

Shaping the Undergraduate Mind through Research

Ms. Brianna Lawton, Morgan State University

Brianna Lawton is a senior civil engineering major at Morgan State University who is not only an avid undergraduate researcher but has had various internships, one being with HDR Inc. while also serving her community on and off campus. She now sits as the President of Morgan's chapter of Chi Epsilon, the notable civil engineering honor society, while also mentoring young middle and high school students under the VEX Robotics program. After graduation, Brianna plans to continue her academic studies in transportation engineering to earn a Master's and eventually a Ph.D. She stated that conducting undergraduate research has opened her eyes to so many possibilities of what she could do with her future.

Dr. Oludare Adegbola Owolabi, Morgan State University

Dr. Oludare Owolabi, a professional engineer in Maryland, joined the Morgan State University faculty in 2010. He is the assistant director of the Center for Advanced Transportation and Infrastructure Engineering Research (CATIER) at Morgan State University and the director of the Civil Engineering Undergraduate Laboratory. He has over eighteen years of experience in practicing, teaching and research in civil engineering. His academic background and professional skills allows him to teach a range of courses across three different departments in the school of engineering. This is a rare and uncommon achievement. Within his short time at Morgan, he has made contributions in teaching both undergraduate and graduate courses. He has been uniquely credited for his inspirational mentoring activities and educating underrepresented minority students. Through his teaching and mentoring at Morgan State University he plays a critical role in educating the next generation of underrepresented minority students, especially African-American civil engineering students. He is also considered to be a paradigm of a modern engineer. He combines practical experience with advanced numerical analysis tools and knowledge of material constitutive relations. This is essential to address the challenges of advanced geotechnical and transportation research and development. He is an expert in advanced modeling and computational mechanics. His major areas of research interest centers on pavement engineering, sustainable infrastructure development, soil mechanics, physical and numerical modeling of soil structures, computational geo-mechanics, constitutive modeling, pavement design, characterization and prediction of behavior of pavement materials, linear and non-linear finite element applications in geotechnical engineering, geo-structural systems analysis, structural mechanics, sustainable infrastructure development, and material model development. He had been actively involved in planning, designing, supervising, and constructing many civil engineering projects, such as roads, storm drain systems, a \$70 million water supply scheme which is comprised of treatment works, hydraulic mains, access roads, and auxiliary civil works. He had developed and optimized many highway design schemes and models. For example, his portfolio includes a cost-effective pavement design procedure based on a mechanistic approach, in contrast to popular empirical procedures. In addition, he had been equally engaged in the study of capacity loss and maintenance implications of local and state roads (a World Bank-sponsored project). He was the project manager of the design team that carried out numerical analyses to assess the impact of the new shaft and tunnel stub construction on existing London Underground Limited (LUL) structures as per the proposed alternative 3 design of the Green park Station Step access (SFA) Project in U. K. He was also the project manager of Category III design check for the Tottenham Court Road Tunnel Underground Station upgrade Project in UK.

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This paper describes the benefits and development of how undergraduate research propels undergraduate students and prepares them for the future in their respective field of study. The opportunity to conduct undergraduate research develops students' technical writing skills, builds understanding of industry terminology and technology as well as efficiency of operating experimentation apparatuses. The paper further elaborates on the importance of incorporating undergraduate research into the curriculum as this will prepare students to be socially, critically, and professionally adequate as they confidently enter the engineering work force and/or pursue higher education. Undergraduate research not only adds a wealth of knowledge to the individual, but teaches patience, ethics, and discipline when applying processes and procedures and designing standards that must be upheld because of the responsibility as professionals to protect the well-being of human life. The above have been substantiated in the paper by the first author through her undergraduate research experience in geotechnical engineering. Lastly, incorporating undergraduate research into the curriculum will expand students' network of professionals, consequently facilitating the connection of the classroom studies with the industry. This displays them with a broad prospective of topics, challenges, and innovative research that they can relate to and work to resolve.

I. Introduction

Research is defined as: 1. a careful or diligent search; 2. investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws; 3. the collecting of information about a particular subject.¹ Research has been known as a term connected to academia on the graduate level in pursuit of attaining post bachelor degrees which consequently individuals gain a wealth of knowledge while hopefully improving their field of study.

Undergraduate research has been studied for over the past few decades by many of educators because of their acknowledgements of the drive it gives undergraduate students to pursue a graduate degree and/or a career in science, technology, engineering, and math (STEM).²

Key research-based organizations like the National Science Foundation invested in initiating a pilot program in 1987 known today as the Research Experiences for Undergraduates (REU)

program, which was designed to attract talented students into research careers in science and engineering (S&E).⁴

Other national organizations also realized the importance of undergraduate research early on.

The Council on Undergraduate Research (CUR), founded in 1978, is a national organization of individual and institutional members representing over 900 colleges and universities. The organization defines undergraduate research as “an inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline.”³

From the myriad of supporting members represented amongst the 900 plus colleges and universities, the notable Massachusetts Institute of Technology (MIT) developed the first institution-wide undergraduate research program at a major research university.⁴

With that being said, this model has spread throughout various colleges and universities across the country.

The following sections of this paper describes the different skills an undergraduate student can develop after participating in undergraduate research and how these skills can advance them in the future.

II. Technical Writing

At the beginning of the first author’s undergraduate experience, it is safe to say that she had little to no technical writing experience. Her first encounter with technical writing was prompted in her chemistry, physics, and biology labs where she followed the outlines given.

As she matriculated through her undergraduate career in civil engineering, depth was added to her lab reports where she was able to include the answers to questions such as: Why does this occur? How do we prevent it? When should other variables be considered? Where can we apply this in industry? She was able to apply these concepts specifically in her geotechnical soil mechanics course and her graduate level pavement design course.

Consequently, through practice, research, and mentorship she has developed and improved to reach the ability to where she is today –constructing abstracts and papers pertaining to her research. This did not all come overnight but adjusted and continues to be refined.

The “gift of gab” as they say is one thing but as a student being able to assemble what she has learned formally on paper and produce substantial data that experts in the field can understand is different.

Technical writing is a type of writing where the author is writing about a particular subject that requires direction, instruction, or explanation. This style of writing has a very different purpose and different characteristics than other writing styles such as creative writing, academic writing or business writing.⁵

Technical writing gives understanding, explanation, and/or instruction concerning a particular subject.

Regardless of the type of document which is written, technical writing requires the writer to know their audience, write in a clear, non-personal style and complete extensive research on the topic. By including these properties, the writer can create a clear understanding and explanation for the reader.⁵

By knowing the intended audience of the paper the author determines the lingo used within the paper which depends on whether or not specific details are explained or spelled out for the readers.

Next, the style of the paper should be impersonal –third person as learned in English class. The first author had to realize that just because she conducted the experiment and solved for the solutions or collected the data solely makes her the messenger. Her personal experiences when the research was being conducted do not need to be documented –just the mere facts and data.

Another property to keep in mind is collecting sources. Being able to validate your results and ideas, and cross-check your information with what experts have said and/or are saying in the topic of study.

Being skilled in technical writing not only gives you a way to communicate your results to your fellow peers and experts in the field of study but to those outside as well. The art of mastering good technical writing skills aids in academia for grant writing funding proposal packages and in industry for project bidding proposal packages, therefore the training must start now in undergraduate research.

III. Industry Terminology and Technology

Industry terminology and technology refers to the terms, lingo, and acronyms that are used to describe software, standard procedures, and experimental apparatuses/machines that are exchanged in conversations amongst experts in both academia and industry within the field of study.

One important aspect of research is the necessity to read and study multitudes of papers and articles published by various noted authors that focus on the topic of study.

The first author used to look up the answer to a question that she had and the first link she read used it as fact. Even if the source was correct, she had to learn that cross-checking and reading multiple sources builds a stronger case that will support and prove your study valid or could deflate the topic of research.

This past summer was the first author's first time stepping into a research lab and being a part of a team. The first day the second author gave her the manual to one of the testing machines in the lab and told her to read the whole thing so she knew the overall idea of the machine: how it works, what is it used for, what information does it output, what type of constraints and/or variables are considered, calibrating the machine if it was not already, etc.

This shows as an example that a student must learn the vocabulary before moving forward. This focuses on the sense of having the right tools in your toolbox in order to fix a problem. This then will assist the student in forming a way to approach that or any problem.

After that summer research experience and the first author's continuation as a research assistant under the second author, she has learned a plethora of words and their meanings and/or uses within the field. Words that she has accumulated over this time frame like AASHTO, TMP, permeability, in-situ soil, CAD, BIM, Static Triaxial, UC, UU, percent finer, sieve, MDD, empirical formulas, moisture content, liquid limit, resilient modulus, CBR, ADT, AADT, Microstation, etc. (See Figure 1 below) Knowing these terminologies and being familiar with the different technology has given her the upper hand at communicating with professionals in the field (civil engineering) and understanding them as well. This has proven itself true at conferences, interviews, and the classroom setting.



Figure 1: Transportation and Geotechnical Guidebooks for Standard Designs

IV. Curriculum Incorporation

The importance of incorporating undergraduate research into the curriculum as this will prepare students to be socially, critically, and professionally adequate as they confidently enter the engineering work force and/or pursue higher education.

Integrating undergraduate research into the undergraduate curriculum should not be thought about but acted upon. It has proven to be beneficial in several living examples including the first author.

Many colleges and universities have added some type of cooperative learning program to their degree programs which prepare students for life after the classroom, which gives them the opportunity to create that bridge between industry and undergraduate studies.

Therefore, the same case can be made for connecting undergraduate students and research.

The *CUR Quarterly* included a study by Angela Wilson from the University of Missouri – Columbia, called *Using the National Survey of Student Engagement to Measure Undergraduate Research Participation* which focused on the confusion of the NSSE questions framed around asking students whether or not they conducted undergraduate research at their respective college or university. ⁶ If colleges and universities incorporated undergraduate research into the curriculum of each respective department at their schools, then students would not have an issue being confused about knowing if they participated in research –clearing up the blur about what is defined as research.

Building the 360 Student: Socially, Critically, and Professionally

Undergraduate research not only enhances students’ hard skills but soft skills as well.

Knowing the facts and information in your head is totally different when having to communicate those results to a group of professionals or your peers –it takes practice.

Being able to connect with people on a social level, while conducting oneself in a professional manner and thinking critically is an art that can be mastered.

At the start of the first author’s undergraduate career, she was shy with a small voice never seeking attention. After being a part of teams due to her engineering labs and later joining the research team that she is a member of today, has changed her into a complete different person. She hated public speaking but after a summer long of weekly presentations paired with requirements to dress “like for an interview” every week from my advisers –she was quickly groomed. Even her speech and diction improved. Not only did her outer appearance upgrade, but her responses to questions posed and her ability to critically analyze what was being asked helped her answer accurately because of the depth of the subject she was studying.

This 360 transformation is not left to utilize in academia at conferences, but also in the working world. If asked to present a project at work on behalf of the team or make a pitch to your boss about an idea for the office these skills will come in hand.

Producing well-rounded students who excel in both hard and soft skills will only be an advantage and set them up for future opportunities as they advance in their careers as professionals.

V. Building Character through Patience, Ethics, and Discipline

Undergraduate research not only adds a wealth of knowledge to the individual, but teaches patience, ethics, and discipline when applying processes and procedures and designing standards that must be upheld because of the responsibility as professionals to protect the well-being of human life. With this being said, conducting research and being a researcher is not usually (if at all) a fast process therefore out of that patience and discipline are birthed. The first author realized this very quickly when learning about the Static Triaxial Testing Machine. The process of testing the in-situ soil for permeability which included several stages of consolidation and draining took the entire summer to run. She learned that being a researcher takes diligence and

ethics too. Being conscientious and abiding by a moral code when it comes down to collecting data and keeping in mind whom, what, or how your results impact others. Students would gain these valuable traits during research that are key when handling designs or sensitive information on a more massive scale that can easily impact the lives of so many people's lives.

VI. Conclusion

With the support of the above information stated in this paper, research at the undergraduate level is a major key to shaping the undergraduate student's mind. The experience of conducting research not only gives the student a sense of pride and self-confidence but molds them into a well-versed diverse professional as they enter into society.

Incorporating undergraduate research into the curriculum will expand students' network of professionals, consequently facilitating the connection of the classroom studies with the industry. This displays them with a broad prospective of topics, challenges, and innovative research that they can relate to and work to resolve.

When the first author began as an undergraduate research assistant to the second author, she was introduced to different notable people (Figure 2) in her field of study both nationally and internationally who were excited to talk with her about what research she was doing. She also found it easier to make real-world connections between what she learned in class, in the lab, and on her internships.



Figure 2: Morgan State University Undergraduate Students and Faculty with Professor Ye from Nanjing University in China

As stated at the beginning, research is the diligent search, investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws, and the collecting of information about a particular subject.¹

When students learn how to be a thorough researcher and exhaust all resources, consider all options, incorporate all indicators and how they are impacted, then that is what opens the door to attack a broader range of topics or challenges that need to be handled. If students are given the toolbox during their undergraduate education and fill it with the tools they learn each year, then this breeds an environment for innovative research.

There have been discrepancies about what undergraduate research is. Some individuals doubting

the idea that 18 to 22 year olds cannot work on anything serious or innovative –people underestimating the undergraduate student’s academic ability. This must come to a screeching halt because there are many of students who are prepared and ready to rise to the challenge.

The first author has proven that she is willing to rise to the challenge after being exposed and given the opportunity to conduct undergraduate research. She was the only student whose paper got accepted to present at this year’s Engineering Sustainability conference in comparison to other students who were accepted for poster sessions. At this conference, she will give a presentation on the *Life Cycle Cost Analysis Framework for Evaluating Resilient Modulus Testing Strategies Used for Characterization and Design of Sustainable Roadway Infrastructure*. Her paper focuses on comparing the AASHTO T99 versus T180 compaction methods used to design pavement through a cost-benefit analysis procedure which takes into consideration the economic, environmental, and social impacts. The aim is to convince FHWA to adopt the AASHTO T180 procedure which yields a more sustainable pavement over the projected life span of the road. As part of preparation and to gain more knowledge of her research topic, the first author decided to take a graduate level course focusing on pavement design. In this course, she experienced first-hand the difference between the graduate versus undergraduate level learning and expectations. While in this class, she gained a wealth of information like various federal and state regulations to consider when designing, different traffic-monitoring technology, vehicle load limits and how they are enforced, subgrade analysis, stress distribution in pavement layers, pavement rehabilitation methods, how environmental changes can impact the roadway characteristics, and analyzing the economic effect of pavement projects using time value of money formulas.

These specific experiences and along with everything else stated above have been a direct consequence or an extension of the first author’s experience and inclusion of undergraduate research, which have shaped her into a well-rounded individual who plans to continue her studies in academia to earn a graduate degree and eventually work to achieve her goal of owning her own business.

VII. Acknowledgments

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