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The Value in Pursuing and Publishing Highschool Research, Especially in a Time of COVID

Editorial

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Now that many elite colleges and universities have recently been waiving or ignoring the need for ACT or SAT scores, ways to distinguish yourself from all the other highschool students has become more essential if you are going to be accepted to an elite post-secondary school. The COVID pandemic has exacerbated the problem as access to NYS Regents, AP, SAT II, and other exams become more difficult to find, and virtual classes often give only P/F grades, more students tend to look more alike on paper in their college applications. COVID has also caused most highschool athletics competitions and many other activities to be cancelled or curtailed significantly. Thus, your résumé may look very thin and ordinary when you apply to "college".

Yet many highschool students fail to understand just how important that CV have science research experience backed up with published research papers and conference abstracts to carry them along their planned career path faster and to propel them higher. In the last 25 odd years, I have helped $\approx$ 1200 science research students to build their professional curriculum vitae, aka their CV, and to help them generally to apply for "college", medical school, graduate school, dental school, not to mention to find jobs.

A Tertiary Education in a "Good" School

In an average year in the US, somewhere near 0.9-1.1 million highschool graduates will plan to start a university (aka "college" in US parlance) or a tertiary education. In the US, approximately 4360 tertiary (post-secondary or post-highschool) colleges and universities accept students as undergraduates, but about 40% only offer 2-year associate degrees. Despite a large number of college closures in the last five years, about 2500 tertiary

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schools still grant 4-year degrees. With so many tertiary schools, not all are created equal: A huge difference exists in terms of

(a) the quality of education that they offer

(b) the cost you must pay to attend

(c) the likelihood they will accept you, or worse, to give you financial aid

(d) the likelihood that attending this school will allow you to fulfill your dreams

Many small tertiary schools are not nationally accredited. In other words, the national accrediting organizations feel that the educations that they offer are very poor to abysmally bad. Some totally unaccredited colleges will steal your money without giving you any recognized degree at all. Obama's administration closed some such institutions, but several reopened after Trump took office.

Of those 2500 tertiary schools in the US, *US News and Reports* ranks 1921 schools in total, but only about 1000 are nationally accredited post-secondary schools. Universities (i.e., Princeton University) offer a wide range of programs, both at the undergraduate (i.e., B.A., B.Sc., B.Eng., etc.) and post-graduate (i.e., M.A., M.Sc., M.B.A., M.Eng., Ph.D., etc.) levels, as well as often offering professional (i.e., medical, dental, pharmacy, law, etc.) degrees. Meanwhile, the nationally accredited colleges which concentrate on liberal arts programs (i.e., Williams College, Amherst College, etc.), engineering and science programs (i.e., MIT, Cooper Union, Rensselaer Polytechnic Institute, etc.), and business courses (i.e., Baruch College, University of Pennsylvania). Unless you really do want to attend a small, expensive, but low quality college, in Nowheresville, you likely will list some nationally accredited institutions on your preferred "Want to Attend" list.

Most highschool students have heard of Harvard, Stanford, Yale, University of Chicago, Princeton, Columbia, NYU, University of Michigan, University of Pennsylvania, and Cornell, among others. These top-25 elite schools, many of which are also very pricey to attend, are also very hard in which to win a place for yourself. In order to get into any of the elite schools, you need to be interesting and, if not unique, at least not like the run-of-the-mill A student.

Thus, for example, if you have competed in the Olympics or the NBA picked you as a highschool student and you have a good GPA, you will likely get into Harvard or some other Ivy school, but just competing on your highschool's NYC varsity team will not likely be enough. If you have written an opera, a symphony, a play that has produced on Broadway, an important book about chess, or the latest hot novel, you can likely get into at least one elite school rated in the top 20 tertiary schools, but just penning a few poems or articles for your highschool's newspaper will likely not get you into Columbia. If you have acted in a major movie or TV series, or in a Broadway production, you also have a good chance at an elite school, but not if you just starred in your highschool play, opera, concert, or band think again. If you have played Carnegie Hall or with Wynton Marsalis' Jazz Band, or you were named to the NYS highschool symphony orchestra, you have a good chance to win a spot

in Princeton, but just playing in your highschool band, orchestra, or jazz ensemble will not likely get you into the University of Michigan. I know highschool students who have done one or two of these amazing feats, and yes, an Ivy League or "baby" Ivy League school accepted them, but all of them also had several other skills in their quiver.

If you have not been well endowed with outstanding athletic or artistic abilities, like most highschool students, you had better have something else special on your résumé about which to boast. Unfortunately, the number of slots in most elite tertiary schools is very small. For example, Harvard accepts about 1000 undergraduates annually, of which about 35% are reserved for the legacy students, those students who parents or grandparents attended Harvard. Nonetheless, Harvard will receive > 30,000 - 40,000 applications annually for its 650 "open" applications. This breakdown seems pretty typical for most Ivy, baby Ivy, and the other top 50 nationally ranked tertiary schools.

If your uncle George resided at 1600 Pennsylvania Ave, you can get into Yale. If your father is a king, you can go where you want for college. If your dad or granddad endowed a new building or a library to Harvard, you can get in as a legacy student. The same is likely true if your mom or grandmother graduated from Cornell or Stanford. As for the rest of the million-odd students applying to college in any year, you must be exceptional in at least one area to be worthy of notice from the elite schools. Watch *Admission* (2013, Paul Weitz director) to get an idea of how elite colleges select students.

Making Yourself Stand Out

If you want to stand out among those many hundreds of thousands of applications, make sure that you have had STEM research experience. If you add all the highschool students in a given national-wide graduating class, those students who have had some experience in science, math, engineering, or technological (STEM) research during their highschool years number between 3000 and 8000 people most years. Some 2000 - 3000 will apply to Regeneron, and another 1000 - 5000 will have had submitted their project, either individually or on a team, at a local, regional, national, or international science fair (Society for Science and the Public, pers. comm., 2019). Thus, by being a STEM researcher, you are now sit among an elite 0.3 - 0.8% of all the students applying to tertiary schools. By that one activity, therefore, you have risen far above the average highschool student.

If, by chance, you happen to win the Regeneron Science Talent Search or the International Science and Engineering Fair, you will likely be accepted to an elite tertiary school, but getting there is still hard. Watch *Whiz Kids* (2009, Tom Sheppard director) to see just how hard it is to win the Intel Science Talent Search (now called Regeneron). To get to compete at ISEF, you usually must first win a local science fair and a regional fair. For example, 1200 - 1800 students submit projects to the NYC Science and Engineering Fair, from which 15 - 20 students will progress onto ISEF after two tough rounds at NYCSEF. This should not to discourage you from trying competing in highschool science fairs or contests, but be realistic about your chances.

Nonetheless, every year, one large public NYC highschool (but not a magnet school) reports that ***all*** their

300-odd highschool researchers will receive a partial or full scholarship when they apply to become undergraduates, and > 90% will attend schools that rank in the top 100 nationally ranked tertiary schools. What is their secret? These students do basic good, but innovative science research, some of it done inhouse in their own school labs, and about 25 - 35% at their mentors' professional labs. The point here is that so many universities value science research that it gets you much farther for your effort than most other extracurricular or curricular activities. For example, one large Ivy university allows applicants who have science research in their background to pick if they will continue to do research as an undergrad. If you select that box, your application along with a few hundred other highschool STEM researchers, now to be reviewed only by STEM professors to see if they want any of those students to work in their labs. If you do not or cannot select that option, you will be reviewed among the other 25,000 - 30,000 regular applicants. This university will accept most, if not all, of those STEM researchers, but < 5% of the regular applicants from the large non-researcher pool.

Among those 3000 - 8000 people who have done STEM research, only a few will actually publish their research. If you really want to excite the people who are selecting applicants for the top-rated tertiary schools, publish your research. Publishing can occur by having one of the research team present the data at a conference, either as a poster or in an oral talk, or by publishing your data in a journal presentation. Even if you are the tenth author on an abstract at a professional STEM conference, you will stand out.

While the actual numbers of highschool student who have published either a conference abstract or a research paper before graduating highschool are hard to lock down, it is rare, probably < 100 students in most years. Thus, now you sit about 1/10,000, or in the top $\sim$ 0.01%. Thus, when those acceptance officers see your publication list, they will really pay attention to the rest of your application.

If you have made a poster presentation yourself at a professional conference, it makes a better impression still. Presenting an oral talk yourself at such a conference gets you more kudos, as does being a first author. If you have given a couple of your presentations yourself or your name appears on a journal paper or two, you are now among maybe 5 - 10 other highschool researchers out of that million other highschool students. For example, I personally know 10 women who were accepted to MIT. Each was a coauthor on at least one journal paper and had 2 - 4 conference presentations. I know six students who attended Harvard for their undergrad educations, each with a similar pedigree. In each case, they had presented their research themselves at one or more major national or international conferences.

So How Do You Publish?

Nonetheless, in convincing your research mentor to publish your work, you might face several challenges. Remember that if you work(ed) in a professional lab, namely any lab at any university, college, government, or research institute, or any company or not-for-profit organization that offered you an internship to produce your data, you must get their agreement to present the data at a conference or to publish it in a scientific journal. When you start to work in any professional lab, be sure that you understand who will own any data that you produce. If you try to do publish those data or present it in a professional conference without your mentor's

agreement, you might be committing a Class D felony, and the professional lab can prosecute you or take you to civil court. Assuming that you have your organization's agreement to publish or present the data, you still must realize that you are not likely to be the first author, even if you were to write the abstract or paper, design the poster or slides, give the presentation, and deal with the journal submission process: The head of the lab, your mentor, or your immediate supervisor is more likely to be the first author. The most important thing here is not whether you are listed as the first, second, or tenth author, but the fact that your data appears in a professional conference or is published in a reputable scientific journal, with *your name* on it!

Where you publish will depend on who is the first author. Usually, your mentor or the lab's chief scientist will like make that decision. Do keep in mind that the *Journal of Dawning Research* does publish highschool research exclusively. Regardless where you publish, be sure to add it to your CV. A good CV will list everything that you have done in your academic career up to now. It differs from a résumé in that it emphasizes your publications, education, and other academic pursuits, rather than your work history. In your CV, do not bury your publications on page 23: Put it up on page 1 right after your educational details, well before the volunteering and your jobs with clubs or tutoring. If you want help on how to build a CV, please consult https://flhsscience.website.com/research/pro_tips.

As you progress through your academic career, continue to do research. After highschool, it does not matter whether you do STEM research or not, but get more experience in the field in which you plan to pursue in your next academic stage. Moreover, remember to keep your CV up to date with these new research experiences. When it comes to applying for graduate school, medical school, dental school, or other professional schools, ensure that your CV is complete and current. If you are applying to a Ph.D. or M.D./Ph.D. program, the number of your publications will weigh heavily in the decision to accept you, especially if your CV can show continued research for more than 3 - 4 years. If you started research as a highschool student, you could have 6 - 8 years of research experience, whereas the average graduate student or applicant for a professional school may have only 0 - 2 years of research experience. Such long research histories indicate that you will bring a better understanding about how to do research and will need less hand-holding in whatever you do down the road.