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Motivation in Pursuing Advanced Degrees in STEM Fields Among Domestic and International Students

Pranshu Adhikari

The United States has seen a sharp increase in the number of international students pursuing and receiving advanced degrees (Master's or Ph.D.) in STEM fields. While much literature has been published about the disproportionate number of international students pursuing and receiving advanced degrees in STEM fields, none have attempted to explain the reason why this phenomenon occurs. The purpose of this study was to identify if there was a difference between the reason domestic students and international students were pursuing and receiving advanced degrees in STEM fields. While the findings showed no statistically significant relationship between the student's status (as a domestic student and an international student) and the reason they chose to pursue an advanced degree in STEM, there was an overwhelming number of respondents from both the domestic student pool and international student pool that indicated that their primary reason in choosing to pursue an advanced degree in STEM was due to their interest in the field.

Keywords: STEM, international students, Master's, Doctorate, domestic student

Introduction

The number of students choosing to pursue advanced degrees (a Master's or Ph.D.) has been steadily rising for quite some time. More students are finding value in higher education for various reasons. The Organization for Economic Co-operation and Development, or the OECD, is an organization that promotes economic development and publishes various reports about demographics in developed and developing countries. Many OECD countries have seen an unexpectedly high increase in the number of students that pursue higher education (OECD, 2006). This trend is expected to grow, as many jobs now require an advanced degree. In particular, careers in science, technology, engineering, and math (collectively referred to as STEM) fields often require a tertiary education; an advanced degree is not an option but is required to succeed in the field. Therefore, many students who are pursuing STEM pursue a higher education.

In the United States, there is a large gap between the number of domestic students pursuing advanced degrees in a STEM field and the number of international students pursuing advanced degrees in a STEM field. While much literature has been published on the disproportionate number of international students in the field, there has not been an attempt to study why that is. This paper aims to understand if there is any difference in the reason domestic students pursue advanced degrees in STEM fields and international students pursue advanced degrees in STEM fields.

For the purposes of this paper, STEM includes any field in astronomy, chemistry, computer science, en-

gineering, geoscience, life science, materials research, mathematical sciences, and physics. Social sciences, STEM education, and medical fields are not included in this definition. Additionally, domestic students were defined as those who completed their high school education in the United States and international students were defined as those who completed their high school education outside the United States.

Literature Review

Much of the relevant literature regarding this subject concerns the reason students first became interested in STEM fields. With growing concern of a shortage of individuals in science, technology, engineering, and math fields, there has been a large movement that pushes for greater STEM education in the K-12 school system in the United States (Xue & Larson 2015). Many are concerned with the low number of domestic students enrolled in graduate school for STEM degrees and therefore advocate for a greater attempt to increase students' interest in STEM fields (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine 2007). The primary goal of gathering relevant literature in the field was to understand the reason individuals became interested in STEM fields, thereby making a distinction between an individual being interested in STEM and an individual actually pursuing STEM. The findings were used to create a survey that listed all the possible reasons individuals pursued an advanced degree in a STEM field.

Interest in STEM Garnered by School

Many researchers argue that the most significant factor in helping generate interest in STEM for students is hands-on experiences (Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa 2016). Employing teaching methods that actively engage the students is closely tied to providing hands-on experiences to students. Such experiences can come in the form of school activities and/or extracurricular activities.

The teaching method is an important factor in garnering interest in STEM in school. Evidence regarding the effectiveness of inquiry-based and investigative-based learning has long been prevalent in the scholarly community (Markowitz, 2004). Students learn and retain information better when they are actively engaging with the material they are studying. This is especially true in a STEM field, where students must attempt to understand the ways in which the physical world works. By engaging with the learning materials, students are able to relate to the information better (VanMeter-Adams, 2014). They have a reason for trying to understand the material. If a student was taught about these concepts in isolation, then there would be no context in which the student could use their knowledge, rendering it useless.

Many students also choose to participate in STEM related activities outside of school. The hallmark of extracurricular activities is that they are voluntary; because they are voluntary, many of the students who choose participate in these programs already have a basic level of demonstrated interest in a STEM field. Otherwise, they would not be participating in those activities. Before participation in such activities, many students had preconceived ideas of STEM as a field that was heavily focused on a system of strict guidelines (Richmond & Kurth, 1999). When those students were exposed to activities that expected them to think critically and act creatively, there was a definite shift in their thinking of what a STEM career meant (Richmond & Kurth, 1999). These experiences allowed students to consider STEM as a field that focused on exploration and creativity, not a field that focused on rigid guidelines and rules. Because the ability to be creative in their career path was important to those students, they were able to view STEM as a viable career path for them.

Some students are involved with STEM fields at a much younger age than other students. A review of the literature, however, illustrates that the age at which a student is exposed to STEM does not play a significant role in their level of interest for the subjects in the field, as long as the student becomes interested before they must choose a career path (Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa, 2016). There is a great difference between the experiences that can be offered to someone that is in elementary school versus someone who is of high school age. For example, the only opportunity an elementary school student might have is the opportunity to attend a STEM promotion fair that has games and activities for the student to do, while a high school student has the opportunity

to partake in an internship at a research laboratory or attend a STEM-based summer program (Quagliata, 2015). Older students have more opportunities to get engaged with STEM simply because of the number of years they have been exposed to the field.

Interest in STEM Because of Possible Economic Opportunities

It has become common knowledge that those with degrees in STEM usually earn much more than individuals who do not have a STEM degree. Data collected and published by the National Center for Education Statistics clearly shows that there is a substantial difference in the salary for those with a Bachelor's degree in STEM and those with a Bachelor's degree in a Non-STEM field; for those who work full-time, the difference is more than $15,000 (Cataldi, Siegel, Shepherd, & Cooney 2014). This figure is greater for those with advanced degrees. The total lifetime earning for an individual with a bachelor's degree is even more if they have an advanced degree. Individuals with a bachelor's degree can expect to make around $2.27 million in their lifetime, while individuals with a doctoral degree can expect to make around $3.25 million in their lifetime; this difference of approximately a million dollars is a significant gap (Carnevale, Rose, & Cheah 2011).

These statistics are not limited to STEM, but trends for STEM fields follow the same model. Therefore, economic opportunities might be in the forefront of a student's mind when deciding on whether or not they want to pursue an advanced degree. Low-income students often want to pursue a STEM field because it has the most payback. Students with such a background often feel obligated to pursue a career that ensures financial security i.e. STEM (Lichtenberger & George-Jackson, 2013).

With the increased dependence on technology today, employers look for those with experience and some skill in STEM. More than half of the employers surveyed in a study conducted by National Association of Colleges and Employers said they planned on hiring graduates with bachelor's degrees in STEM fields (Koc, Koncz, Tsang, & Longerberger, 2016). There is an increased need for individuals with a STEM degree in today's workplace, allowing for more opportunities to be available to graduates with STEM degrees. STEM has become a financial safety net; a graduate with a STEM degree has a greater chance of finding a job in his/her field than someone who majors in a non-STEM field.

Different Experiences Among Foreign and Domestic Students

In order to analyze the motivations behind wanting to join the STEM field, it is important to establish that foreign nationals have significantly different experiences in the United States than those who grew up in the U.S., no matter their reason for residence in the country. At the most general level, foreign nationals are likely to earn less than their native-born counterparts (Takei, 2011). This is especially true within the first few years the individual is in the United States. The individual takes time to get settled and adjusted to the new cultural norms of America (Jiang, 2010). Moving to a country with a different culture and possibly a different language than what the individual grew up in can be jarring and could have a profound affect on their experience.

As various studies have shown, international students typically get more advanced degrees in STEM fields than their native counterparts. Although domestic students are regularly shown to receive about 73% of total advanced degrees in the United States, they only receive approximately 50% of advanced degrees in STEM-related fields (Han, 2016). International students are also more likely to receive more grants than their native counterparts (Corley & Sabharwal, 2007). These grants are used to conduct research, which increases their standing as a professional in their respective field.

It is difficult to make a generalizing statement for the whole population because each group (domestic students and international students) has totally varied previous experience. Doing so would invalidate the different experiences of each group. What is clear, however, is that domestic students and international students have differing experiences in the United States as is apparent through the need of international students to familiarize themselves with American society and the discrepancy in the number of advanced degrees awarded to both groups. Therefore, it is critical that domestic and international students are evaluated as two separate groups.

Research Gap

A substantial body of research has attempted to gauge the reasons why individuals choose to pursue a STEM field. Additionally, it has been shown that international students pursue and earn advanced degrees in STEM fields in much larger numbers than in any other field. However, there have not been studies that have tried to find if there are any differences in motivation to pursue an advanced degree in a STEM field among international students and domestic students. There seem to be many assumptions made by the general public on the relationship between nativity status and the reason for pursuing an advanced degree in a STEM field. The purpose of this study is to discover if such a relationship exists and if so, what that relationship is. As noted previously, international students and domestic students have quite a different experience in the United States. Therefore, their motivations and interest in pursuing advanced degrees will be evaluated separately.

Method

Previous studies attempting to determine a population's reason for pursuing STEM- related careers took a survey approach to arrive at their conclusions. Such an approach is one of the best methods that allows the researcher to make conclusions about the way a population thinks and acts during current times, which is why the same approach was taken when conducting this research project.

The survey used to collect the data was modeled after a survey conducted Maltese, Melki, and Wiebke (2014) from Indiana University titled "The Nature of Experiences Responsible for the Generation and Maintenance of Interest in STEM" that attempted to analyze the primary reason individuals became interested in a STEM field. The survey was modified to fit the needs of the research, as this research targeted a different demographic than the population surveyed by the original survey. The modified survey asked individuals where they completed their high school education -- to distinguish between international and domestic students -- and their primary and secondary reason for choosing to pursue an advanced degree in a STEM field. This was done to ensure all individuals taking the survey had the same definition of "domestic student" and "international student" for the purposes of this research study; if not, the data would have been skewed. In the data analysis, individuals who completed their high school education in the United States were categorized as domestic students and those who completed their high school education outside the United States were categorized as international students.

The research procedures, methods, and the survey were approved by the Institutional Review Board, or IRB, of Norman Public Schools in order to ensure ethical research practices.

The same survey was used for both international and domestic students. It was not possible to distinguish between international students and domestic students based on publicly available information. Participants indicated their status as international or domestic student on the form. This also allowed for a more random sampling of the data.

The surveys were sent via email to individuals at institutions of higher education that were likely to have access to the faculty and to graduate students (as my research focused on those two groups) in STEM fields. Institutions of higher education were chosen through a multistage random sampling method by using the Forbes "Top American Colleges" list of the top colleges in the nation. With the time constraints that were in place, it was not practical to select institutions of higher education from a spreadsheet of all such institutions in the United States. Therefore, a college ranking list was used to determine the institutions that would be sent the survey. More specifically, the Forbes list was chosen instead of other college rankings because of its focus on post-graduate success. As this research was primarily concerned with the work individuals do in their graduate studies, the Forbes list was the most practical (Howard 2016). Additionally, the ranking of liberal arts colleges, as well as research universities within the same ranking system done by Forbes, allowed for a greater and more randomized sample to choose from.

After that process was complete, it was clear that there needed to be contact with certain individuals at each institution that would distribute the survey. It would have decreased the validity of the research if the survey was sent to individual graduate students or professors at the university. Therefore, it was decided that

sending the surveys through an intermediary would be the best option. The intermediary would have to be someone who had a position at the institution that allowed them access to professors and/or graduate students in STEM fields. For most of the institutions selected through the multistage random sampling, such an individual was one who held the position Departmental Chair or Departmental Head, or the equivalent, of a STEM department. Additionally, the survey was also sent to the Department's Administrative Assistant or Executive Assistant, or the equivalent, as individuals in those positions have access to professors and/or graduate students in their department. The email addresses for these individuals was publicly available on each institution's website. Individuals at institutions that did not have email address of faculty publicly available or institutions that clearly stated that available email address were only to be used by students of the institution were not contacted.

Due to the time constraints of this research project as well as the vast scope of higher education institutions that were chosen, it was not practical to receive an approval from each institution's Institutional Review Board. Therefore, the participants were informed that their participation in the survey would also serve as their consent to taking the survey. This meant that there were no consent forms that were used while conducting this research project as participation was also understood to be consent. (Please consult the Appendix for the survey used.)

Results

Data were analyzed based on whether the participant completed their high school education in the United States or outside the United States. Participants that completed their education in the United States were classified as "domestic students" while participants that completed their education outside the United States were classified as "international students". Participants were asked to choose the primary reason they chose to pursue an advanced degree in a STEM field as well as a secondary reason they chose to pursue an advanced degree in a STEM field. These responses were then analyzed separately for domestic students and international students. The figures below display the results of the survey.

Fig 1. Domestic Students Primary Reason

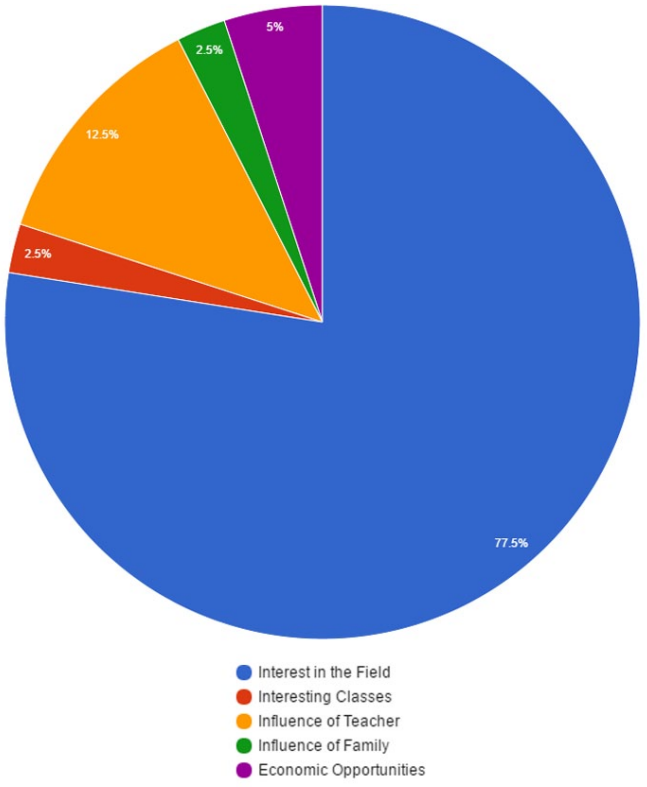


Fig 2. International Students Primary Reason

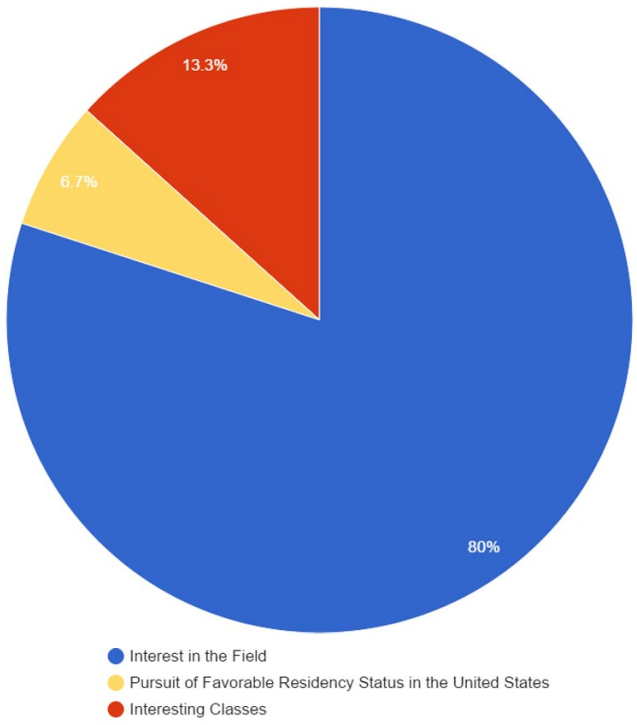


Fig 3. Domestic Students Secondary Reason

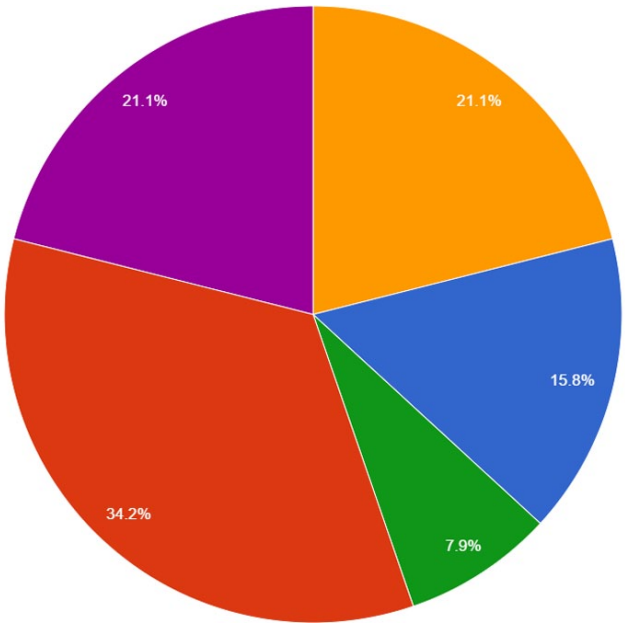
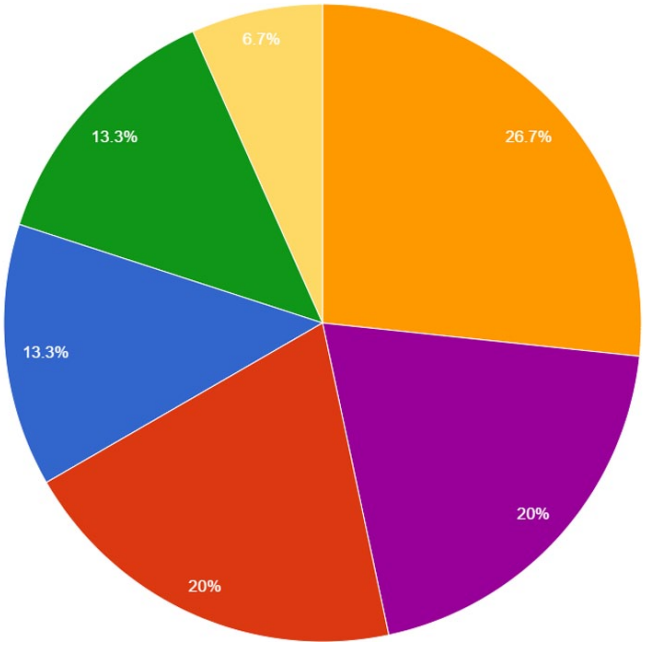


Fig 4. International Students Secondary Reason



Key for above graphs.

- Influence of Teacher
- Economic Opportunities
- Interesting Classes
- Interest in the Field
- Influence of Family
- Pursuit of Favorable Residency Status in the United States

	A	B	C
1 - Economic Opportunities	0 (0%)	2	2
2 - Influence of Teacher	0 (0%)	5	5
3 - Influence of Family	0 (0%)	1	1
4 - Interesting Classes	2 (	1	3
5 - Interest in the Field	12	31	43
6 - Pursuit of a Favorable Residency Status	1	0	1
	15	40	55

Fig 5. Table of values where A represents the number of international Students and B represents domestic students that chose each option for their primary reason. C represents the total number of students (both international and domestic) who chose each option.

	A: Primary	B: Primary	A: Secondary	B: Secondary
1	--	5%	20%	21.1%
2	--	12.5%	26.7%	21.1%
3	--	2.5%	13.3%	7.9%
4	13.3%	2.5%	20%	34.2%
5	80%	77%	13.3%	15.8%
6	6.7%	--	6.7%	--

Fig 6. This chart shows the corresponding percentage of participants in each group who selected each option. This chart displays the values that are present on the graphs.

	A	B
1	0.545	1.45
2	1.36	3.64
3	0.273	0.727
4	0.818	2.18
5	11.7	31.3
6	0.237	0.727
	p = 0.150	

Fig 7. Contingency table that shows the expected values using Fisher's Exact Test.

Discussion

The p value calculated using the Fisher Exact Test as shown in Figure 7 was shown to be statistically insignificant. As a p value of over 0.05 indicates weak evidence against the null hypothesis, it is clear that statistically, there is no evidence to show that there is any relationship between the two variables. Weak evidence against the null hypothesis indicates that the results collected are either due to coincidence or chance and are not related in a significant way. The Fisher Exact Test was used in place of a chi-squared test because of the small sample size (the sample size of this survey was 55); both tests produce the same results.

Although the results were shown to be statistically insignificant, it is possible to look at the trends found from the survey and analyze that data. The primary reason for most people in pursuing an advanced degree in STEM was interest in the field. In fact, for both domestic and international students, approximately 80% of respondents indicated that this was a primary motivation. This trend is surprising, as international students and domestic students have very different experiences in the United States, a phenomenon discussed in the Literature Review section of the paper. The survey leads to the conclusion that the differing experiences of domestic and international students makes no difference in their reason for pursuing an advanced degree in a STEM field.

Such a conclusion can have many valid explanations. International students might have decided their career plans before coming to the United States. This would explain why their social and educational experiences in the United States had little to no effect on their reason to pursue an advanced degree -- because their reason to pursue such a degree was already well established before they came to the United States. However, as this was not the focus of the research project, a more concrete and valid statement cannot be made.

Another interesting trend to identify are the graphs that show the secondary reason for pursuing an advanced STEM degree. Specifically, it is interesting to note that the option for "economic opportunities" was chosen as a secondary reason for pursuing an advanced STEM degree by both domestic and interna-

tional students in similar proportions (approximately 20% of respondents from each group chose this option). Even so, it was not the principal secondary reason for either group. This suggests a break from the popular belief that those who pursue STEM fields typically do it for the economic opportunities that are present in the field. Pay for those in STEM fields is much higher than in any other field and this trend is expected to continue (Carnevale, Rose, & Cheah, 2011). Even so, the survey shows that economic opportunities were deemed to be an advantage in obtaining an advanced degree in STEM, but were not the primary reason individuals pursued the field. This challenges the popular notion that STEM graduates and those in STEM fields simply do it for the economic security or job opportunities that are provided to them by an advanced degree in a STEM field.

Research conducted by the OECD has shown that more international students are pursuing and receiving advanced degrees in STEM fields than domestic students. This leads to the conclusion that currently in the United States of America, there are more international students in the STEM field than domestic students. Such a difference in the number has many implications.

First, there is one of diversity. It is no question that the more diverse a group, the more innovative and successful the group is. Places that advocate for collaboration among individuals from various parts of the world (such as the European Organization for Nuclear Research, or CERN, and the Fermi National Accelerator Laboratory, or Fermilab) are often at the forefront of the research done in the STEM field. Such collaboration allows for professionals and individuals to create large projects that have meaningful impacts on society. It is much more likely that such a discovery or massive finding will be achieved through collaboration among individuals rather than work done by a single person. For example, the recent detection of gravitational waves was a massive collaborative effort among groups from all around the world, as evidenced by the fact that the list of credited authors and collaborators in the paper that was published on the topic spanned more than five pages (Abbott, 2016).

Another implication of the difference in number between domestic students and international students is related to an option presented in the survey and one that previous researchers have found to be instrumental in getting students interested in STEM: the influence of STEM classes. Almost all respondents except one said that they had taken a STEM-related class in high school. STEM education in the United States lags behind many countries, as measured by the low scores in science and mathematics by the United Scores on tests such as the Programme for International Student Assessment, or PISA (Kelly, Nord, Jenkins, Chan, & Kastberg, 2013). This lag in providing quality, current, and interesting STEM education to students could be a potential reason why domestic student do not dominate these fields. Because these classes in the United States are not taught in a manner that allows students to engage with the material, students do not become interested in the field. For many students, interesting classes are a precursor to having a genuine interest in the field. Within this criterion, the results of the survey might have been skewed as participants might have become interested in their respective field through engaging classes.

While distributing the surveys, there was an unforeseeable limitation. Some of the individuals that were emailed were concerned with the fact that the link to the survey was fake or would have led to viruses. This concern was discovered when some recipients of the email contacted the faculty advisor of this project asking if the research project was real and serious. Many others might not have taken the time to inquire and simply disregarded the email. The low number of survey results is perhaps a reflection of the hesitation from those who received the emails because they were worried that it was a scam. In order to combat any such questioning of validity, further correspondence stressed the fact that the project had been approved by an Institutional Review Board before being conducted. Additionally, the use of an intermediary, while necessary to establish credibility, might have led to the low amount of survey responses.

While this research project answered a few questions about why domestic and international students choose to pursue an advanced degree in a STEM field, it led to more questions that were not within the scope of this particular research project. For example, it is clear that the survey (found in the Appendix) did not ask any demographic questions such as the participant's gender, race, ethnicity, or age. As the focus of the research project was not on gender, race, ethnicity, or age, these questions were not included in the survey.

Including those questions would have been unnecessary because the research question did not attempt to link such variables with an individual's motivation in pursuing STEM; it only attempted to link where they studied for high school with their reason for pursuing STEM. However, an interesting research study could be conducted to assess if the age of participants had an effect on their reason for pursuing an advanced STEM degree. The answers could also vary depending on the race or gender of the individual. Gender would be an interesting demographic to study along with this phenomenon because there is a large push to increase the number of women in STEM, as it is still a male-dominated field. Therefore, it would be interesting to see if there are any differences in motivation based on gender among domestic and international students.

Conclusion and Future Directions

This study attempted to answer "why" to a phenomenon that has been present for quite some time. In doing so, it was concluded that statistically, there was no difference why a domestic student and why an international student pursued an advanced degree in a STEM field. While that is the case, interesting conclusions can still be drawn from observed trends. Both groups pursued advanced degrees in STEM primarily because of an interest in the field and economic considerations were secondary to both groups. The results found through this research helps lead to a greater understanding of the current trend in higher secondary education in STEM fields. These findings are a step in fully understanding why there are a disproportionate number of international students receiving advanced degrees in STEM fields.

Future researchers might attempt to explore if gender played any significant role in the reason student pursued an advanced degree in a STEM field by conducting a similar study to see if there is a relationship between gender and the reason an individual pursues an advanced degree in STEM. Other demographic indicators and their correlation to the primary reason individuals want to pursue an advanced degree in a STEM field might also be of interest.

The number of people pursuing STEM fields is projected to grow in the coming decades. The current demand for STEM professionals has been rising because of the need for technical skills in this increasingly modern world. The number of international students in the United States is currently helping fill that demand but there is likely to be a push for more domestic students to enter the STEM field. There is also likely to be a shift in the reasons students pursue STEM fields because of the push to engage students in STEM fields earlier in their academic careers.

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