Recruiting, Preparing, and Retaining STEM Teachers for a Global Generation

Jacqueline Leonard, Andrea C. Burrows and Richard Kitchen (Eds.)

There is a critical need to prepare diverse teachers with expertise in science, technology, engineering, and mathematics (STEM) with the skills necessary to work effectively with underrepresented K-12 students. Three major goals of funded STEM programs are to attract and prepare students at all educational levels to pursue coursework in the STEM content areas, to prepare graduates to pursue careers in STEM fields, and to improve teacher education programs in the STEM content areas. Drawing upon these goals as the framework for *Recruiting, Preparing, and Retaining STEM Teachers for a Global Generation*, the 15 chapters contained herein highlight both the challenges and successes of recruiting, preparing, and sustaining novice teachers in the STEM content areas in high-need schools.

Recruiting, retaining and sustaining highly-qualified teachers with expertise in STEM content areas to work in hard-to-staff schools and geographic areas are necessary to equalize educational opportunities for rural and urban Title 1 students. High teacher turnover rates, in combination with teachers working out-of-field, leave many students without highly-qualified teachers in STEM fields. Most of the chapters in this volume were prepared by scholars who received NSF funding through Noyce and are engaged in addressing research questions related to these endeavours.

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CHAPTER 9

World Class STEM Faculty: An International Dual-Degree Program

Karen E. Irving, Anil K. Pradhan and Sultana N. Nahar

Abstract

The global community is engaged in educational reform to improve opportunities for young people in higher education and scientific research. The responsibility of science teacher educators extends to the preparation of world-class faculty in STEM disciplines at institutions of higher education (IHE). This chapter describes a highly intensive and innovative international dual-degree program designed to prepare world-class professors in STEM fields for colleges and universities. With about 150 million future students, some reports indicate that 50,000+ new colleges and universities are being formed in India (Choudaha, 2011). These new institutions of higher education need highly-qualified STEM faculty to train the next generation of leaders in STEM fields. A collaboration funded by the US-India Education Foundation (USIEF) between The Ohio State University (OSU) and the Aligarh Muslim University (AMU) was established with the primary goal of exploring pathways to prepare the next generation of world-class STEM faculty for universities in India. Theoretical frameworks and logistical challenges are described.

Keywords

international dual-degree program – STEM faculty preparation – international university collaboration

Introduction

In the last 100 years, enormous societal transformations have stimulated international science research and academic collaborations (Lasthiotakis & Sigurdson, 2013). The growth of multinational companies in STEM fields such as telecommunications, biotechnology, and pharmaceuticals has been

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widespread. Communication technologies and decreased cost of international travel have eased mobility between nations and supported increased cross-national collaborative work in both business and the academy (Lasthiotakis & Sigurdson, 2013). Scientists and academics participate in international professional organizations, travel widely to present their work, and have developed uniquely differentiated fields of study that demand a global search for others equally interested in similar problems. An increase in national spending on Big Science initiatives since World War II has also driven the growth of transnational collaborations. In policy circles, the general consensus is that international research is good for universities, scientists, and the competitive advantage of nations (Asgary & Robbert, 2010; Higgitt et al., 2008).

Study Abroad Programs at Institutes of Higher Education

The Institute on International Education (IIE) reported that in 2017, 91% of U. S. institutions of higher education were creating or expanding international degree granting programs. The number of academic programs that require a study abroad component has increased 64% among institutions of higher education (IHEs). Short-term non-credit bearing experiences have been developed or expanded at 77% of reporting institutions, including work experiences, internships, and volunteering abroad opportunities. To support these initiatives, 71% of U.S. institutions are also committing the financial resources for faculty to develop and lead study abroad programs (Generation Study Abroad, 2017).

The arguments for transnational degree programs at IHEs relate to national security and domestic prosperity (NAFSA Lincoln Commission Report, 2005). Globalization, international collaborations, and economic competitiveness require political, economic, and social cooperation between partners. College graduates with global literacy skills are valued workers for transnational corporations and governmental agencies. National security is enhanced by cultural understanding among allies, and having diverse foreign language speakers in the U. S., who can communicate with friends and foes, is seen as a national defense imperative. Programs sponsored by the U. S. Department of State's Bureau of Educational and Cultural Affairs such as the National Security Language Initiative (NSLI) are designed to strengthen our cultural awareness and improve our ability to interact with people from around the world (U.S. Department of State, n.d.).

Research on students who have studied abroad reveals benefits such as higher grades, lower attrition, and higher college completion rates for study

abroad students when compared with students who have not enjoyed international study (Paige, Fry, Stallman, Josić, & Jon, 2009). The University of Georgia reported a 17.8% higher four-year graduation rate for study abroad students when compared to other students. Indiana University compared grades for study abroad students with students who had not studied abroad and noted higher grades and greater four-year completion rates for study abroad students. The Sage Research Project surveyed over 6,000 alumni over a 50-year period and reported that study abroad had a substantial impact on five "key domains: civic engagement, knowledge production, philanthropy, social entrepreneurship, [and] volunteer engagement" (Paige et al., 2009, p. 18). Surveys of returnees from study abroad programs report overwhelming positive feelings about their experiences. Students and parents consider the opportunity for international study when selecting an institution of higher education (Asgary & Robbert, 2010).

Several researchers have attempted to describe typologies for international or transnational study experiences. Youssef (2014) considered desired mobility and found three main program designs: (a) cross-border mobility of people; (b) cross-border mobility of programs using face-to-face, e-learning, and distance learning for program delivery; and (c) cross-border mobility of providers – usually involving branch campuses or study centers. In this model, students do not travel, and the provider establishes a presence in the partner country (Youssef, 2014). The Institute of International Education (IIE) presents another typology that considers whether the program includes awarding a diploma or degree. In this typology, non-degree programs include volunteering, interning, research, field work, attending international conferences, language study, athletic team competition, religious mission work, artistic performance groups, and study abroad field trips with designated themes such as architecture, culture, language, or environmental studies.

In degree awarding transnational programs, considerable variation also exists. A student can earn one degree by completing course work at two institutions (or more), or two degrees at two (or more) institutions. Sometimes the same course can count for more than one program so that the student can complete both degrees in a shorter time frame. Other designs require the student to complete coursework on more than one campus to meet requirements for more than one degree program. Curriculum and quality of the experiences are important elements that partner institutions must control (Smith, 2010). In a dual-degree program, the student completes different curricular requirements for each degree and is awarded more than one degree. The main point of these experiences is to broaden the cultural and academic experiences of both students and sometimes their advisors (Asgary & Robbert, 2010).

Establishing a transnational degree program requires a deep level of commitment and skill in transcultural collaboration for both partner institutions (Higgitt et al., 2008). The potential for misunderstanding is greatly increased when institutions with different cultural and management styles attempt to collaborate to provide degree programs for students. When one institution is in a developing country and the partner institution is located in a developed country, the potential for difficulties increases. Some issues that can be anticipated related to managing an international collaborative effort include sensitivity to (a) intercultural differences with how students interact with the university, (b) unevenness of engagement of partners and of students, (c) technological constraints, (d) communication missteps, (e) agreements on learning outcomes, (f) assessment procedures, and (g) evaluation of the final collaborative initiative. Establishing these programs can be costly in time and money.

An International Dual-Degree Program: India and the USA

The need for STEM professionals is especially acute in India, home of the third largest higher education system after the USA and China (World Bank, 2007). With about 150 million students, reports indicate that 50,000+ new colleges and universities are being established in India (Choudaha, 2011). These new institutions of higher education need highly-qualified STEM faculty to train the next generation of STEM professionals. To address this problem, The US–India Education Foundation (USIEF) awarded a grant under the Obama-Singh 21st Century Knowledge Initiative (now known as the Indo-US 21st Century Initiative, IUS21CI) to support a collaboration between The Ohio State University (OSU) and Aligarh Muslim University (AMU) with the primary goal of exploring pathways to prepare the next generation of world-class STEM faculty for universities in India. Elements of this project included establishing a joint Indo-US OSU-AMU Center of Excellence for STEM Education and Research at AMU as well as the creation of an innovative international dual-degree program for faculty training. The project situates both AMU and OSU to participate in the fourth age of research, driven by the growth of international collaborations between elite institutions (Adams, 2013). Benefits to both countries include nurturing research collaborations needed to remain competitive in a global economy, as well as the development of STEM talent. USIEF funded the project with the goals of facilitating mutual understanding, educational reform, and economic development by engaging communities in both the USA and India in academic cooperation.

The project unfolded in stages over a four-year period with unique challenges associated with each. In this chapter, we will describe the evolution of the project focusing on administrative challenges in the first year, program delivery in years two through four, and overall outcomes of the project. We chose to focus this project on the important task of educating undergraduate students. The research question that we address is:

How can two major universities in different countries collaborate to produce world-class faculty for STEM undergraduate instruction who know their STEM content, engage in cutting-edge research, and also know how to teach?

Year 1: Getting Started

Memorandum of Agreement (*MOA*)

The USIEF award to The Ohio State University and the Aligarh Muslim University under the Indo-US 21st Century Knowledge Initiative (formerly Obama-Singh) was announced in July 2013. Soon after the announcement of the award, work began between representatives of both major universities involved in the project to prepare and endorse a Memorandum of Agreement (MOA) that detailed the planned work. The MOA addressed multiple elements including (a) the establishment of a joint OSU-AMU Center of Excellence in STEM Education and Research (ER) at AMU; (b) creation of a two-year graduate level STEM-ER program at OSU for Fellows from AMU to introduce them to andragogy for STEM teaching at the undergraduate level, as well as to conduct state-of-the art research; (c) launching of a dual-degree program that allowed Graduate Fellows to earn both a Master's Degree in STEM Education from OSU and a PhD in their STEM field from AMU; (d) details about the substantial direct and indirect resources that each partner in the project would contribute, including tuition and fee waivers from OSU for the AMU Fellows; (e) OSU support for the development of interdisciplinary collaborative projects in advanced research and innovation in the disciplinary area of the AMU Fellows with inclusion of a chapter in the doctoral dissertation of each Fellow that describes this work; (f) creation and formalization of a comprehensive Indo-US inter-university consortium of leading universities in India and the USA; and (g) the preparation of a report on national capacity building in STEM faculty training and research for India.

More specifically, Ohio State provided faculty time and resources to direct the project, provided significant cost share in tuition and fees for participating Fellows, administrative support to members of the College of Education and Human Ecology, the College of Arts and Sciences, and the College of

Engineering to produce a new degree program designed specifically for the Fellows, as well as orientation and logistics support by the OSU Office of International Affairs. The Aligarh Muslim University developed a plan and provided space for the new OSU-AMU Center of Excellence in STEM Education and Research (ER) on their campus, encouraged departments and colleges and their representative faculty and staff to support the program, collected applications for the Fellowship from various STEM departments, which were evaluated and selected for the program by the OSU team at AMU, and provided local hospitality (accommodations and food) for visiting OSU faculty and researchers. The MOA was signed by the OSU and AMU leadership in November, 2013.

The Dual-Degree Program

At the same time the MOA was negotiated and signed, members of the OSU team began work on the design of a new program for a Master of Education program for the participating Fellows. The goal was to produce world-class STEM professors with both exceptional andragogical and science research skills to staff STEM department positions in universities in India. Graduates of the program would hold dual degrees, both a PhD degree in their science discipline awarded by AMU and a Master of Education Degree awarded by OSU. One chapter in their PhD dissertation would be on the research in the STEM field completed at OSU as part of their Fellowship experience and long-term collaboration. A logic model describes the theoretical foundations of the program (Figure 9.1). Careful attention was paid to both the andragogical focus of the program and the research role for a STEM professor at a research-intensive university. The adopted design allowed the Fellows in the first year of the program to spend half of their time in science education coursework and the other half working with a STEM faculty researcher who was engaged in a scientific research field aligned with their AMU advisor. The Fellows spent the second year at their home institution—AMU—but registered for an OSU course on their teaching experience, wrote a paper on their research project on STEM education, and wrote a PhD dissertation chapter on the research carried out at OSU. The intent was to promote an added benefit of the experience in the form of increased collaboration between science researchers at both institutions of higher education.

The constructivist approach to teaching and learning underpinned the andragogy elements of the project. The program was designed to provide opportunities for both individual sense-making and social negotiation of meaning (Brown, Bransford & Cocking, 2000; Tobin & Tippins, 1993). The Fellows participated in a set of learning experiences that exposed them to university teaching and learning, university scientific research endeavors, and university govern-

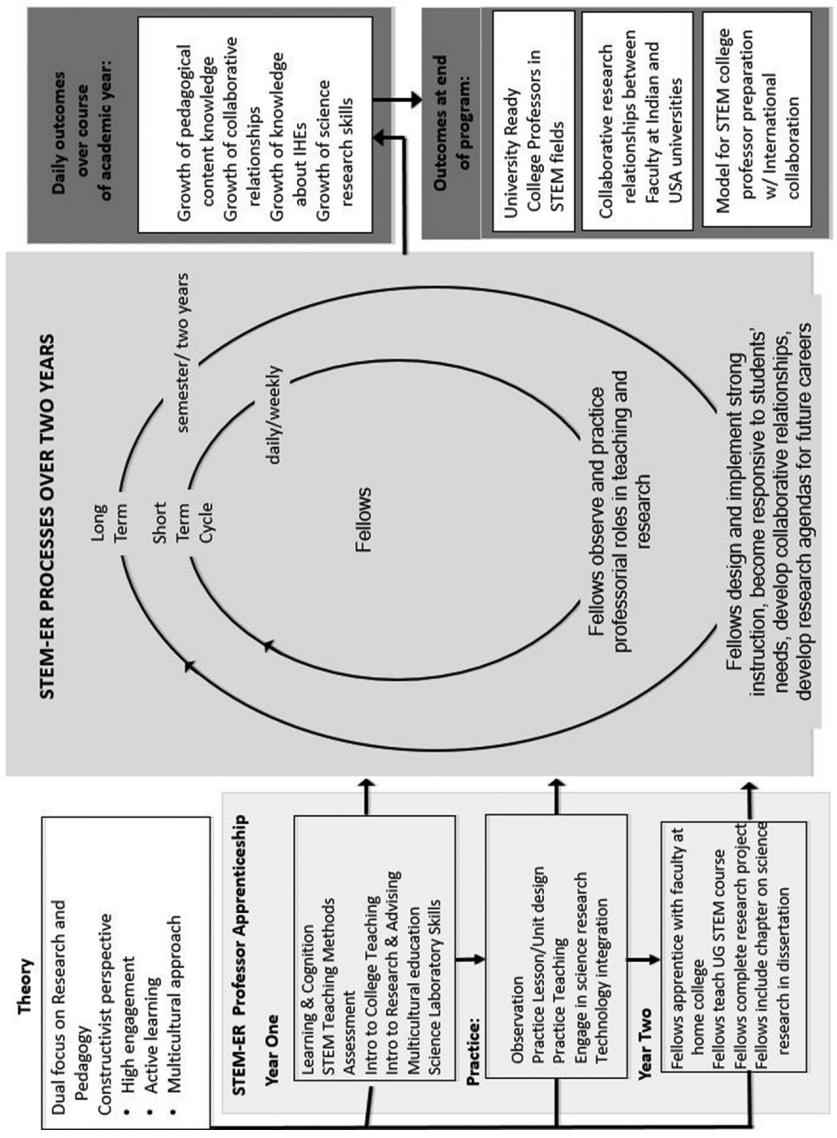

FIGURE 9.1 Logic model for the STEM-ER program

TABLE 9.1 Master of education program design

	STEM Med India Semester Program 2014–2016				
	OSU–USA			AMU–India	
	Autumn 2014	**Spring 2015**	**Summer 2015**	**Autumn 2015**	**Spring 2016**
1	STEM Teaching Methods; EDTL 5722 (5 hr)	Assessment in STEM EDTL 5745 (3 hr)	Travel	Field Experience at AMU; EDTL 8898 (2 hr)	Independent Study Field Exp Capstone Project EDTL 7193 (2 hr)
2	Apprenticeship in Education Research; EDTL 8898 (5 hr)	Multicultural & Global Perspectives; EDTL 6808 (3 hr)		Research with Science Research Advisor (1 hr)	Research with Science Research Advisor (1 hr)
3	Research w Science Research Advisor (8 hr)	Apprenticeship in Education Research; EDTL 8898 (3 hr)			
4		Research with Science Research Advisor (8 hr)			
5		Life Science 5001; Teaching College Biology (1 hr)			
	16 credit hours	18 credit hours		3 credit hours	3 credit hours
	40 credit hours total				

ance and administrative practices. Program designers intended that the fellows would gain sufficient andragogical and content knowledge, experience opportunities for practical learning in both the classroom and the laboratory, and become part of a group of students and instructors to provide a socialization process for their learning (Straits & Wilke, 2007). Table 9.1 shows a semester by semester plan for the Master of Education program developed for the Fellows.

The Master of Education program was approved in January 2014 by administrative leaders of OSU and AMU. The offices of the Vice-Chancellor, the Pro-Vice

Chancellor at AMU, and the Provost and Deans of affiliated colleges and the Graduate School at Ohio State as well as the Council of Academic Affairs all reviewed and sanctioned the plan. Primary elements of the andragogical experience included STEM teaching methods, Assessment in STEM, Multicultural and Global Perspectives on Education, field experiences teaching undergraduate students in the second year at AMU, and the completion of a STEM education research project. Each semester, every Fellow also enrolled in research with their OSU STEM advisor. Forty credit hours of study were required for completion of the program.

Recruitment of Cohort 1 Fellows

Announcement of the four fellowships occurred in September 2013. Graduate students in all AMU STEM departments were eligible to compete for the award. Ideal candidates were finished with their doctoral coursework at AMU and ready to begin their dissertation research. From the initial group of 35 interested students, 12 were selected as finalists. Intensive interviews occurred including Skype conversations with faculty in the USA as well as on-site personal interviews at AMU. Applicants were asked to conduct a short lesson on a science topic, and responded to a series of pre-planned questions as part of a semi-structured interview. Selection of the first cohort of students was completed in April 2014, following the conclusion of the interviews and with input from both the education director (Irving) and the disciplinary research director on the project (Nahar).

After selection of the finalists, a comprehensive process of matching each Fellow with a STEM researcher at Ohio State was undertaken by the principal investigator (Pradhan) and the research director (Nahar) on the project. With a large and diverse research program at OSU, many possible STEM advisors were considered. OSU faculty in the science discipline fields that matched the Fellows were eventually identified and invited to serve as research advisor to each of the Fellows. These new STEM research advisors were also then introduced to the aims and goals of the larger project. Costs of laboratory equipment and research facilities were borne by the OSU faculty. Each Fellow received a stipend commensurate with OSU graduate students (about $2000 per month for 10 months from August to June) from the USIEF grant and tuition and fees from graduate fellowships provided by the OSU Graduate School. The STEM research advisors were able to invite the Fellows to join their research teams with little cost to their programs, except laboratory supplies. AMU research advisors were invited to visit OSU during 2014–2015, and OSU research advisors were invited to visit and participate as invited speakers at an international conference on STEM ER, held jointly with an international

nanotechnology conference, Aligarh Nano-V, at AMU during March 8–12, 2016. During these visits, OSU research advisors made personal contacts with the science research advisors who were guiding the doctoral research of the Fellows at AMU. This opportunity strengthened the relationships between scientists at both institutions.

Details and logistics regarding visa applications, accommodations in Columbus, Ohio, and enrollment as students at Ohio State were completed in spring 2014 with the help of the OSU International Office and the India based OSU Gateway team. Four Fellows, two males and two females, arrived on the OSU campus in August 2014 for the autumn semester.

Summary of Year 1 Accomplishments

In the first year of the project, the major achievements were negotiation and signing a Memorandum of Agreement between OSU and AMU, the design and approval of a two-year Master of Education program specifically designed for the participating Fellows, recruitment and selection of the first cohort of students, successful placement of the Fellows with an appropriately matched research advisor at OSU and meeting enrollment, travel, and housing issues.

Year 2: Implementing the Program

Cohort 1 – Master of Education Coursework

The first cohort of Fellows arrived in Columbus in August 2014. The initial cohort included two women and two men with a variety of science content backgrounds (see Table 9.2).

After a brief orientation by the Office of International Affairs and settling in period, the cohort members began both their research apprenticeships with their OSU research advisors as well as their classes in the College of Education and

TABLE 9.2 Cohort 1 description

#	Gender	AMU science field	OSU research advisor department
1	male	Biochemistry	Radiology
2	male	Zoology/genetics	Center for RNA Biology
3	female	Biochemistry	Radiology
4	female	Atomic spectroscopy	Physics/Astronomy

Human Ecology. Most notable among the start-up challenges for this group of students was adjustment to the extensive role of electronic communications at Ohio State. Registration and almost all interactions with the university are completed online. The classroom management system in use for faculty and students was a new experience for the Cohort 1 Fellows. Downloading readings, locating assignment descriptions, and uploading individual work as well as tracking their grades through the online classroom management system were initially unfamiliar tasks. The use of collaborative learning approaches in the classroom with students playing an active role in discussion of readings was also different from the more traditional lecture style instruction to which the Fellows were accustomed.

The expectation that students would read and understand assigned articles, and also form and articulate individual opinions about the readings, applying the readings to their personal circumstances and Indian culture differed considerably from the work they had done in science content classes. Smart boards, videography, online animations, online databases, and web tools played important roles in each of their education classes. As part of their education research seminar experience, Fellows were asked to compare and contrast the curriculum for science majors at AMU with the curriculum for science majors in a similar field at OSU. Differences between what each cultural community considered important academic knowledge and experience became readily apparent and opened discussions about what a scientist and professor in the 21st century should know and be able to do. One culminating project in the seminar asked Fellows to design a curriculum for students who would graduate from AMU with a degree in their science field in 2036, twenty years in the future. Issues of language of instruction, the role of electives, and the importance (or lack of importance) of particular courses created interesting debate in the cohort. Admission processes and the importance of including underrepresented groups in university education were discussed and compared. Fellows considered strategies that universities in the U.S. have tried and policies that institutions of higher education in India have adopted to encourage and support higher educational opportunities for many.

India is a multi-ethnic, multi-language, multi-caste, and multi-religion country that strives to provide educational and economic opportunity to people from many subcultures (Sukdev, 2016). The United States is also a multi-ethnic country with citizens who come from many different cultures and religious traditions. As part of the Master of Education program, the Fellows completed a course on equity and diversity in education with an emphasis on current conditions in the United States. Topics included white privilege, students who speak English as a second language, gender equity, and issues specific to students in the LGBTQ community. The course focused on issues of

diversity, equity, teacher beliefs, and multicultural education. Emphasis was placed on the roles of identity and lived experience and their influences on approaches to teaching and learning in educational settings. The international nature of the students enrolled in the course (Turkey, China, India, USA) provided the Fellows with interesting and unique perspectives on these topics.

The science methods course and the assessment course completed in the autumn semester introduced a variety of strategies to teach science, including reading reflections, demonstrations, the use of whiteboards for representation of ideas as the result of group discussion, lesson and unit planning, use of online data sets in inquiry lessons, concept mapping, laboratory activities, independent studies, and engineering design projects. Students compared and contrasted the way topics such as energy and matter, models and modeling, constancy and change, and structure and function were introduced in different science disciplines. Assessments such as lab practical proficiency, projects, papers, short answer essays, problem sets, and multiple-choice questions were examined and critiqued. Rubrics were used to identify quality work and backward design processes to create lessons that resulted in the intended learning outcomes. Statistical methods of measuring student success, including value added assessment, measures of central tendency, correlation and causation, and inferential statistics such as *t*-tests, were addressed in the assessment class.

In the spring semester, each Fellow identified an area of educational research of interest. An educational research proposal was written and submitted to the Internal Review Board (IRB) of the Office of Responsible Research Practice to obtain permission to conduct a research study with human subjects. By the end of the first year of the program, each Fellow had received the necessary IRB approval for his/her research project. In each case, the research they proposed would take place at AMU during their second year

TABLE 9.3 Educational research topics for Cohort 1 fellows

Fellow	Topic	Study participants
AR	Nature of Science & STEM	AMU/OSU biology faculty & post docs
AM	Use of classroom management systems & STEM	OSU students & Post-Doctoral researchers
NR	Approaches to learning & STEM	AMU Undergraduates
HN	Quantum Mechanics conceptions of Undergraduates & STEM	AMU Undergraduates

in the program. Table 9.3 details the research topics and study participants planned by Cohort 1 Fellows.

The Laboratory Research Experience

Fellows spent half of their time working as research assistants in the laboratories run by their research advisors and half of their time attending classes and participating in activities related to the Master of Education program. Different research advisors were able to provide varying levels of support for the Fellows. For example, a new assistant professor at OSU recently establishing his research agenda and a research group was able to provide significant hands-on training to help the Fellow advisee learn the procedures necessary to move his work forward. More established research advisors asked post-doctoral researchers or graduate students to provide the guidance and training needed to orient the Fellows to the work expected on their science research projects. The access to specific equipment and materials related to the research advisor's scholarly agenda helped the Fellows learn and master new procedures that they were able take back to their advisors in India. In addition, communication between the AMU and OSU advisors furthered collaboration between the research groups in each country. See Table 9.4 for titles of the science research projects that the Fellows completed. Fellows joined journal groups and met other doctoral candidates as part of the work with their research advisors. As one of the Fellows reported:

> In research, I received hands-on training for novel techniques in a well-equipped research laboratory. Most importantly, I grasped the scientific temperament that makes science in U. S. different from other parts of the world. I benefited from lab meetings, discussions with research advisor, journal clubs, seminars and symposiums. It was a fortunate experience for me to have a discourse with a woman Nobel laureate (Carol Greider) at a conference in OSU. (personal communication, NR, 2018)

Probably the most challenging aspect of the year that the Fellows spent at OSU was finding a reasonable balance between the work asked of them by their education and research advisors. The education program is usually a full-time endeavor for students. Science research advisors also prefer their graduate assistants to spend all hours at the laboratory bench working on their projects. The Fellows needed to find a balance between these competing demands on their time and energies. It is fair to say that the work expected from the Fellows was nearly twice that of an average post-candidacy graduate student.

TABLE 9.4 Science research topics for cohort 1 fellows

Fellow	OSU Research Department	Research topic
AR – male	Radiology	On the breast and lung cancer in rats and immunity development using vitamin D
MA – male	Department of Molecular Genetics	Study of RNA protein complexes responsible for modulating the expression of genes
HN- female	Astronomy	Calculation of collision strengths for electron impact excitation using relativistic Breti-Pauli R-matrix (BPRM) method for Si IX
NR- female	Radiology	Copper dependent enhancement of DNA damage and X-ray induction by L-DOPA and Dopamine: Putative neurotoxic mechanism

Program Year 2: Summary of Accomplishments

At the end of the second year of the project, Fellows had completed two semesters of study at Ohio State and were ready to return to India. In their scientific research studies, each had established relationships with scientists at Ohio State and made connections between their AMU research advisors and their new OSU research advisors. Fellows spent half of their academic time and efforts working on procedures and projects directed by their OSU science research advisors. Fellows produced a poster summarizing their work, as well as presentations for their respective research groups. Among several accomplishments, the Fellows made potentially important discoveries in molecular genetics, cancer radiology, and astrophysics, which they presented at international conferences and institutions in the USA. In addition, members of Cohort 1 completed significant coursework in the College of Education and Human Ecology, designed and obtained IRB approval for a study on a topic of their choosing, and were prepared to conduct the educational research study on their return to India.

Year 3: Teaching Apprenticeship and Research Presentations

Undergraduate Teaching Apprenticeship at AMU

On return to India, each Fellow was assigned an undergraduate teaching task for the autumn semester at AMU. Their AMU research advisors facilitated this

assignment with administrators at AMU. Table 9.5 indicates the variety of teaching assignments made for each member of the cohort.

During the autumn semester, Fellows videotaped teaching sessions and uploaded them to an online video annotation site to allow the education advisor at OSU in the U.S. to view. Together, they commented on the differences between teaching at OSU and AMU and efforts made by the Fellows to include some strategies they liked from their experiences at OSU. In particular, the ideas formulated during small group discussions of readings and multiple representations of scientific ideas were included in their lessons. The use of electronic media such as Facebook pages provided a connection between the Fellows and their new students. Fellows attempted to reduce the amount of lecture and increase the amount of more student-centered learning experiences. Bringing new ideas back to their Indian university environment involved challenges. As two Fellows reported:

> Coming back and teaching in India was a different ball game altogether. Coming back armed with new knowledge was not easy. There was faculty resistance in what and how we should teach at our Indian university. Implementing the 'methods' was the toughest. However resilience and tactfulness helped us teach using the alleged 'American methods' at 'the Indian university.' (Personal communication, AR, 2018).
>
> I was totally surprised when I attended the classes on STEM education at OSU as these classes were totally inquiry based which actually helped me to realize how we can make the STEM teaching more interesting and attractive with maximum learning. The method of evaluation (providing rubrics and giving feedbacks) is something which I adopted during my STEM field work at AMU was much appreciated by the students. Applying the pedagogical methods during my field work was a challenging problem (as it is not a common practice), but the training at OSU along with the technical and laboratory facility (for inquiry based learning) motivated us (me and the students) to go beyond our expectations. (Personal communication, HN, 2018)

These sentiments were echoed by the other fellows. As might be expected, introduction of new ideas was not always welcomed by faculty colleagues.

> It was a bit difficult to resume and align the courses in a different setting and environment….Also, the teaching methods and classroom setting at OSU [were] primarily focused on the technical facilities (internet, smart classes, online portals) and support. I struggled with the lack of such

TABLE 9.5 Apprenticeship undergraduate teaching assignments at AMU, Autumn 2015

Fellow	Course	Class type	Per week	Length (min)	M/F Ss	# Ss
AR	Cell Biology	Lecture	2	120	M&F	32
	Practical	Lab	2	180	M&F	32
MA	Genetics & Evolution	Lecture	4	50	F	85
NR	Environmental Biochemistry & Immunology	Lecture	2	50	M&F	32
HN	Optics	Lecture	4	50	M	40

> setting while implementing pedagogical techniques during the teaching fieldwork at AMU. Since the program and training was novel, there was little support from faculty/advisors who favored [a] didactic and conservative mode of teaching. As STEM trained researchers, it would have been beneficial to be part of the board of faculty meetings for providing pedagogical suggestions (curriculum designing and assessment plans). Still, I implemented some training independent of faculty or technical support such as Socratic seminars, dialectical journals, social media learning platforms, e-mailing learning materials, facilitating active discourse and accommodating learning differences. (Personal communication, NR, 2018)

Educational Research

Each Fellow mounted an educational research study during the autumn semester after their return to AMU (see Table 9.4). Data related to their individual research projects were collected through interviews and surveys. For example, AR interviewed faculty about teaching natural selection and evolution, MA interviewed students about the use of classroom management systems, NR collected survey data and interviewed students about their learning preferences, and HN interviewed and surveyed students about their conceptions in quantum mechanics. Procedures as outlined in the research protocols were followed to gather information about various questions. Appropriate permissions forms were collected as required by human subject protocols. Data collection was completed by the end of the autumn semester. In the winter, data analysis led to the preparation of a master's project paper summarizing their studies and findings. These findings were presented orally to their Master of Education Committee in March when the OSU delegation visited AMU.

Research Conferences at AMU

In March 2016, AMU hosted joint research conferences on Nanotechnology (ALIGARH NANO-V) and STEM Education and Research (STEM CON-16). Faculty members of the Ohio State and Aligarh Muslim University teams served as conference chairs and presented research presentations and keynote talks. Fellows were tasked with organizing and presenting at the conferences, providing valuable experience as part of both the scientific and educational research communities. Research advisors from OSU attended and presented at the conference. Researchers from other universities in India and from the international research community were introduced to the program and invited to express interest in expanding the program beyond AMU and OSU.

Year 3: Summary of Accomplishments

In the third year of the project, Fellows experienced an undergraduate teaching apprenticeship at AMU to experiment with some of the teaching and learning strategies and ideas they brought back from their OSU experience. Each collected and analyzed data on an educational research project and prepared a manuscript describing each specific project and their findings. An oral presentation of this educational research study to their MED committee members completed their work on the Master of Education program. All four Fellows received their Master of Education degree from OSU in 2016. In addition, two research conferences were held at AMU in spring 2016 during which the Fellows presented their work and served as conference organizers.

Year 4: Final Year

Cohort 2

A second cohort of Fellows were selected for an abbreviated five-month visit to OSU to engage in research with a scientific advisor. Owing to insufficient

TABLE 9.6 Cohort 2 fellows

Fellow	Gender	AMU science discipline	OSU research advisor department
1. TK	Male	Mathematics	Mathematics
2. PA	Male	Biotechnology	Chemistry
3. SP	Female	Chemistry	Chemistry
4. SN	Female	Nanotechnology	Physics

funding for OSU tuition and fees, these students did not participate in the Master of Education program or in any coursework related to teaching and learning. Also their stay at OSU was for half the duration of the first cohort. Students were able to engage in laboratory work with their research advisors at OSU full time for the autumn semester. Table 9.6 details this second cohort and their disciplinary backgrounds.

Related Activities

Formation of an Indo-US Consortium of universities in March 2016 led by AMU and OSU intended to facilitate the expansion of the project to other universities in India. In addition, proposals have been submitted to the University Grants Commission to obtain funding to continue the STEM Faculty Training program. As a consequence of this collaboration, Dr. Nahar and Dr. Pradhan were invited to teach a graduate-level course on Atomic and Astrophysics Spectroscopy in 2014, 2015, and 2016 for the AMU physics department. In 2017, Dr. Nahar was awarded a grant from the U.S. Mission to India to support a Women in STEM Roadshow (WSR). A key feature of the WSR were nine workshops for women students from underrepresented groups that were conducted in February 2018 in six cities (New Delhi, Calcutta, Patna, Kurnool, Hyderabad, and Aligarh). The final WSR workshop was held at the APJ Abdul Kalam Center at AMU, the Indo-US center established as part of the Obama-Singh 21st Century Knowledge Initiative project.

Year 4: Summary of Achievements

At the end of Year 4, three of the four Cohort 1 Fellows had completed their doctoral studies. The fourth will finish his work in the near future. One of the

TABLE 9.7 Obama-Singh fellow progress

Fellow	M/F	Completed PhD?	Where is s/he in 2018?
HN	F	Yes, 2017	Post doc at the National Institute of Standards and Technology, NIST, Washington DC
AR	M	Yes, 2016	Lecturer at AMU
NR	F	Yes, 2017	In the U.S. with her husband
MH	M	No	At AMU, writing thesis
TK	M	Yes, 2017	Assistant Professor
PA	M	Yes, 2017	Post Doctoral Fellow
SP	F	Yes, 2018	Assistant professor at AMU
SN	F	No	Expected finish in 2018

Fellows is teaching at AMU, two are continuing with post-doctoral work. Three of the Cohort 2 Fellows have completed their doctoral studies at AMU. Two Cohort 2 Fellows are employed as assistant professors at universities in India, and one is completing post-doctoral studies (see Table 9.7).

An organizational structure for The Abdul Kalam Center located at AMU was formalized in April 2017. The center is expected to benefit AMU and OSU in a variety of ways. The award of the Women in STEM Roadshow funding represented the first project for the new center.

Fellow Achievements

During and since their tenure at OSU, the fellows have amply demonstrated their enhanced capabilities in education and research as a result of this program, which may be quantified by data about publications, presentations, awards, honors, etc. A partial list of achievements is shown in Table 9.8.

TABLE 9.8 Fellow achievement metrics

Fellow	M/F	Publications	Presentations	Honors/Positions	Awards
AR	M	2	1	1	2
NR	F	1	2		2
HN	F	6	7	1	3
MA	M	No Data			
SN	F	4	2		1
PA	M	43	6	2	1
SP	F	6	6	1	1
TK	M	1	1	1	1

The data for PA deserve special mention. He is an exceptionally brilliant scientist with an unusually large number of collaborative projects, as reflected in 43 publications and 1030 citations, and the quality of publications in journals with total impact factor of 140. PA is now a postdoctoral fellow at Aarhus University in Denmark.

Conclusion

The US-India Foundation (USIEF) award to the Ohio State University and Aligarh Muslim University under the Indo-US 21st Century Knowledge initiative opened a new frontier in Indo-US collaboration on STEM, Education, and

Research. The goals of the Obama-Singh 21st Century Knowledge Initiative (OS21CKI) project included facilitating mutual understanding, educational reform, and economic development by engaging communities in both the USA and India in academic cooperation. The pilot program described in this chapter aimed at addressing the premier priority national need in higher education as identified by the Indian government—preparing world-class faculty to teach in Indian universities. In this work, we provided one possible answer to the question regarding how two major universities in different countries might collaborate to produce world-class faculty for STEM undergraduate instruction who know their STEM content, engage in cutting-edge research, and also know how to teach.

The model that we present and the work we have completed represents a proof of concept achievement. Two major research universities in different cultures were able to modify their programs to accommodate this innovative opportunity, sign a memorandum of agreement, negotiate differences, and encourage faculty and students at both institutions to participate. The strongest elements of the program that we developed are the combined emphasis on content knowledge, research skills, and andragogy. World-class faculty know their science, they know how to generate new knowledge through the unique research skills of their discipline, and they know the science of learning and how best to teach the next generation of students. By creating a dual-degree program that allows each university to own one of the degrees, and by establishing links between researchers at both universities, the model we present honors both institutions and points a way forward for international cooperation in STEM Education and Research.

The model described herein is based on a highly intensive dual-degree program encompassing both education and research in an accelerated time frame of two years that should form the basis of a successful academic career. The OSU-AMU collaboration met its goals and exceeded expectations in terms of the number of trainees and scope of training from that originally envisaged. However, we might also note that securing a faculty position at AMU in particular, and major universities in general, depends on extraneous factors not related to the objectives of the program. Those pertain to available positions in the university, college or the department, areas of emphasis for faculty hiring, personnel issues, and other factors germane to the local environment. We expect all the fellows to eventually obtain faculty positions at Indian universities. The first one, Dr. TK, was appointed Assistant Professor of Mathematics at a central university, the Jamia Millia Islamia University in Delhi in 2017, following a national search which ranked him number one out of 65 applicants. A second fellow, Dr. SP, has recently been appointed as an assistant professor

in the chemistry department at AMU, a particularly noteworthy achievement since AMU is ranked close to the top of Indian universities.

As members of the global community dedicated to improving the quality of life for citizens worldwide, the responsibility of science teacher educators extends to the preparation of world-class faculty in STEM areas at institutions of higher education. In the U.S., while the importance of teacher education is generally acknowledged for preparation of K–12 teachers, the idea that college professors might also benefit from andragogical knowledge is relatively new. This innovative international program to prepare world-class professors in STEM fields for colleges and universities in India identified some of the theoretical frames and logistical challenges for preparing STEM faculty for IHES, including universities and colleges in the United States. We assert that this program is easily replicable in other venues and hope to demonstrate the generalizable nature of our success by expanding to other U.S. and Indian institutions of higher education.

References

Adams, J. (2013). The fourth age of research. *Nature, 497*, 557–560.

Asgary, N., & Robbert, M. A. (2010). A cost-benefit analysis of an international dual degree programme. *Journal of Higher Education Policy and Management, 32*(3), 317–325.

Bransford, J., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school* (*expanded edition*). Washington, DC: National Academies Press.

Choudaha, R. (2011, July 24). India, A crisis of confidence in higher education? *University World News.* Retrieved from http://www.universityworldnews.com/article.php?story=20110722202005936

Generation Study Abroad. (2014). *What will it take to double study abroad? Generation Study Abroad™ IIE | Opening Minds to the World.* Retrieved from https://www.p.widencdn.net/gbnycj/Generation-Study-Abroad-Green-Paper

Higgitt, D., Donert, K., Healey, M., Klein, P., Solen, M., & Vajoczki, S. (2008). Developing and enhancing international collaborative learning. *Journal of Geography in Higher Education, 32*(1), 121–133.

Lasthiotakis, H., Sigurdson, K., & Sá, C. M. (2013). Pursuing scientific excellence globally: Internationalising research as a policy target. *Journal of Higher Education Policy and Management, 35*(6), 612–625.

Paige, M. R., Fry, G. W., Stallman, E. M., Josić, J., & Jon, J-E. (2009). Study abroad for global engagement: The long-term impact of mobility experiences. *Intercultural Education, 20*(supp 1), S29–S44. doi:10.1080/14675980903370847

Singh, M. (2007). PM's address at the 150th Anniversary of University of Mumbai. Retrieved from http://www.pib.nic.in/newsite/PrintRelease.aspx

Smith, K. (2010). Assuring quality in transnational higher education: A matter of collaboration or control? *Studies in Higher Education, 35*(7), 793–806.

Straits, W., & Wilke, R. (2007). How constructivist are we? Representation of transmission and participatory models of instruction in the Journal of College Science Teaching. *Journal of College Science Teaching, 36*(7), 58–61.

Sukhdev. (2016). A study of multiculturalism in India. *International Journal of Research and Scientific Innovation, 3*(9), 96–97.

Tobin, K., & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 1–21). Hillsdale, NJ: Erlbaum.

U.S. Department of State. Bureau of Educational and Cultural Affairs (n.d.). National Security Language Initiative. Retrieved from http://www.nsliforyouth.org/

Wattal, A. M. (2004, September). Teaching for tolerance, respect and recognition in relation with religion or belief: Indian perspectives. *Report from the Global Meeting on Teaching for Tolerance, Respect and Recognition in Relation with Religion or Belief, Oslo.* Retrieved from http://www.folk.uio.no/leirvik/OsloCoalition/WattalIndia0904.htm

World Bank. (2007). *India country summary of higher education.* Retrieved from http://siteresources.worldbank.org/EDUCATION/Resources/278200-1121703274255/1439264-1193249163062/India_CountrySummary.pdf

Youseff, L. (2014). Globalisation and higher education: From within-border to cross-border. *Open Learning, 29*(2), 100–115. doi:10.1080/02680513.2014.932686