Powering the Future Nuclear Security Through Regional Programs

B. D. Fisher*
Nuclear Security Science & Policy Institute,
Texas A&M University

(Federation of American Scientists Collaboration)
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This paper discusses the various nuclear science educational programs and opportunities in the United States (US) that could lead to a career in nuclear security. Having regional opportunities produces a more diverse, and multidisciplinary workforce, which will drive the future of nuclear. This is because regional educational and training opportunities mitigate the problem of attracting and retaining high potential students who for one reason or another would not otherwise study nuclear science. From personal experiences, as a former high school teacher, the largest reasons why high potential students may not enter nuclear is because of the conceived notion that it is too difficult and not worth it. Very often, students cite the cost associated with an education, the long distances, and perceived lack of technical employment opportunities as reasons why they prefer to study something else, despite having an interest in the topic. Communicating about the various nuclear security programs and how they can fit into a students career and life is essential for powering the future of nuclear.

I. INTRODUCTION

Only 28% of the US adult population over the age of 25 years old has conferred a bachelors degree. Of this college-educated population, 63% do not hold an advanced degree, and only 4% have a PhD.[1] Despite a small fraction of the population being prepared to take on challenging roles in nuclear security, this not necessarily reflect any negative or significant impacts on the future of nuclear security. However, it is undeniable that as the US nuclear workforce ages and more baby boomers retire, the demand for nuclear scientists with advanced training will grow. Consequently, it is essential to attract and retain high potential students from the time they graduate high school until they complete their graduate coursework. This paper addresses the regional opportunities for students who have a high potential to successfully complete the program. However, it is limited to the technical nuclear science educational and training opportunities in the US.

A. Regional Programs

The path to a career in nuclear security does not require one specific degree or curriculum. Rather the combination of related coursework and specialized training opportunities make unique candidates who are diverse and multidisciplinary.

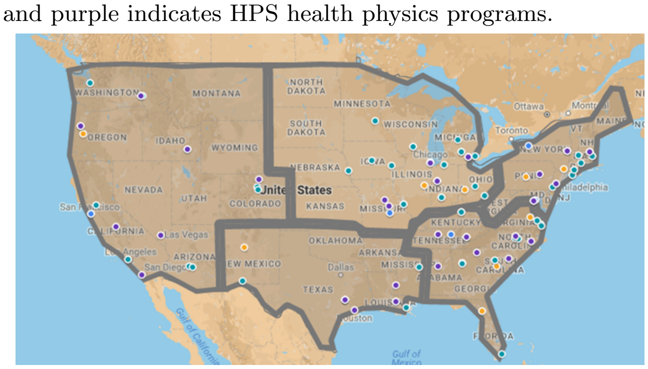
* bdfisher@tamu.edu

1. *Where are the major educational opportunities?*

High potential students can identify degree programs through the Accreditation Board for Engineering and Technology (ABET), American Chemical Society (ACS), American Physical Society (APS) Division of Nuclear Physics (DNP), and the Health Physics Society (HPS). Each party has a database that contains the different nuclear science degree programs;

- ABET identifies nuclear engineering programs [2]
- ACS identifies nuclear chemistry and radiochemistry programs [3]
- APS DNP identifies nuclear physics programs [4]
- HPS identifies health physics programs [5]

FIG. 1. Nuclear science degree programs in the USA; yellow indicates ABET nuclear engineering programs,blue indicates ACS recognized nuclear chemistry and radiochemistry programs, green indicates APS DNP nuclear physics programs, and purple indicates HPS health physics programs.



The figure above compiles the identified degree programs offered throughout the continental US. In this figure, the continental US is also divided into 5 regions;

northeast, southeast, midwest, south central and western. In total there are 24 ABET nuclear engineering programs, 13 ACS nuclear and radiochemistry programs, 49 APS DNP nuclear physics programs, and 28 HPS health physics programs. The data from these resources should not be considered all inclusive guideline, rather a resource that details potential educational opportunities. This is because there are some states that appear to lack a nuclear science program. However, this is not always the case. For example, some nuclear engineering departments are joint with mechanical engineering, and so the ABET accreditation is in mechanical engineering instead. Consequently, this degree program would not be listed in the ABET directory for accredited nuclear engineering programs, despite having an accredited program that offers a nuclear specialization. Similarly, this could also happen with the nuclear and radiochemistry, nuclear physics, and health physics programs.

In regards to regional educational opportunities, a potential student has the most options with nuclear physics, particularly in the Midwest and Southeast. There are very few options for nuclear and radiochemistry, regardless of the region. Nuclear engineering and health physics have similar opportunities across the regions. The number of regional degree programs identified by ABET [2], ACS [3], APS DNP [4] and HPS [5] are detailed in the table below;

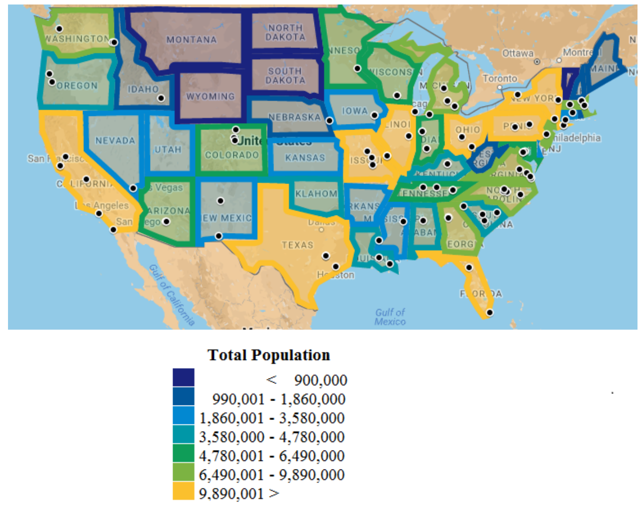
Region	ABET	ACS	APS	HPS	Total
Northeast	7	3	8	5	23
Southeast	6	1	12	7	26
Midwest	2	4	16	5	27
South Central	6	2	5	4	17
West	3	3	8	7	21
Total	24	13	49	28	114

TABLE I. The number of ABET, ACS, APS DNP, and HPS identified degree programs varies by region.

When observing the locations of the degree programs, it is also important to consider the regional population. States and regions with higher populations can be assumed to produce more students, albeit this does not necessarily correlate to the population's ability to complete the programs or academic support of the subject matter. Simply put, a higher population does not reflect whether or not students will want to study the subject or can successfully finish the program, rather it signifies the increased probability that there exists a student who would be an excellent candidate for a career in nuclear security.

Figure 2 illustrates the population across each state in addition to the location of the previously identified programs from Figure 1. The population in parts of the western region (particularly in North Dakota, South Dakota, Montana, and Wyoming) is lower and also does not have many regional educational opportunities dedicated specifically to nuclear science. The states that have larger populations, also have substantially more opportunities. This disproportionate spread of identified programs, when combined with population creates disparity. Meaning that even within a region, a student may feel discouraged to move to another state, in order to enroll in a program dedicated specifically to nuclear science.

FIG. 2. Data from the American census bureau was used to create this map. The black dots indicate a nuclear science program. [6]



From my experiences as a teacher, it was rare for a student to have no concerns regarding the location of the program. This is because the move to another region or state would incur costs associated with the move itself and for visitations. It could also place the student in a different time zone entirely, which could affect contacting their support network from home, but ultimately the student will adjust. However, in some extreme cases, a move may cause isolation and affect the student's mental well-being. This is particularly true, if the student is moving to a completely different region, in which the culture, climate and environment will not be the same. Consequently, if a student does decide to leave "home," then they may not be able to successfully complete the program, due to what some people would consider "silly" reasons.

2. Where are the major training opportunities?

Because a student's educational path may not be specifically focused on nuclear security, the training opportunities which are focused on nuclear security provide invaluable experiences. Training opportunities refers to educational programs which include internships and practicums. The major programs are offered through the Department of Energy (DOE), the Department of Homeland Security (DHS), and the Department of Defense (DoD). The National Nuclear Security Administration (NNSA) is a semi-autonomous organization within the DOE, that provides significant exposure to nuclear security to students.

The DOE, DHS Domestic Nuclear Detection Office (DNDO) and the NNSA has an array of opportunities for students at both the undergraduate and graduate level. Through the various programs, students have the opportunity to work at a site that has nuclear security research opportunities.[7] , [8] , [9] The following figure outlines the major security programs in the US.

FIG. 3. This map was compiled using the participating university locations for programs relating specifically to nuclear security. [9]

The major sites are scattered throughout the continental US. Although there are significantly less locations to complete internships and practicums for nuclear security, this does not necessarily reflect the availability of these opportunities. Meaning that there are multiple opportunities per site.

Region	Number of Sites
Northeast	2
Southeast	6
Midwest	4
South Central	2
West	5
Total	19

TABLE II. The number of participating universities that a student may pursue specialized nuclear security training throughout the various regions of the continental US.

When observing the regional training opportunities, the sites appear to be evenly distributed, with the Southeast having the most opportunities. However, upon analyzing the map. there are states within the regions that have no opportunities. Again, from my experiences with students, the limited number of locations for internships and practicums instills the idea that there are also a limited number of positions and potential careers. Consequently, some students falsely believe that there is a lack of future opportunities altogether. However, this is not always the case, although successfully applying for a position will undeniably be competitive. In these cases, it is very important to communicate that the student must be persistent and consistent, when applying for competitive opportunities.

B. Students

1. *Who are high potential students?*

In a classroom setting, it is difficult to distinguish between the potential of students based on personality and communication skills alone. Additionally, observing standardized test scores is also a misleading metric. This is because a high potential student is not necessarily defined by their past performance on assessments or personality traits, rather by their ability to retain the subject matter. This could be influenced by the teaching techniques.

A very popular pedagogy paper discusses why learning mathematics should be like learning an art-form or how to play a musical instrument. From my experiences, I found many of the sentiments to be true. In particular, training students to solve problems should not be a creative process, until they fully understand the subject matter. Unfortunately, there is not enough time for a high school student and in some cases an undergraduate to fully understand the mathematics that they are essentially regurgitating.[10] This is why pursuing a PhD is so valuable, because the formal education provides the time needed to truly understand the concepts and how to creatively solve technical problems in a scientifically correct manner. Moreover, when this process is not given sufficient time, then it is likely that the student will fail. Thus, creating the image of a subject being "too difficult."

2. *When self-doubt affects the field of study.*

High potential students sometimes do not recognize the caliber of their own abilities, despite positive reinforcement. Similar to how the limited number of training locations affects a student's perception of the future career opportunities, past performances on assessments will influence the student's perception of their ability to successfully study nuclear science. Self-doubt is a difficult problem to not only identify, but also mitigate because it results from psychological mechanisms. Unfortunately, it also leads to an interesting, but common problem among high potential students otherwise known as "imposter syndrome." Imposter syndrome is the personal belief that you are not capable of accomplishing a certain objective, despite evidence of high achievement. [11]

Self-doubt has repercussions beyond dictating what a high potential student may feel about their skills. It is a powerful thing that if not recognized can lead to believing that they do not bring value to a field. This is because they may feel that their achievements resulted from "luck" or "chance." The factors that contribute to this are past experiences, where the student did not perform well in related subjects or their peers struggled. Therefore, the student views their success as less valuable and a "random" occurrence. In cases like this, a high potential student may opt to study something else, although it is not clear how often this phenomena occurs.

II. CONCLUSION

There are many nuclear science educational programs and opportunities in the US. The regional opportunities pave the path to a career in nuclear security, while producing a more diverse, and multidisciplinary workforce, which will drive the future of nuclear. The regional opportunities mitigate the problem of attracting and retaining high potential students who for one reason or another would not otherwise study nuclear science. Some of the reasons why a student would not study nuclear science include distance, time zones, cost, self-doubt and the perceived lack of career opportunities. Communicating the regional opportunities is important to mitigate the problems arising from the aforementioned reasons.

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