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UNDERGRADUATE AND HIGH SCHOOL STUDENTS RESEARCH MENTORING

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Abstract:

Effective mentoring of undergraduates and high school students in the research laboratory is a significant challenge. This complex responsibility is rewarding for senior scientists, faculty members and community leaders, as well as many young students. Evidence is given that high school and undergraduate students are capable of conducting competitive research.

Introduction:

More than 50 years ago, research was restricted to senior level students and scientists who have at least a master degree or terminal degree. Very few people, including experts, could recognize that research can also be conducted with the help of young students in those days. In contrast, recently many senior scientists at various institutions, industries, and the government level have adopted high school students and undergraduates in their research laboratories as part of educational programs. This action and philosophy has become popular. However, success from this procedure is not described with convincing data. In this article, I describe my mentoring views with high school and college students and evidence of their successes in research.

Discussion:

Most of the high school students are not adults. Therefore, a permission note from the parents/guardians is required to include them as a research student. High school students are not required to conduct any type of research. In addition, it requires a significant ability to explain the research topic to the students. Many countries including the USA have initiated plans to educate high school and college students in research by changing the curriculum and arranging several training sessions to the high school teachers. It is true that some positive changes are observed by a few school districts in USA. To improve the educational quality, almost all major federal funding societies in the USA have initiated competitive research grant programs for the high school and college students. However, the majority of the high school districts and their students are not aware of these developments. Some of the school districts are interested, but their infrastructures are not adequate. A number of critical surveys are conducted to identify the standard of the high school students in science subjects.

Despite a number of problems encountered by many professionals, I have a different opinion regarding the ability of high school and college students' research at the laboratory. I would like to highlight the successes of my high school students and undergraduates' chemistry research.

Based upon my 28 years of experience as an educator in the USA, I believe students should be taught to understand the concepts of science subjects matter over memorization. Realizing the potential of young students, I started to recruit high school students and undergraduates when I obtained an independent research position in 1995. It is necessary to develop young skills, so that the high school and college students can think and work both alone and in groups with constant supervision. If they work with a teacher or more experienced scientist, it does not mean that they may not learn and conduct experiments of their own. The mentors have a lot of responsibility to educate the students in unknown matters. I follow numerous methods necessary to allow these young students to develop concepts via assignments, notes, discussions, and laboratory research. I identify topics that create huge interests among students. For example, my students were involved in various research projects in organic and medicinal chemistry. High school and college students worked in my laboratory in competitive research that is normally performed by graduate students.

A crucial part is to create a supportive environment and remain available to the students at the research laboratories. A mentor can easily understand whether a student needs help and attention. Like many successful professionals, I also strongly believe that teaching and research are parallel. My active research in numerous areas provides me with an outstanding opportunity to attract attention from diverse students. A successful mentor passes knowledge to students through appropriate examples by citing suitable references, explaining the subjects thoroughly, and describing the progress in that particular area. In many instances, mentoring can be correlated very well with the activities of our daily lives. Most of the students' attitudes are to learn new ways of conducting science. Some of them are aware that research exposure is very beneficial to them in their future career. It is the mentor who can activate students' academic qualities and shape their future by involving in research with them. It is obvious young students who have research experience are the front-runners in numerous competitions for future academic study and career. Undoubtedly, early college students and college students who are the co-authors of publications/presentation receive significant credit compared to those who do not have these achievements.

It is important that a mentor or an organization support the students academically and also financially. It is a very crucial task to develop facilities for the students in laboratory, so that they can participate in unknown work with the help of research mentors. The research mentors could be from the high school district, college itself, or someone from an external institution/organization. As a result of my mentoring, my high school and college students have become co-authors in more than 375 publications and presentations. They work on diverse research areas at my laboratory that include the followings: 1. Metal-and Metal Salts-Mediated Reactions; 2. Catalysis and Microwave-Induced Reactions; 3. Cancer and Medicinal Chemistry; 4. Beta-Lactams; and 5. Science Education (reference section). Most of my students are well-placed in reputable academic institutions, medical universities and pharmaceutical/drug companies. Many of my students have received university, state, national, and international Awards. The exceptional satisfaction of mentoring young minds in research laboratory has been rewarding.

Conclusion:

Overall, my research mentoring activity with high school and undergraduate students is fruitful. Research activities by these students have helped them significantly in their career development.

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Biography of Dr. Bimal Krishna Banik

Dr. Banik is the Vice President of Research and Education Development of Community Health Systems of South Texas. He was a Tenured Full Professor and the First President's Endowed Professor at the University of Texas-Pan American and an Assistant Professor of University of Texas M. D. Anderson Cancer Center for many years. He was awarded Bachelor of Science Honors Degree in Chemistry from Itachuna Bejoy Narayan College (Hooghly, India) and Master of Science Degree in Chemistry from Burdwan University (India). He obtained his Ph. D. degree based upon his thesis work performed at the Indian Association for the Cultivation of Science, Jadavpur, Calcutta. Dr. Banik was a Postdoctoral Fellow at Case Western Reserve University (Ohio) and Stevens Institute of Technology (New Jersey). He is a Fellow (FRSC) and Chartered Chemist (CChem) of the Royal Society of Chemistry.

The principal areas of Dr. Banik's research are divided among several disciplines: (a) chemical and biochemical investigations of new β -lactams as anticancer and antibacterial agents; (b) synthesis and studies of mechanism of action of novel polyaromatic compounds as anticancer agents; (c) catalysis with molecular iodine and bismuth salts; (d) microwave-induced and ultrasound-mediated reactions;

(e) green chemistry; (f) metal-mediated reactions; (g) natural and non-natural products including terpenoids, alkaloids, heterocycles, carbohydrates, hormones and steroids; and (h) chemoenzymatic reactions. Dr. Banik has demonstrated that some of the β -lactams and polyaromatic compounds possess selective antitumor activity *in vitro* against many cancer cell lines (ovary, colon, breast, blood, prostate, pancreas and skin) and in animal models. He has also identified new compounds with unique mechanisms of actions for preclinical testing and target identification against different types of cancers.

Dr. Banik, as Principal Investigator has been awarded \$7.25 million USD grants from National Institutes of Health, National Cancer Institute, Kleberg Foundation, University of Texas M. D. Anderson Cancer Center, UTPA and UTHSCSA. He has acted as the Program Director of numerous US Federal grants. Importantly, he has published approximately 285 papers, patents, reviews, perspectives, books, book chapters, and editorials along with approximately 450 presentation abstracts. The number of citations of his research papers is close to 5500. His research contribution has been published in major journals and books (ACS, Elsevier, Wiley, RSC, Springer, Springer Nature, Bentham, Taylor & Francis, CRC, Raman, MDPI, International Innovation and Thieme).

Dr. Banik has been involved in teaching chemistry courses to undergraduates and graduate students for many years. He has mentored 20 postdoctoral fellows, 7 Ph. D. Research Scientists Associates and more than 450 students in research laboratories. Most of his students are well-placed in all over the world. In addition to teaching students, Dr. Banik has acted as the advisor of two major scientific societies that have 1400 diverse students belong to Arts, Science, Engineering, Business, Pharmacy, Clinical Science and Education.

Dr. Banik has served as the Principal Investigator of a collaborative green chemistry symposium between USA and India. He presided 20 research sessions at the American Chemical Society National Meetings, over two dozens of conferences at the State and International level including one at the Nobel Prize celebration in Germany. He is a reviewer of 93, editorial board member of 28, editor-in-chief of 8 and guest editor of 10 journals. He is an examiner of NSF, NCI, ACS and International grant applications; reviewer of promotion & tenure of faculty members of national and international universities; examiner of 24 doctoral theses; and panel member and reviewer of NSF and NCI grant study sections.

Dr. Banik is chosen as one of the “Eminent Alumni” of Burdwan University in 2016 and selected as “One of the Most Influential People on Earth in 2016 out of 500 Most Influential Living Human” by USA News Corporation. Dr. Banik has received many awards and recognitions for his diverse contributions. Some of these include Mahatma Gandhi Pravasi Samman gold medal, Indian Chemical Society’s Professor P. K. Bose endowment medal, Dr. M. N. Ghosh gold medal, University of Texas Board of Regents’ Outstanding Teaching award, 5 top-cited papers awards by Elsevier Journal, Indian Association of the Rio Grande Valley’s Community Service award, Best advisor award in USA by the National Society of Collegiate Scholars (Inspire-Integrity award), American Chemical Society Member Service award, National Cancer Institute webpage recognition, Best research & creativity award by the UTPA, and highly prestigious First President’s Endowed Professor position by the UTPA.