarz, M. & Chakaraverty, D. (2015). Short and long-term impacts of the Cottrell Scholars Collaborative new faculty workshop. Journal of Chemical Education, 92 (9) pp. 1466-1476.

Van der Klink, Kools, Q. Avissar, G., White, S. & Sakata, T. (2017). Professional development of teacher educators: what do they do: Findings from an explorative international study. Professional Development in Education, 43 (2) pp.163-178. Retrieved from: https:///doi.org/10.1080/19415257.2015.1114506

Vermunt, J. D. & Endedijk M. D. (2011). Patterns in teacher learning in different phases of the professional career. *Learning and Individual Differences* 21 (3), pp.294 – 302.

Wieman, C. E. (2017). *Improving how universities teach science: lessons from the Science Education Initiative*. Cambridge, Massachusetts: Harvard University Press, 2017.

Zhang, X., McInerney, J., & Frechtling, J. (2010). Learning after you know it all: When STEM faculty teach teachers, who learns? *Change* 42, (3) pp. 24 – 28 Retrieved from: https://eric.ed.gov/?id=EJ882619

List of Tables

Table 1: MEI Participation by Year

Year	Institutes	Universities	Pre-service Teachers	Faculty Sponsors	Total
2016	11	56	336	65	401
2017	12	71	355	80	435
2018	13	81	386	91	477
Total	36	*208	1077	*236	*1313

*Duplicated count due to participation in multiple years by some universities and faculty sponsors.

Table 2: Attributes of High-Quality Professional Development

High-Quality Professional Development	MEI Evidence of Quality Professional Development
Is content focused	MEI learning activities have been developed by NASA educators to address important STEM content necessary to aeronautics and space science. NASA learning activities are tied to state/national standards and resources are labeled with the STEM standards being addressed in the activity.
Incorporates active learning	MEI teams participate in STEM classroom learning activities that are “hands on” along with tours of NASA facilities that are mediated by NASA scientists and engineers.
Supports collaboration	MSIs send teams of 5 faculty and preservice STEM motivated teachers for the week-long immersive STEM education institute. MEIs accommodate 30 – 50 teacher preparation faculty and preservice teachers who have a high interest in STEM education.
Uses models of effective practice	MEI STEM classroom learning activities are modeled by NASA Education Specialists and their teaching assistants.
Provides coaching and expert support	Preservice teacher candidates are provided coaching and support by their faculty sponsors, the MEI instructors who have extensive experience delivering NASA content to both students and educators, and NASA scientists and engineers who are working in the fields upon which the activities are based.
Offers feedback and reflection	Participants engage in ongoing reflection throughout their Institute as well as during the 5-day Institute. MEI instructors evaluate their online assignments and provide feedback on their submissions.
Is of sustained duration	The MEI experience consists of 8 hours of pre-institute online instruction 40 hours of face-to-face instruction at a NASA Center, and 8 hours of post-institute online learning.

Table 3: Representative Sample of Items from The Post-Institute Survey

Sample Items	Median Average Center Rating
As a result of the pre-institute professional development, I feel better informed about the work that NASA does and the NASA resources available to educators.	3.77
My institute instructional team was highly knowledgeable and helpful.	3.87

The instructional team led a well-organized institute.	3.77
The subject matter experts (NASA scientists) were highly knowledgeable and helpful.	3.89
The tours of Center facilities (labs, work areas, visitor centers, etc.) were beneficial in helping me understand the work underway at the NASA center.	3.96
Having the opportunity to experience NASA classroom learning activities and teaching resources at the institute was a valuable experience for me.	3.92

(rating scale for above items: 4= Strongly Agree; 3= Agree; 2= Disagree; 1= Strongly Disagree

Table 4: College Students Impacted by MEI Faculty Sponsors

Level	Teacher Ed	Teacher Ed	STEM	STEM	Total	Total
Undergraduate	81	63%	18	14%	99	77%
Graduate	27	21%	3	2%	30	23%
Total	108	84%	21	16%	129	100%

Table 5: College Courses Impacted by MEI Faculty Sponsors

Type of College Course	Classes	Students Served	Average Students per Class
Teacher Ed Undergraduate	81	1806	22
Teacher Ed Graduate	27	578	21
STEM Undergraduate	18	456	25
STEM Graduate	3	54	18
Total	129	2894	22

Table 6: MEI Impact on Collegial Interactions

Events	Event Type	Audience	Hrs
19	PD sessions	College faculty	54
19	PD sessions	K-12 educators	46
12	Professional Conference Presentations	Professional Organization Membership	21
8	Community Presentations	Community members	19
7	PD sessions	Afterschool or summer camp staff	10