

The value and importance of conducting forensic science research with undergraduate students

Forensic Science in Academia

In recent years, forensic science has been gaining interest among people all over the world; this can be linked to the CSI effect caused by the popularity of crime documentaries or crime shows such as CSI (1), and perhaps to a stronger sense of civic duty due to a “cultural awareness” of crime and justice (2). Historically, universities have been the environments that contribute to the involvement of societies; they do so by responding to and addressing social phenomena through research, education, and communication (3). Universities encourage debates, challenge ideas, foster diversity and inclusion, and work to offer a safe space to express oneself and grow as an individual and a citizen (4). The forensic sciences have been growing in academia as well; numerous undergraduate and graduate programs in various forensic sciences have been appearing all over the world, attracting scholars and producing research that has majorly affected the way that forensic investigations are conducted and the way that science is brought to a courtroom. As reported by the American Academy of Forensic Sciences, 78 schools offer a Bachelor’s degree in forensic science (68 in the US, 10 in other countries), while 46 schools offer a Master’s, 36 of which are in the United States (5). Federal funding in the field has also increased over the course of the years; in 2007, only 0.01% of the total funding for research and development went to forensic science related research (6). Since 2009, however, the National Institute of Justice (NIJ) has funded over 660 forensic science research and development projects, and in September 2023, NIJ announced \$16 million in new funding to support 33 forensic science research projects (7).

Conducting research with undergraduate students

When conducting academic research, graduate programs and graduate students are one of the most valuable resources to produce helpful data and prestigious publications, which are ultimately sought after by all academics (8). While the importance of graduate students cannot be praised enough, they are not the only resource that academia has to offer. Undergraduate students can be equally precious in conducting useful research, running a lab, and contributing meaningfully to the literature. It has also been shown that having students engage in undergraduate research experience is an effective way to increase interest and retention in STEM degrees and willingness to pursue a masters or Ph.D. (9, 10). For example, SRI International conducted a nationwide survey in 2003 and 2004 to evaluate undergraduate

research opportunities (UROs) and their impact. It was shown that out of the 3,400 undergraduate students that participated in research activities, 68% of them claimed that their interest increased at least somewhat as a result of their experience and that those who participated in UROs were twice as likely as those who did not to obtain a doctorate’s degree (9). In certain countries, undergraduate students must perform a research project, whether experimental or a literature review, and write a thesis in order to complete their degree (11). This results in the incorporation of professional training and a research-based knowledge in the program; the final thesis represents the connection between academic and professional knowledge (12), and it contributes to diversifying students graduating from the same program. In other countries, however, undergraduate students are not always required to complete research during their program. Often, they have the option to conduct a semester of independent research, such as Course-based Undergraduate Research Experiences (CUREs) (13). Even if in different forms, engaging in research offers undergraduate new perspectives on the scientific world. By becoming familiar with the practical challenges of experimental design, procuring the materials, and executing the research, these students now have a better sense of how science works and how much work and preparation is required before the project is even started (13). Most often, undergraduates do not truly know what research is or what it means to conduct a project; they possess a general idea from knowing the steps of the scientific method, but that does not necessarily mean that they fully grasp the entire process. A study conducted by Cartrette *et al* (14) aimed to explore what the conceptions of undergraduate students were on research and whether these changed over the course of their experience. The authors found that the most common pre-conceptions included research as being similar to laboratory courses, as a solitary activity, and a well-defined and well-planned process; however, as students participated in the 10-week research program, they discovered that their pre-conceptions were actually misconceptions. Other studies have shown that when students are introduced in their undergraduate studies to research-based courses, they gain problem solving, critical thinking, communication skills, and they improve their understanding of their field of study (15). Students who participate in research improve their technical skills, gain confidence, and become more aware of the advancements in their field. Moreover, they refine their scientific communication when they present their projects to the community within their institution or at conferences to peers and other scholars (9). When their research leads to publications, students also acquire knowledge of how the peer-review process works and make themselves more competitive for their next career steps (16). These are aspects of

paramount importance in all scientific fields. Forensic science is a cornucopia of applied scientific disciplines that requires hands-on experience, whether it is in the field or in the lab; thus, research presents a unique opportunity for students to gain those skills prior to working in the real world (17).

Challenges of conducting research with undergraduate students

When working with undergraduate students, there are certain limitations that one must keep in mind, which do not necessarily apply to graduate students; these limitations may sometimes become a challenge for the PI and for the project. Overall, the challenges that undergraduate research presents can be divided broadly into three categories: lack of knowledge and skills to participate in research; little faculty support, mentorship and funding, and structural/policy barriers (e.g., lack of time, strategies) (16). In some cases, undergraduates cannot be alone in the laboratory meaning that every time they are working, the PI, a lab manager, or a graduate student must be present as well; depending on the institute and the circumstance, this is not always logistically possible. Furthermore, providing students with an appropriate learning experience and providing them with knowledge and skills requires additional time that faculty may not have available (18). Undergraduate students may have limited time for research as well; they must focus on their classes, and some may even have to work in addition to that. Thus, many undergraduates may be available only for a limited period of time or during the summer, during which students often engage in internship opportunities (19). Many studies also report that lack of inadequate funding is one of the major challenges that undergraduate research faces (20, 21, 22). In the US, undergraduate research can be federally funded by government agencies; for example, there are Research Experiences for Undergraduates (REUs) which are funded by the National Science Foundation (NSF) each year (23). However, state, and federal resources can still be scarce and getting internal or external grants can be challenging at times (18).

The fact that, despite these limitations, undergraduate research is still conducted by many students and their mentors in a successful and effective way highlights even more the tenacity and value of undergraduate projects. These are not “just undergraduate projects”. These are research.

The value of undergraduate research

Being that forensic science academic programs are still quite “new”, it is common for forensic scientists to come from various academic programs that have allowed them to focus on the forensic applications of their field,

rather than strictly from a forensic science program. In 2014, according to the Bureau of Justice Statistics, about 14,000 full-time forensic personnel were employed in publicly funded crime labs (24); it was also estimated that between 2014 and 2024 there will be a 27% increase in open positions for forensic technicians (25). Academia should respond to this demand by improving forensic science education with experiences that better prepare those individuals that will fill those positions, and by sparking scientific curiosity, and encourage students to remain engaged and pursue further educational opportunities. It has been shown that being involved in research as an undergraduate can help increase the understanding of how to conduct a research project, increase the willingness to obtain a Ph.D., and an increase interest in a STEM career (9). Moreover, exposing undergraduates to research can help them refine their interests, comb through graduate programs, or enter the workforce more prepared and with a higher chance of success. As such, undergraduates should be exposed to research as early as possible in their academic career to allow them to identify, develop, and nurture their interests (16), but also increase their motivation to learn (26). Undergraduate students, based on their experience in research, can have a great impact in bringing benefits to other students, and can also have a great contribution in outreach activities and recruitment from high schools (19). In addition to the value research may have on the students themselves, this also benefits the institution and more directly the faculty collaborating with them, who are able to continue and expand their scholarship even when their department does not have a graduate program.

Undergraduate students’ perspectives on their research experience

Here we report some experiences from undergraduate students who engaged in research projects.

Testimony 1:

“Initially my undergraduate experience felt precarious. It was built on a shaky foundation of being one of the first women in my family to pursue a degree, combined with the isolating experience of being a first-generation immigrant mixed with tribulations of life. However, through the difficulties of my journey, the climax was held up by the opportunity to work along brilliant minds in forensic research. This fueled my scientifically charged curiosity towards my academics and potential career. My personal growth, in turn, flourished as well. Despite my doubts, with the encouragement from my mentors, I pursued research.

My mentors instilled confidence in me which allowed me to gain invaluable technical and practical lab skills. Working alongside other peers, I accumulated several experiences and one of my most treasured ones is the

value of mastering teamwork. I had the opportunity to collaborate with peers playing different roles across our projects. Through this, I became more responsible and more aware of how the actions of each member of the team contribute to the success of the research. This is essential, especially when the nature of forensic research involves coordinating with each other to collect data in time sensitive projects. Typically, as students we accept the nature of science and take it to be true as we do not necessarily consider the inner workings of how scientific knowledge is produced. Prior to my firsthand involvement in science, my viewpoints were strictly based on literature and academia, which lacked the dimension of physical involvement. I learned how experiments should be structured, where to find reliable reference literature, and how to conduct an experiment, especially if this involved live organisms. The variables of live specimens also involved troubleshooting through animal behavior. This also extended to human behavior - specifically human error. As students we are bound to make mistakes. Mistakes lead to improvement and building more educated competence.

Before my experience, I had never envisioned myself as a student capable of conducting research, even less a person capable of giving a talk during a national conference. My trajectory has been growing exponentially since my involvement and my academics have improved. I have developed a hoard of technical skills that will be useful in my future career. This experience has been transformative and significant in my personal development as well. Despite the occasional burst of imposter syndrome, doing research fertilized my confidence and pushed me to continue to immerse myself in scientific endeavors. As I continue to pursue my personal and professional goals, the skills, and experiences I acquired will continue to bear fruit and will guide me in my next steps for my career.”

Testimony 2:

“I started doing research during my sophomore year. When I first took a research class, I had no idea what research was; I did not know what it meant, the work behind it, and I did not know how to search the literature or cite papers. I have been involved in research for about two years and a half now, and I can say that the experiences I had improved my understanding and skills. I now know how to conduct an experiment, I know how to get the background information needed, and I know how to work in a team. I also gained various skills both in the field and in the lab, which are valuable for both academic and career paths. I have published articles, attended, and presented at various conferences, I supervised other students in the lab and helped them understand the principles of research and teamwork, and I also had opportunities to train law enforcement in forensic entomology. This is something I had never thought I

could do. Research has given me the opportunity to improve my communication and writing skills, it has given me the chance to know other people in the field and make connections, and it has given me the opportunity to explore other people’s work. I get excited about sharing my experience in research with other undergraduate students because I know that most of them do not know anything about it and they do not know the benefits they can get. It is a lot of work, and you really need to put a lot of effort and time into it while still attending classes and taking exams, but it is highly rewarding, and the pros overcome any “negative” side that can come with research. I always put emphasis on how research has helped me network with other people in my field and how conferences can greatly improve your resume and just give you a sense of how the science community is. My suggestion to all undergraduate students out there is to talk to your professors about your interest in research, explore how it works and what it can do for you; you will quickly understand what your interests are, and this will allow for an easy process if you decide to continue with your masters or Ph.D. degree. One of the first questions you will be asked by a professor when you show your interest in research is most likely “what do you like?” or “what are you interested in?”, so make sure to take some time to explore what research your institution can offer or what other studies have been conducted that may be of interest. Finally, my suggestion to all professors that conduct research is to take a few minutes in your classes to explain to your students what research is, the benefits, and give the opportunity for them to reach out to other students who had already hands-on experience in your lab. Peer feedback is always the best way to get involvement in the lab.”

Testimony 3:

“Research is formalized curiosity. It is poking and prying with a purpose.” In the 1942 autobiography *Dust Tracks on a Road*, American anthropologist Zora Neale Hurston once said this. Being someone deeply curious about the unseen, little has stopped me from exploring the world via my own poking and prodding. Answering questions tangibly and visualizing the results connects me to the obscure, subtle parts of daily life. Informally and formally, research has been a predominant part of me and, as a result, the majority of my undergraduate studies centralized it. I have been assisting in a forensic entomology research lab for the better part of a year now. During my time here, I have been lucky enough to work on three projects. In the first semester of my sophomore year, my team performed a morphological analysis of blow flies using a dichotomous key to understand which species are present in a specific area during a specific time of the year. However, I had never truly appreciated a fly – an insect many consider “insignificant” – until this experience. Their exoskeletons, eyes, and wings are

brimming with complexity. Every hair count when determining the species. This project revealed part of the microscopic world I had never noticed before. During the summer, I started as a lab assistant for the second project, the molecular identification of various organisms. While still in progress, this study drastically improved my efficiency using scientific equipment. Not only that, but this project allowed me to understand the complexity of getting material for a project and setting up lab activities to complete all the tasks. I also worked on an insect development project that consisted of several laboratory checks; this required all the members of the lab to coordinate and communicate, and to troubleshoot in case of issues. Recently, I also had the opportunity to present the result of our research to a national conference, which was an incredibly rewarding experience for me. What was exceptionally impactful was how I got to bear witness to a full life cycle – birth, death, and all the stages in between of the research process. Understanding and appreciating the workings of life is especially meaningful since forensic science is my career aspiration. Overall, research has been and will continue to be important to me. Not only will it help me reach my career goals, but it connects me to the world in ways I could have never imagined. The majority of life on Earth remains unseen – hidden in plain sight and so easily missed in our bustling societies. Research allows me to be intentional in how I examine the world and to see the “little things.” I am excited to see where the next few years of research take me!”

Conclusions

While there are challenges associated with undergraduate research in forensic science, there are plenty of advantages to it that can significantly impact the academic offer of an institution. Faculty and students can both enrich their experience by engaging in research while, at the same time, the practical forensic applications of science become more and more evident since the start of a student’s academic journey. With new minds bringing in new perspectives and voicing the new demands of the field, it is possible to build projects that may lead to producing results ultimately useful to law enforcement and forensic scientists. More resources should be dedicated, and more credit should be placed on undergraduate research in the forensic sciences; by increasing opportunities for students and faculty and by creating new dedicated spaces to present and publish such results, memorable academic experiences will be created, and valuable data will be produced for forensic applications.

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