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STEM Education Discrepancy in the United States and Singapore

Elizabeth K. Worsham, Aaron Clevenger, and Kelly A. Whealan-George

Abstract

One of the hottest topics over the past several years has been science, technology, engineering and mathematics (STEM) education. The United States is lagging behind in STEM education rankings as compared to its counterparts in Europe and Asia, including Singapore, ranked second overall in math and science based on the Program of International Student Assessment. Even as a small country, Singapore has one of the best education systems in the world, one of the busiest ports, and is a leader in the science and technology market. One factor of this is family life and the culture that education should improve one's quality of life. Parent involvement and the drive of the student help them to become more apt learners and pursue a STEM career. The government also plays a role in creating an environment where students will become innovating minds in the workforce and help sustain the country's economy and place in the global market. The education system fosters students' interests in math and science and caters to different levels of students abilities in order to retain them in schools. All these factors contribute to Singapore having a higher percentage of students who graduate from universities with STEM degrees than the United States.

Introduction

The term STEM (Science, Technology, Engineering and Mathematics) was coined in the early 2000s by the National Science Foundation and defines educational areas that are important for students and the country's economic growth (Dugger, 2010, pg. 2). According to the U.S. Department of Labor, the five percent of U.S. workers in a science or engineering related field are responsible for 50 percent of the sustained economic expansion. The job market for STEM majors is growing at twice the rate of other occupations, but in 2011 only 13 percent of United States students chose a STEM major in college as compared to almost 50 percent of students in Singapore (Center on International Education Benchmarking). A saturated STEM job market benefits the economy as well as the technological growth of a country, yet United States students are not graduating with STEM majors at a comparable rate to those in European and Asian countries, especially Singapore.

This study investigates this discrepancy through literature review, interviews with Singaporean students and observations from a visit to Singapore. Unlike other studies that have been performed using strictly quantitative surveys to gather information, this research is unique in its research method, incorporating qualitative data collection and first-hand interviews. While many of the conclusions are the same as for other studies, this research uncovers many different causes for the STEM

discrepancy. There are an infinite number of factors that can affect a country's culture and societal norms, but three specific factors were found to have the most influence on the graduation rates and education of students in the U.S. and Singapore. This discrepancy is due to family life and culture, government policy and the need for sustainability, and the education system of each country.

Methodology

Recruiting Participants

Participants were invited to participate in the study on a volunteer basis by Embry-Riddle Aeronautical University (ERAU) Ignite staff via email. The participants were not preselected and all students who volunteered were available for interview. Students of the Embry-Riddle Asia campus who participated in the study were aware that they would be interviewed for research purposes. Students who were interviewed were informed of the purpose of the research before participating in the interview. Interviews were conducted with students at Embry-Riddle Asia who are studying in technical fields. Information was also collected informally through conversations with the students, tour guides, and other Singaporean residents encountered during a March 2015 Ignite research trip to Singapore.

Data Collection Method

In any research study, it is important to collect data without influencing the views of participants and to collect multiple types of data in order to validate the research findings. This is especially important in qualitative research because the results are not always black and white and often involve direct interaction with the participant. A researcher should be “self-reflective about his or her role in the research, how he or she is interpreting the findings, and his or her personal and political history that shapes his own interpretations,” (Creswell, 2012, p. 259) which is why it is crucial to verify the accuracy of the information through processes such as triangulation. “Triangulation is the process of corroborating evidence from different individuals (e.g. interviewing both a principal and a student), types of data (e.g. observational field notes and interviews), or methods of data collection (e.g. documents and interviews)” (Creswell, 2012, p. 259). The three methods of data collection used in this study are interviews, artifacts, and literature review.

Interviews

Interviews conducted with the participants explored their reasons for choosing a technical major and what they enjoyed about technical subjects. To accomplish the study’s purpose, three Embry-Riddle Asia students studying for a Bachelor of Science degree in Aeronautics were interviewed. The students were asked to describe what or who influenced them to choose a technical major. Clarifying questions followed to encourage a dialogue with the participants and better understand the influence. Following the interviews, surveys were distributed to students at the Embry-Riddle Asia campus to gather more specific information and obtain quotes. The surveys were distributed to a small group by an ERAU Asia student, and four completed surveys were returned. The survey is included in Appendix A.

Informal interviews were also conducted by listening to conversations between the students and between other people encountered during the trip. It was noted when anyone mentioned the subject of education to connect the information to others’ perspectives.

Artifacts

Spending several days exploring Singapore offered the unique opportunity to observe the dense and bustling landscape. School buildings and education centered billboards assisted in the understanding of education attitudes throughout the country.

Literature Review

A literature review was conducted to obtain data through the collection of documents and the evaluation of previous research. This method assisted in verifying observations and supporting conclusions.

Limitations

There are several limitations of this study, and future considerations would improve the quality of the study and strengthen the conclusions. First, a small number of students were sampled within the same university and the same major. In the future, the study would include students from different universities across Singapore with a variety of technical and non-technical majors. In addition, no students from the United States were sampled for interviews, and their inclusion would help strengthen connections between the educational culture of both studies.

Family Life and Culture

In Singapore, parents are highly involved in their children’s education both inside and outside the school. Outside of the classroom, 39 percent of Singaporean parents reported using a math tutor to help their children as compared to 16 percent in the United States (Australian Council of Learned Academics, pg. 5). They also focus heavily on extracurricular STEM activities; 26 percent of Singapore students reported participation in a math focused camp or extracurricular activity while only 11 percent of students in the U.S. participated (Australian Council of Learned Academics, pg. 6). Two out of the four ERAU Asia students surveyed in this study participated in a STEM related activity outside of school. Parents in Singapore are also involved directly with their children’s educations through Parent Support Groups (PSG), set up by each school with support from the Ministry of Education. The PSGs organize extra tutoring for students and orientation courses for parents as well as other activities (ACOLA, pg. 6). Compared to the United States, a study by the Department of Education found that only 19 percent of elementary (K-8) schools reported most or all parents typically attended science fairs or other academic demonstrations at the school (National Center for Education Statistics, 1998, pg. 14). Parental involvement in a student’s math and science education helps push the students to be more competent in those areas, and their exposure through STEM related activities and competitions fosters an interest in those

fields that can lead to them choosing that career in the future.

The large number of students graduating with STEM degrees in Singapore also means that many parents are employed in a STEM field. In interviews and surveys with students from the Embry-Riddle Asia campus in Singapore, students cited their parent's occupation in STEM as a factor that influenced their decision to pursue a STEM degree. One student responded, "My [mother] is an administrator while my dad is a technical engineer. Both of them influence me to do what I love ... They are very supportive of what I like and have always encouraged me endlessly to pursue my goals." The positive influence and pressure from a parent who is in a STEM field could account for the high number of students in Singapore that choose a STEM degree.

The education culture in Singapore focuses on improving the quality of life through learning and a person's chosen career. An ERAU Asia student surveyed wrote, "Education is very important to me. I believe with education it will help you go far, not only career-wise but also in life." Education is of high importance in Singapore, and students believe that their education will help them in all aspects of life. The quote follows, "Most importantly, with education, it will provide me with a better position and pay in a company." Three out of four students surveyed cited employment opportunity as an important factor in receiving an education, meaning they are not only concerned with their quality of life, but are looking to pursue an education that will lead them towards a high paying career and help them stand out from competitors. About 27 percent of Singapore students who finish high school attend a public university based on qualifications from their secondary school track (Gooch, 2012), so they strive to do well in school in order to achieve the highest level of education and the highest quality of life. At a Taoist temple in Singapore, there is a well where people can throw in a coin and ring different bells that will bring them anything from fertility to prosperity (Figure 1). The guide noted that the bell that brought people good luck in their schoolwork was the most worn. This implies that education is valued by the people of Singapore over many other factors in their lives. A billboard for a secondary school read "Adding Value to Your Life," which shows that a good education is linked to the idea of a good quality of life (Figure 2).



Figure 1: Visitors ring bells at a Singapore temple to bring fortune upon themselves.



Figure 2: Photograph of a billboard for a Singapore secondary school

Government Policy

STEM education and employment is vital to a country's economic growth and infrastructure. The Singapore government has built an education system focused on creating quality labor, rather than low cost labor, so

businesses would want to locate in Singapore (CIEB, 2012). In a country of just over 5.5 million people, ensuring its place in the global market is essential to its survival. In 1968, the government formed the Ministry of Science and Technology to enhance secondary and tertiary education in order to develop the country (ACOLA, pg.8). According to a report by the Australian Council of Learned Academics,

“Employers are willing to invest and open the companies [in Singapore] because they know that the country has sufficient human capital in the field ... With the setting up of numerous multinational companies in the STEM related fields, Singapore has been able to provide sufficient jobs in the field.”(pg. 11)

Singapore has become an invaluable location for the STEM market because of the quality and talent of its residents. In 2012, 20.6 percent of the total government spending in Singapore was on education as compared to 13 percent in the United States (UNESCO). This means that the government of Singapore has a higher emphasis on education than the United States. By placing this emphasis, citizens are more aware of the importance of STEM education and may be more likely to pursue it.

In addition to a greater percentage of federal funding, schools are receiving money from their students. Unlike the United States, where public education through high school is compulsory and free to students, every level of education in Singapore has a monthly tuition. This cost, in Singapore dollars, ranges from S\$246 for primary education to S\$772 for junior college education (Cost of Living in Singapore). By paying for education separately, families see education as an investment rather than just a required activity. Parents would encourage their children to succeed in order to get the most for their children and the most out of their investment.

Spending more money on education also means students are better prepared for their studies and more capable of handling the challenging material of STEM. The U.S. is performing well below Singapore and much of the globe in science and math, and this is partly due to the lack of education funding. Without the proper funds, schools have a harder time affording the best teachers and materials to help students excel in these subjects. Another major way the government affects education is by setting up the structure of education. The effects of this are explored in the following section.

Education System

Singapore's education system has gone through distinct phases of focus. The first two were literacy and quality of labor. This required creating an education system that brought students up to the global standards. The third and current phase supports the creativity and innovation of Singapore students and focuses on the understanding of material rather than memorization (CIEB, 2012). The system also separates students into different secondary schools according to their education goals and their score on the Primary School Leaving Exam (PSLE) at the end of Primary 6 (Singapore Ministry of Education, 2015, pg. 9). This is much different than in the United States, where a majority of students follow the same academic path during their 12 years of grade school. In some cases, students can start determining their own academics in high school, where they prepare for their career by choosing from various levels of classes such as Advanced Placement and International Baccalaureate, or by attending a vocational school. By separating students into aptitude groups early, they can receive an education that caters better to their interests and ability levels. Also, students can be taught at different levels depending on their path, rather than teaching at one level to a group of students with varying aptitudes; some are receiving information at too high a level for their understanding, and others don't find the material challenging enough. The National Math and Science Initiative states that only 44 percent and 36 percent of 2013 U.S. high school graduates were prepared for college level math and science, respectively (pg. 2). The students who struggle with math and science classes in the United States could lose interest in those subjects or feel they are not good enough, which causes them not to choose a STEM career. Similarly, students who find the material too easy may not be prepared for the level of courses they take in college, causing them to switch their interest from a STEM career, as 38 percent of students who start in a STEM degree do not graduate with one (NMS, pg. 2). However, in Singapore, the separation of students helps them to be prepared for precisely the level of education needed for their chosen career path, meaning that they can have a higher retention rate and therefore graduation rate.

This pattern of selection is also seen at the university level. In the United States, any student can apply to a university, and 66.2 percent of high school students enroll in college the fall after graduating high school

(NCES, 2014). By comparison, students in Singapore must pass tests in order to apply to a university, and in 2012 only 27 percent attended after secondary school (Davie, 2012). The philosophy of open enrollment in the U.S. means more students can enroll at varying levels of aptitude compared to a Singapore university. With only a 29.4 percent acceptance rate in 2013, Singapore Universities take students in a much smaller range of aptitudes. By being more selective in which students can go to a university, students who reach that level are more prepared and capable of overcoming the challenges of a STEM major. Students may also be more driven to STEM majors because many offer high salaries and a better quality of life. U.S. university students, having not experienced the same selective process in lower schooling, may be more inclined to choose majors that match their interest and ability levels. With over half of U.S. students enrolling in college after high school compared to less than a third of Singapore students, it cannot be expected that they are all of the same aptitude or of the aptitude to complete a STEM major. U.S. students also do not face the same societal and family pressure as their counterparts in Singapore, as mentioned previously, and therefore choose their major and their career more freely.

Students in Singapore also receive a better math and science foundation throughout their primary school than U.S. students, which could contribute to their readiness and interest in pursuing STEM degrees. In the 2012 Program for International Student Assessment (PISA), students in Singapore scored a mean of 573 in mathematics and 551 in science, as compared to U.S. scores of 481 and 497, respectively (Weisenthal, 2013). When asked about how lower schooling prepared students for a university education, one Singapore student responded, "I would say that my secondary school made me realize that I liked science and math a lot. From there, I decided to pick up engineering..." Another student noted that math and science were "heavily concentrated" subjects in primary, secondary and polytechnic school. By better preparing students in STEM subjects, students are likely to choose a STEM career because they feel confident in the subjects.

Conclusion

Students in Singapore graduate with STEM degrees at a higher rate than U.S. students because they are encouraged by their family, culture, and government policy and are better prepared for the degrees by the education system. In the family, parents are much more involved

in their children's education, and education is seen as a way to improve one's quality of life. Government policy encourages students to enter STEM fields through the creation of the Ministry of Science and Technology and a high percentage of government spending on education. The education system also fosters interest in STEM and helps prepare students in the subjects at the level of their capability. All these factors contribute to the higher graduation rate of STEM students. These conclusions were verified through data collection methods of interviews with students in Singapore, artifacts and observations from a personal visit to the country, and a literature review.

Although not all these factors could be introduced into the United States to raise the percentage of graduates with STEM majors, perhaps the most straightforward approach would be to better prepare students in these subjects. As shown through the research, one of the biggest reasons students are studying STEM degrees in Singapore is that they are better exposed to the subjects in lower schooling and better prepared for the challenges. Some of these programs are already in place, including extracurricular programs such as FIRST robotics programs, Science Olympiad, and President Obama's "Educate to Innovate" campaign. Giving students in the United States a better STEM foundation in lower schooling may ignite their interests and confidence to pursue them in higher education. In return, the country will see greater economic growth, especially as the world becomes more technologically advanced.

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Appendix A: Singapore Student Questionnaire

Please answer the questions below with as much detail as you are willing to provide. The information collected will be used to support a research study about education in Singapore, and may be referenced or quoted in the research paper. You don't have to answer every question, but the more detail you give, the more thorough my research will be. Thank you for your participation!

Please provide your name, age and gender.

What is your major at Embry-Riddle?

Who or what influenced you to choose your major? Please be specific.

What do you want to do in your career?

What are the occupations of your parents? How influential was your family in choosing your major?

When were you first exposed to STEM subjects (Science, Technology, Engineering and Math) at school?

How much emphasis was put on STEM subjects in school compared to other subjects?

How involved were you in STEM related projects and activities outside of school? What activities?

How did your lower schooling prepare you for your University education? How influential was it in choosing your major?

Is education important to you? Please explain.

Please provide any other details or comments about your education, major, career plans, family or anything else.