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University Students Pursing STEM Degrees at Liberal Arts Institutions

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As students continue to pursue a higher form of education upon graduating high school, there seems to be an endless amount of items factoring into the decision of choosing a university. How a student decides upon an institution could be dependent on a variety of geographical, financial, and academic factors. Many of the questions associated with choosing a university revolve around whether the student will commute from their parents' house or live far enough away to stay in a residence hall, if the student has high enough grades to be admitted to the university, if the prospective student will be awarded scholarships and grants, if other payment options are available, what to study, etc. Considering these factors, as well as hundreds of others, leads a student to choosing their place of study.

One item that many students may not ultimately consider is what *kind* of academic experience that they want to be involved in; however, how does one evaluate what an academic experience really looks like? The foundation of what students learn comes from the classroom, thus an educational experience really does revolve around that environment. When choosing a university, prospective students should really consider the way the classrooms run at their future alma mater.

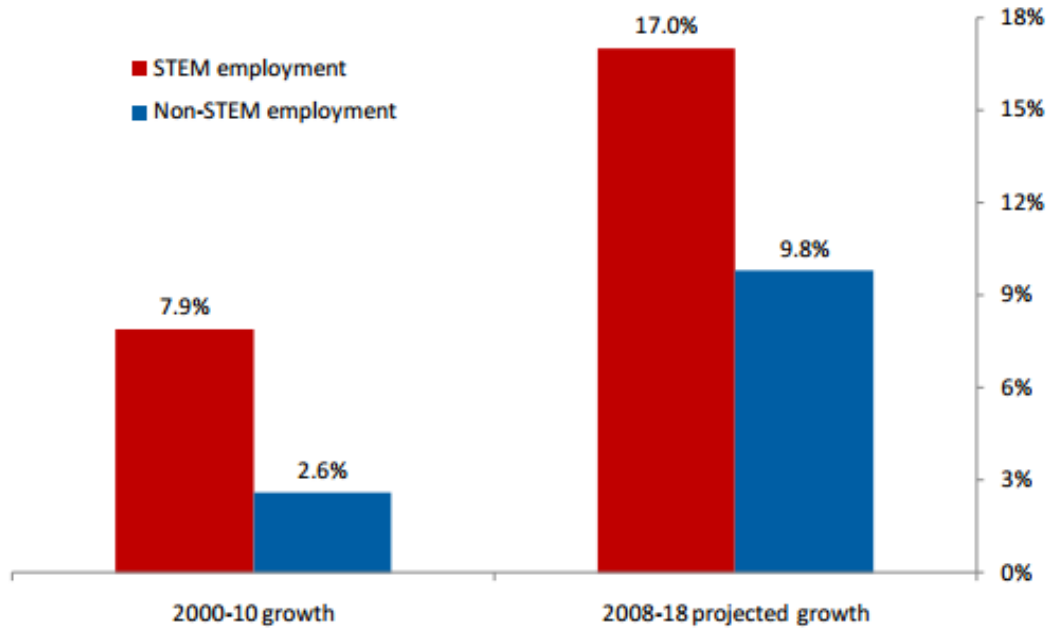
How could a student possibly know what kind of experience they will receive just by researching institutions at a glance? Knowing how one's experience at a particular university will be only seems possible by attending the school, so it is rather hard to tell what their classroom experience will be like throughout their academic journey just by applying to schools. However, there may be a way to better understand what one's academic experience will look like once they begin. The way that one learns throughout their journey of higher education can

easily be determined by the type of institution the students chooses to attend. There are differences between public and private institutions; where a public institution is government funded as opposed to private colleges, which are involved with no government entity, smaller schools and larger schools, religiously affiliated institutions, and other factors across the board.

Another factor of choosing a place of higher education could be whether the school focuses on the liberal arts or research. Research institutions focus on the major subject of the student's interest (typically the student's major) and usually has some type of research involved in the curriculum for a degree from the school. Liberal arts colleges focus more on the humanities, and embrace the concept of a liberal education. This liberal education style approaches learning in a very unique way: it embraces the collaboration, diversity, and individual-thinking of each student in order to help those students to think critically about issues in their field as opposed to only learning about the field. For example, if a student were to study chemistry at a liberal arts college, they may have to take a course in philosophy.

With technology and other products advancing so rapidly, it seems completely obvious that fields related to the advancement of products are incredibly important to life in the present day. As stated by Modis, jobs in the technical field are expected to rise 18% by 2022, making this a hot field to go into ("Tech Jobs on the Rise", *Modis*). It seems completely apparent that there is a major push for students to choose a career that falls underneath the realm of Science-Technology-Engineering and Mathematics, in short, these programs are called STEM programs. Why are these fields so important to study? Do they really pay-off during life-after-diploma? According to the United State Department of Commerce, students who

specialize in STEM fields are more likely to be in demand as these are growing fields, as opposed to those with non-STEM degrees, as shown in the figure below (Langdon).



Source: ESA calculations using Current Population Survey public-use microdata and estimates from the Employment Projections Program of the Bureau of Labor Statistics.

The current need in the workplace is for individuals to be technically-advanced in order to better serve the rapidly growing field of technology, hence students who graduate with degrees in STEM are incredibly marketable after graduation. With students enrolling in classes of computer information systems, mathematics, engineering, etc., it seems like these students are a crucial investment to companies. It does appear that these students have a lot to offer to the advancement of a company; however, these students also appear to be built almost machine-like in their field. These students are prepared to work hard in their field with their up-to-date knowledge of the latest programs and trends in different fields of science; but are they

really trained for the work force? How can they learn to work collaboratively with a team if the student has only worked on their schoolwork on their own?

This is where the concept of a liberal education becomes crucial, but we must first understand what an educational experience at a research institution looks like. At a research institution, students are placed in classes of top professors who are researchers in the field in which they are lecturing. So a student at one of these institutions may be delighted by the fact that their professor is a top academic in their chosen STEM field, however their lecture may be filled with 400 other individuals. Professors in these areas also seem to spend little to no time regarding the course outside of the lecture because they are too busy with their research that does not involve the course. For a three credit hour course, there are approximately 3 hours worth of lecture per week. If students are exposed to their professor for only this amount of time, how can they be expected to learn much from them without much personal interaction?

Typically, these students are left to learn the material either from their Teacher's Assistant (usually referred to as a TA) or to educate themselves via the incredibly expensive textbook assigned to the course. It is hard to determine if having an award-winning professor is even worth it when the student receives almost no contact time with them, yet they are paying top dollar to take the course. According to College Data, the average price of an in-state public institution is averaged at $23,410 for the 2014-2015 academic year, as private colleges average about $46,272 (What's the Price Tag for a College Education?). Does that ever seem like an awful lot of money just for one to sit-in on a massive lecture and essentially teach themselves. After this giant chunk of change is contributed to the funding of the student's shiny new

research degree, they are off to the working world. The student has no problem landing a job considering they have a STEM degree from a praised university, yet what skills do they really contribute?

Of course, this student can easily crank out a line of code (or do another similarly impressive trick) considering that is what they spent their undergraduate career doing – but what about the rest of this student's new team that he works on? Throughout his education, the student worked mostly alone, discouraged from working with others on assignments in order to remain ethical in his or her work, and turn in his assignments in a very orderly fashion. Turning in papers and assignments in this way may contribute to the student's overall knowledge of their area of study, but how does this prepare the student for the work face and tasks that they will encounter there?

Really, students at research colleges are not being trained to be a contributing and creative employee, but are trained to be able to understand the subject matter in which they are studying. Yes, this does go a long way, but being able to work on a team is arguably the most important factor of working for a company. If one has the knowledge to help a team tackle obstacles and knows much about the process of their system of interest, yet does not know how to work on that team, that employee might as well not have the proper skill set at all. If an employee cannot communicate their ideas or compromise their ideas in a concise and creative manner, then the employee is considered for of a detriment than an asset. This leaves learners with the question of: is it possible to obtain a STEM degree while also learning how to prepare for the work force? The answer: of course.

If we were to take studying a STEM field from a different approach, we may understand what it truly means to contribute to the work force. Now that we have examined what it looks like to study Science-Technology-Engineering-Mathematics fields at research institutions, what about liberal arts colleges? At a glance, it may seem pretty much out-of-the-question to study a research-based field (like sciences and mathematics) at a school that is not research-based; however, a liberal arts college may not be totally out of the question. Is there any chance that a school founded upon the principals of a liberal education might actually be preferred?

Most of the time, many students wouldn't even consider pursuing a STEM field at a liberal arts college. Why should they want to? The faculty at their research institution would be a contributor to new discoveries in their area, research in their subject would be active at their current institution with a possibility of being able to participate, and many greats have studied at their school-of-choice. Doesn't it seem that despite the big lecture halls and little interaction with faculty that all of this would be worth it? Maybe it is for the right-minded individual, but what about those who want to create an educational experience that will prepare them for the working world?

This is where a liberal arts college fits in. It may be a misconception that it is impossible to gain a firm understanding of one's STEM field through a liberal education, but there are many things that this type of educational experience offers that a research institution does not. For one, liberal arts colleges, on average, have much smaller class sizes than a research institution. Many liberal arts colleges have classes as small as about 15 students. With these small courses, which generally decrease in size as students begin taking higher-level courses

later in their degree program, students have access to a fundamental feature of the classroom: their professor. Smaller classes make contacting, interacting with, and asking questions to the professor much easier. In a class of about 20 people, asking questions throughout the lecture is much more welcoming than taking a question from a pool of hundreds of students, thus leading to better comprehension of the material being presented to the students.

How might having the ability to ask questions in a small-group setting as opposed to in a lecture hall benefit the student? If questions even were welcome in a lecture hall of hundreds of people, most would be ignored, due to an influx of questions and too little time. In a small classroom, which is likely to be more of a standard scenario at a liberal arts college, students are in a small group setting where, throughout the semester, it is easy to get to know others in one's class and to be able to ask questions to the professor. This asking of questions leads to discussions in the classroom that help with the comprehension of the material to the group as a whole. Since the liberal arts are so focused on open discussion and questioning of a subject, it really allows students to critically think as well as bounce ideas off of their classmates and professors.

With smaller class sizes, students are also encouraged to pursue areas of study of their own and present them to the class. For example, in a class where there are approximately 20 students, it gives students a better chance to be able to present projects done in class to the class. If a class were to have hundreds of students, it would essentially be impossible to have each student present his or her findings throughout their project. With a smaller class, it makes it much easier to accommodate every students' work and allow them to spread their

knowledge amongst their fellow classmates. This opportunity really sets students up for what their work-life will eventually be, presenting ideas to bosses and fellow workers that will better their workplace. With this experience under their belt as an undergraduate student, these STEM students at liberal arts colleges are set up to excel in their life after graduation.

Pualo Friere introduces the topic of a banking concept of education versus a problem-posing concept. The banking style of education refers to the student as a filing cabinet and the teacher is simply a narrator. Essentially, what is happening at a research-based college is that students are taking lectures courses that deal only with this banking concept of education. Here, the professor speaks about their knowledge on a specific topic and the students try to retain as much as they can, since, obviously, the professor is the all-knowing resource in the room. This banking-style of learning serves as a one way streak of knowledge, a stream from the professor to the student. The professor contributes essentially all of the information that is presented in the classroom (Whipps).

On the other hand, a problem-posing learning environment encourages all to contribute to the process of learning and to ask knowledgeable questions and contribute introspections. This usually stems from a professor beginning a topic of discussion and teaching about important ideas within the area. From here, many students are encouraged to ask questions and provide examples of what they might deem a contributable piece to the discussion.

It seems obvious, when learning about the humanities, ethics, philosophy, or other subjects of this sort, it seems that it is extremely logical to that the learning approach of problem-posing. It is easy to start a discussion about what Plato actually meant when he said a

specific quote, or about why it is important to remain ethical even when being caught is not a factor. When we look at our STEM fields, the discoveries within these fields are typically concrete things: such as in biology we know that all things are made up of cells, and in physics we know that gravity will pull objects down. Why would we teach these STEM subjects in a problem-posing way if they seem to be concrete ideas?

Problem-posing does not necessarily mean that the subject matter is open to being changed by the learner, but it does mean that learners (and the professor) learn through contributing ideas to the discussion. For example, if students in a mathematics classroom were to discuss the discovery of non-Euclidean Geometry, they might have a better idea of understanding the subject as a whole if they know the process of how it was discovered. The discovery was lead by the way that certain axioms and postulates failed to be true when dealing with geometry on a sphere or a hyperbolic plane. If students can see the way that their subject-area was created, then they may have a better grasp on how to go about proving well-known theorems and understanding processes. Take concepts within engineering as well. It appears obvious that when learning about how certain types of parts work, the best way to learn is through example. Somebody can only tell you how a gear will function for so long until you reach a level of understanding that will not grow until you experience these parts hands on. Thus, working with others with these parts could help with the learning process exponentially.

That is not to say that in a research-based institution there is not hands-on experience, because there is. Labs are built into courses so that a portion of the course is dedicated to the lecture while the other portion is dedicated to a lab. However, if these “lectures” were taught

in a problem-posing manner, then the extra discussion and hands-on time will lead to the student having a better understanding. The more exposure to these discussion-based situations, the better the student will be able to comprehend his or her learning tasks at hand.

Now, let's take a look at two curriculums of STEM programs: one from a liberal arts college and one from a research-based institution. For example, we will look at the curriculum of Grand Valley State University, a public liberal arts institution located around the Grand Rapids area of Michigan and Michigan State University of East Lansing, Michigan, which focuses more on a research-based curriculum. We will examine a similar programs from each school, both a Bachelor of Science in Mathematics.

Students studying for any Bachelor's degree at Grand Valley State University are subject to complete a series of general education requirements that are based upon the concepts of a liberal education. Students can choose specific classes they want to take that fall underneath the realm of the category of the requirement. Each student will have to take one course each that falls under the "Foundation" categories of Arts, Philosophy and Literature, Historical Perspectives, Social Sciences, Behavioral Sciences, and Writing; as well as two courses in the Natural Sciences, where one class falls under a physical science as the other is a life science. Only one of these science courses must contain a lab section. Additionally, students must fulfill two "Culture" requirements: one United States Diversity course and one World Perspectives course. Lastly, Grand Valley students are also subject to two courses from the "Issues" category, which is an upper-level course designed to integrate learning and co-curricular

experiences in order to build connections between old knowledge and new knowledge (General Education Requirements).

In order to complete a Bachelor's degree at our research-based institution of choice, Michigan State University, students are also subject to a much less intensive general education program than that of Grand Valley State University's. Spartan students must complete two English/Writing courses, one four-credit course in Mathematics, two Social, Behavioral, and Economic Sciences, two Arts and Humanities, and a course in the biological sciences and ones in the physical sciences, with at least two-credits of lab attached (General Education Requirements, Michigan State University).

As a part of their general education requirement, it seems that Michigan State University is lacking a major component of something similar to what Grand Valley has, an "Issues" course. This Issues course at Grand Valley, as stated before, offers a unique educational experience to students, as it is a small that that integrates people of different degrees. The aim of this course is to be able to merge old knowledge with new knowledge, and to collaborate with classmates of different major and perspectives. Think about it: imagine if an engineering student and a philosophy student were both taking a class in the Liberal Studies department for one of their Issues requirements. In this class, students are encouraged to find new ways to be creative. By working with other upper-level students of different degrees, each student may have a different idea of what it means to be creative. The engineering student may view it as being innovative with products, where as the philosopher might view it as having a unique view on a worldly issue.

As part of the major requirements for a Bachelor's degree in Mathematics, both schools require the foundational mathematics courses, such as Linear Algebra multiple semesters of Calculus. However, Michigan State requires students to take a class in both Chemistry and Physics whereas Grand Valley offers more of a variety of requirements, where students can fulfill their conjugate course with their choosing of Genetics, Physics, History of Science, Strategic Games (within Economics) or others. This allows students to make their educational experience their own. Grand Valley's emphasis on liberal education allows many students obtaining STEM degrees to be able to pick and choose what kind of degree experience they would prefer. So while one mathematics major at Grand Valley may be taking a course on the History of Science and learning about the history of astronomy, the other could be learning about the evolution of human genealogy in a genetics course, yet these students would still obtain the same degree at the end of their undergraduate career.

The "Issues" course at Grand Valley State University really embraces the idea of a liberal education. With a liberal education, students are encouraged to focus on diversity, complexity, and change. This upper-level course helps students come together to really feel how different them and their fellow students are, even though they attend the same schools. Not only are they encouraged to understand the difference between everyone's chosen degrees, but they are also encouraged to get a better perspective on how different each other are as individuals, even if they do have the same degree path. The way a student interprets a reading or discussion might be different than the way the professor or other students are interpreting the same material. A liberal education encourages the idea that all of these possibly wild interpretations are considered, and that there is importance to everyone's perspective.

As said before, this embracing of different opinions is what sets students of a liberal arts degree up for their future careers and life-long aspirations. It is one idea to be able to have a perspective and opinion about a particular subject matter, but it's an entirely different concept to be able to be empathetic about other's opinions as well. Is it even possible for a workplace to peacefully and happily function without the presence of listening and compromise? These are very crucial skills for corporations, since deals require a bit of negotiation. Having the ability to think creatively and diversely about these transactions could make a complicated deal a little bit easier to work with.

Studying a STEM field is crucial for job security after graduation; however, how one chooses to study their STEM program, as stated before, can be decided by the type of university the student goes to. It almost seems too obvious that a research-based institution and liberal arts college both offer the same amount of classes in regards to mathematics, but a liberal arts college offers these programs in a less-than-traditional lecture hall structure. This traditional structure could be classified as the banking concept, as mentioned earlier, and can easily be found in the major lecture halls of a research-based institution. However, at a liberal arts college, communication is accepted and encouraged. This problem-posing method of learning prepares students for the workforce and for critical thinking situations during the rest of their time as a student, and for problem-solving skills that they will encounter throughout the rest of their life.

By examining what a liberal education is and how the small classes of a liberal arts college help STEM students succeed throughout life, it is apparent that a liberal arts college is a

great buy for college despite preconceived notions that liberally focused institutions cannot deliver like a research-based university can. Of course, the decision to choose what type of university to go to for a STEM degree is completely up to the student; however, maybe writing off liberal arts colleges entirely is not the first move to make. Students all learn best in different ways, so maybe some students will get more out of a research-based institution. A liberal education does help a student learn to discuss matters, rather than memorize them. Overall, liberal arts colleges could potentially be the best buy for a STEM degree as opposed to their competitor of research institutions.

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