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Interpretation of educating virtue ethics of scientists

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Abstract

This article presents a comprehensive discussion on the critical role of scientists who are also educators in modern society, detailing their responsibilities in nurturing, supporting, and fostering talent in the field of science and technology. The article draws upon both foreign scholarship and practical observations, elucidating specific criteria for scientist-educators. The focus of the discussion includes both formal and informal education, emphasizing the need for balance between transmitting solid factual knowledge, encouraging constructive criticism, and maintaining an effective interplay between personal research and teaching. The article affirms that regardless of geographic location or specific educational approach, the principal ideal of fostering talent remains a consistent goal for scientist-educators.

Keywords: Scientist-Educators; Science and Technology; Talent Nurturing; Formal Education; Informal Education; Foreign Scholarship; Constructive Criticism; Educational Approach

1. Introduction

The great majority of modern scientists are also teachers and educators, and some are even considered educationists. They should embrace the spirit of serving as a ladder for others, displaying enthusiasm, proficiency, and courage in discovering, nurturing, and fostering talent for scientific endeavors. They should not only teach and lead by example but also offer support and guidance to their students, willingly serving as steppingstones, erecting "ladders to the clouds," and acting as guiding oxen for young talent. They should passionately care for, guide, and instruct young talents in science and technology, consciously undertaking the historical task of fostering young talents and paving the way for exceptional innovative individuals to stand out.[1] Foreign scholars have provided specific criteria for scientists who are also educators: they should demonstrate excellence in teaching at all levels, treat students as equals in the process of information transmission, maintain student interest and engagement in teaching, interact informally with students, maintain a relaxed and friendly attitude when discussing with others, emphasize concepts but also stress solid factual foundation, encourage constructive criticism, and strive to maintain an effective balance between education and personal research.[2] Regardless of their geographic location, scientist educators shoulder the significant responsibility of nurturing talents.

Scientists' educational efforts involve both formal and informal education. Research training represents an informal form of education where students acquire various skills and a practical understanding of scientific practice through imitation, internship, or apprenticeship. Well-trained scientists possess tacit knowledge of their discipline, which far surpasses what can be learned from textbooks or in the classroom. During the formal education process, some scientists may focus on postgraduate education, while others may concentrate on undergraduate education. Some scientists may guide many students, while others may not.[3] Regardless of the approach, the ideal of fostering talents among scientists remains consistent.

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2. Talent Discovery

While it is commendable for a scientist to achieve significant scientific accomplishments, it is even more important for the sustained development of a country's scientific research to establish good traditions and discover outstanding young talents. "There are talents, but without an eye for recognizing talents, talents are hard to come by," Talent discovery is a prerequisite for nurturing and cultivating talents. Chandrasekhara Venkata Raman, an Indian physicist and Nobel laureate in 1930, believed that one of the duties of an old scientist was to discover talent and genius among the younger generation. However, recognizing and discovering talent is not easy. Academician Wu Wenjun pointed out that to judge whether a researcher who has not yet made high-level work has development potential and can achieve something, one must understand and inspect talents from multiple perspectives, and examine whether their thinking is active, and whether they have innovative abilities to discover and propose new questions. Brian P. Coppola from the University of Michigan, from the perspective of contemporary education, pointed out that talent recognition is about creating opportunities for others to grow and show their abilities, which is a balance between nature and nurture. China needs a "Bole plan," the main contents of which include: stopping testing and ranking, giving students time to think, increasing the number and diversity of activities compatible with the course, and adopting a "transformative teaching" model.[4] There is a considerable room for reform in China's education in talent selection and recognition.

Deng Xiaoping said in his speech at the opening ceremony of the National Science Conference in 1978: "Some scientists in the world regard the discovery and cultivation of new talents as the greatest achievement in their lifelong scientific work. This is quite reasonable. Some of our country's outstanding mathematicians were also discovered and helped by the older generation of mathematicians when they were young. Although some newcomers have surpassed their teachers in scientific achievements, the contributions of their teachers are still indelible."[5] Michael Faraday, a bookbinder in a printing factory, studied hard, was very knowledgeable, and was obsessed with scientific experiments. In 1812, after listening to the academic lecture of the renowned scientist Humphry Davy, Faraday wrote a letter expressing his dream of becoming a scientist and attached his well-organized notes. Professor Davy saw Faraday's intelligence, perseverance, and sincerity from the notes and quickly recommended him to work and study at the Royal Society. When asked about his greatest achievement in life, he said it was discovering Faraday. Charles Robert Darwin, who had a wide range of interests in his youth, was not interested in medicine when he studied medicine at the University of Edinburgh. After transferring to Cambridge University to study theology, the results were still not good. However, Professor Henslow, a naturalist at Cambridge University, discovered that Darwin had a strong observation ability for animals and plants. He recommended him to participate in the investigation voyage of the Beagle, starting his journey to discover the theory of evolution.

The tale of mathematician and educator Xiong Qinglai, breaking the conventions to nurture talents such as Hua Luogeng, Yan Jici, Wu Han, and Qian Lingxi, has always been praised in the educational community. In his opening speech at the first semester of Yunnan University, he declared: "The brilliant young scholars in Yunnan and neighboring provinces should strive to gather for teaching and research, serving on one hand and studying on the other, in order to become well-educated individuals, the pillars of academia in the future." When mentioning Xiong Qinglai, Mr. Fei Xiaotong said: "I deeply miss the passionate Mr. Xiong Qinglai. As early as the 1930s, he had broken the obsolete practice of imperial examinations and promotion by seniority, introducing a promising high school teacher to the highest academic institution at that time... A talent scout merely selects good horses from the herd, while Mr. Xiong nurtured talents with spring breeze and rain, truly a worthy gardener of human cultivation. Looking around at recent times, how many could there be?" Yet, Xiong Qinglai always modestly stated: "I consider it my fortune to gather with the talents of the time, which greatly inspired my teaching work."[6] Xiong Qinglai was both an exceptional talent and a talent scout. His discerning eye set a standard for Chinese scientists. Academician Wu Jieping started his teaching career in 1946 and developed a unique dialectic concept of talent identification and cultivation, closely integrating "knowledge-practice-thinking". In 1987, Beijing Medical University awarded him the first "Talent Scout Award". He said, "I have received various awards in my life, but I value the 'Talent Scout Award' from Beijing Medical University the most because it involves the issue of nurturing the next generation."[7] There are many examples among Chinese scientists similar to Ye Qisun identifying talent Li Zhengdao, Hua Luogeng identifying talent Chen Jingrun, and Wang Zhenyi identifying talent Chen Zhu, which are worth pondering and drawing lessons from for contemporary scientists.

3. Fostering and Cultivating Future Scholars

The French mathematician Gaspard Monge (1746-1818) was an extraordinary educator. Among the institutions he co-founded, namely the École Normale Supérieure and École Polytechnique in Paris, he engaged many truly learned elites as teachers. By replacing the privilege system with an examination system and substituting face-to-face instruction with classroom teaching, teachers became public servants of the state. Almost all textbooks were innovated, with an

emphasis on practical skills and hands-on abilities. Consequently, École Polytechnique quickly became one of the most advanced schools in France at the time. Furthermore, Monge was a remarkable, ingenious teacher who established the Descriptive Geometry school. Under his guidance and influence, a large number of accomplished geometers were trained, at least 12 of whom became the most renowned figures in the mathematics field in the early 19th century. This includes Nicolas Léonard Sadi Carnot (1796-1832), Jean-Victor Poncelet (1788-1867), Dupin (1784-1873), Charles-Julien Brianchon (1783-1864), and Jules Henri Poincaré (1854-1912).

The American experimental physicist Robert Andrews Millikan (1868-1953), winner of the 1923 Nobel Prize in Physics, embarked on a comprehensive reform of the lagging physics education in the United States during his teaching tenure at the University of Chicago's Physics Department. He organised the compilation of textbooks such as *College General Physics Laboratory Course*, *Mechanics, Molecular Physics and Thermodynamics Course*, and *Electricity, Acoustics, and Optics*. He also compiled high school physics textbooks, which were bestsellers for 40 years and inspired millions of students' interest in physics. Adhering to the textbook approach, he strongly advocated for the integration of classroom teaching and experimental teaching. The University of Chicago's Physics Department gained a reputation for its high-level teaching and cultivated a large number of physics talents.[8] Millikan played a key role in transforming the California Institute of Technology from weakness to strength, promoting institutional reform, integrating research with teaching, expanding cooperative research, advancing forward-looking disciplinary construction, and strengthening basic science education and humanities education.

Professor Ye Qisun, a physicist and educator, and a distinguished organiser and leader in China's physics community, started to establish the Physics Department and the College of Science at Tsinghua University in 1925. He hired first-class scholars to teach, insisting on the importance of theory and experimentation, quality over quantity, and the balance of teaching and research. He founded the "Science Report" magazine and established the Physics Research Institute, the Intentional Point Research Institute, the Metal Research Institute, the Aeronautics Research Institute, and other "special research institutes", transforming Tsinghua University's Physics Department into one of the country's academic centres at the time. He persisted in teaching on the frontline, offering courses such as General Physics, Modern Physics, and Electromagnetism. Among his students were the earliest two Chinese-American members of the US National Academy of Sciences and the US National Academy of Engineering, Lin Jiaqiao and Dai Zhengtong. Furthermore, seven of his students at Tsinghua University, including Wang Ganchang, Zhao Jiuzhang, Peng Huanwu, Qian Sanqiang, Wang Daheng, Chen Fangyun, and Qian Xuesen, were among the 23 scientists awarded the "Two Bombs, One Satellite Merit Medal" by the Central Military Commission in 1999. Other notable students of Ye Qisun include scholars in magnetism Shi Ruwei, earthquake expert Li Shanbang, and many more.

The University of Science and Technology of China (USTC) is a university abundant with scientists. One of its founders, Qian Xuesen, valued talent cultivation from the inception of the university. He emphasized the combination of theory and engineering, science and technology, and the reinforcement of foundational knowledge and interdisciplinary knowledge. Renowned scientists such as Yan Jici, Wu Wenjun, Qian Linzhao, Yin Gui, Lin Tongji, and Guo Yonghuai were organised to teach, and Qian himself taught courses such as "Introduction to Interstellar Travel" and personally guided students in the production of small rockets. Under his leadership, the Department of Modern Mechanics at USTC, which admitted students from 1958 to 1965 before the Cultural Revolution, produced seven academicians and nine generals out of a thousand students. The first 200 graduates produced three academicians, leading to the phrases "one academician out of a hundred people" and "one general out of a thousand people". Even when seriously ill, Qian was still concerned about talent cultivation and proposed combining science and art, logical thinking, visual thinking, innovative thinking, human-machine combination, emotional intelligence, and rational intelligence.

During his tenure at Xiamen University, the physical chemist and academician Lu Jiaxi single-handedly taught six courses including material structure, quantum chemistry, thermodynamics, statistical thermodynamics, crystallography, and modern crystallography. He also organized tutoring sessions and practical exercises. His lectures were characterized by clarity of thought and an ability to simplify complex concepts, earning the admiration of both students and fellow teachers. He often stated: "If a teacher is unable to cultivate students who surpass him, that teacher has not fulfilled his responsibility."[9] Among his students from Xiamen University, Zhejiang University, Fuzhou University, and the Fujian branch of the Chinese Academy of Sciences, there were several academicians, a former president of Xiamen University Tian Zhaowu, a former director of the Fujian Institute of Material Structure Liang Jingkui, an academician of the Third World Academy of Sciences Chen Chuangtian, an expert in structural chemistry and quantum chemistry and a member of the Chinese Academy of Sciences Zhang Qianer, an expert in structural chemistry and a former president of Fuzhou University Huang Jinling, and many professors and researchers. His contributions to chemical education profoundly influenced a whole generation.

Qian Weichang, one of the founders of mechanics in China and an academician, established the first mechanics research laboratory in China and participated in the creation of the first mechanics specialty in Chinese universities. He offered courses such as elasticity mechanics, plasticity mechanics, and applied mathematics to students at Tsinghua University and other universities, cultivating a large number of outstanding workers in mechanics for China's machinery industry, aerospace, and ordnance industry. During his 27 years as president of Shanghai University of Technology and Shanghai University from 1984 to 2010, he proposed the "four walls demolition" theory aimed at eliminating the barriers between universities and society, departments and specialties, education and research, and teaching and learning. He advocated for interdisciplinary integration, unity of science and engineering, combination of liberal arts and sciences, and implemented a credit system, elective system, and three-term system reform, which significantly influenced the educational reform of China's universities. Ning Jinsheng, a geodetic surveying expert and academician, found during his tenure as president of Wuhan University of Surveying and Mapping that although the university's surveying and mapping specialty was ranked first in the country, 70%-80% of the new students admitted each year did not list it as their first choice, and 20%-30% of students strongly requested to change their majors. Against this backdrop, as early as 1996, Academician Ning proposed the idea of "academicians teaching a foundational course to undergraduate freshmen," and officially started this in 1997, forming a teaching team for the surveying and mapping engineering specialty led by Ning Jinsheng, Li Deren, Chen Junyong, and other famous professors like Liu Jingnan, Zhang Zuxun, Gong Jianya, Tao Benzao, Zhang Zhenglu, He Zongyi, and Zhao Jianhu. Over the past 20 years, the team led by Academician Ning has continually adjusted the curriculum, updated textbooks, and developed massive open online courses (MOOCs). This course is hailed by students as the "most luxurious foundational course,"[10] truly embodying the educational concept of "foundation-centered."

4. Nurturing the Growth of the Young Generation

The Danish astronomer, Tycho Brahe (1546-1601), after seeing the "Mysterium Cosmographicum" gifted by Johannes Kepler (1571-1630), recognized Kepler's talents in mathematics and astronomy, and invited him to join in his astronomical studies. Their collaboration in 1600 marked the combination of astronomical observational experience and mathematical theory. Despite their brief collaboration, before Brahe's death in 1601, he designated Kepler as the inheritor of his scientific legacy, leaving his over 20 years of observational material to Kepler. Kepler's historic breakthroughs in the study of planetary motion were closely tied to Brahe's contributions. After being admitted to Trinity College, Cambridge, Isaac Newton was quickly recognized by Professor Isaac Barrow (1630-1677). Barrow's "differential triangle" had a significant impact on Newton. In 1669, after Newton obtained his master's degree, Barrow voluntarily vacated his professorship to pave the way for Newton to excel, which has since been hailed as an exemplary tale in the history of science.

The inventor of the telephone and scientist, Alexander Graham Bell (1847-1922), possessed extraordinary talents. It has been said that if he had chosen to research crystals and biochemistry after graduation, he could have won multiple Nobel Prizes. However, he did not choose this path. Instead, he posed many pioneering topics to his students, guiding a large number of students and peers to the summit of science. Many of his students won Nobel Prizes, a phenomenon that psychologists refer to as the "Bell Effect" or "Human Ladder Effect." This demonstrates that for a team to thrive, it needs a leader like Bell who prioritizes talent cultivation. The renowned Cavendish Laboratory at the University of Cambridge not only produced significant scientific achievements but also made immortal contributions to the cultivation of scientific talent, generating 29 Nobel laureates from 1904 to 1989, accounting for one-third of the total number of laureates from Cambridge. Ernest Rutherford (1st Baron Rutherford of Nelson, 1871-1937), the fourth director of the laboratory, was particularly remarkable. As an outstanding scientist and the pioneer of nuclear physics, he excelled at creating conditions and opportunities for the success and development of talent. He understood the strengths and weaknesses of each student and assistant, never declaring anyone incapable. Even ordinary researchers could become first-class scientists after studying with him for two or three years.[11] Among his assistants and students, 12 won the Nobel Prize. Niels Henrik David Bohr (1885-1962), the laureate of the 1922 Nobel Prize in Physics, referred to him as "my second father".

Academician Su Buqing, a mathematician, advocated the philosophy of "Strict teachers produce outstanding students, and outstanding students become famous teachers," and "In talent cultivation, each generation should surpass the previous one". He believed that "blue comes from the indigo plant but is bluer than the indigo," is the law of scientific development. He summarized three practices to cultivate excellent students: first, encourage students to surpass their mentors; second, do not block their path to success; and third, push them from behind, encourage them to take on heavy responsibilities and chart new paths, and become successful as soon as possible. He stated, "Personal fame and fortune are secondary. The most important thing is to strive to constantly promote our country's scientific research and education in accordance with the requirements of the times. As a leader in a discipline, we should not only cultivate students but also encourage and help students to surpass ourselves, truly carrying forward the past and ushering in the

future." He also adhered to the principle of "selecting and promoting top talents, nurturing a group through one"[12]. This means choosing the right individuals to cultivate, promoting them to academic leadership positions after they have matured in their fields, and leading others in research. He wrote in a poem: "We pledge not to cease nurturing talents until they fulfill their grand ambitions of moving mountains one day, and while today we are busy mapping out the country with our pens." During his 21 years at Zhejiang University and half a century at Fudan University, Su Buqing cultivated a large number of outstanding mathematical talents, including eight academicians represented by Gu Chaohao, Hu Hesheng, and Li Daqian.

After mathematician Hua Luogeng became famous, he never forgot the mentorship and assistance from Wang Weike and Xiong Qinglai, always encouraging himself with the motto "A wall can be a ladder for others, a ditch can be a bridge for others," and allowing the younger generation to climb the peak of science on his shoulders. He was devoid of parochialism and spared no effort in cultivating a group of top talents, including Chen Jingrun, Wang Yuan, Wan Zhe, Yang Le, Xu Kongshi, Wu Fang, Wei Daozheng, Lu Qikeng, and Gong Sheng. Academician Gu Chaohao, a mathematician, whenever he pioneered a new field and made groundbreaking contributions, he would unreservedly teach it to his students, pushing them to the forefront of this field, while he would go on to pioneer another new field. His students, academicians Li Daqian and Hong Jiaxing, grew up in this way, which required great magnanimity! Wheat expert Jin Shanbao was deeply concerned about the aging of the scientific community and voluntarily applied to retire from leadership positions. When handing over work to his successors, he said, "Every old member of the Communist Party and party cadre, not only should we select young and middle-aged scientific and technological personnel to be leaders, but we should also give them their deserved academic status. Young people say 'it's good to enjoy the shade under a big tree,' but we must not let 'no grass grow under a big tree'!"[13] This fully demonstrates the breadth of mind and responsibility of the older generation of scientists in mentoring their juniors.

5. Inheritance of the Scientific Spirit

Academician Dai Lixin, an organic chemist, attaches great importance to the continuity of the scientific spirit and scientific traditions. He stated, "I often miss the elder generation of the Institute of Organic Chemistry, whose pursuit of truth and reality, like torches, guided my research path. Their spirit truly deserves the reputation of having both moral integrity and professional competence. I believe this is the highest realm for a scientific researcher and the goal I strive for in my life." Speaking about Han Yu's "Explanation of Advancing in Learning" in a lecture, which states, "Mastery in a profession comes from diligence and is ruined by frivolity. Accomplishment in behavior comes from contemplation and is destroyed by conformity," he recalled, "This is what Director Zhuang Changgong admonished Huang Yaozeng, and Mr. Huang passed it on to our generation... Every success requires undergoing a thousand refinements." [14] He often uses the poems of his teacher, Wang You, which include lines such as "knowledge has no bounds, it is the work of generations" and "once the work is done, it needs a thousand hammerings, and when we are not careful, there is a hundred years of worry," to educate his students and young scholars. Besides teaching by example during the guidance of postgraduates, he also focuses on the research ethics of young scholars, inspiring their scientific dreams through various means such as party lectures, academic reports, the first class of the semester, the "Academician Lesson" in the "society education large classroom," and summer schools, and disseminating the scholarly spirit of the older generation.

Mineral processing expert Academician Chen Qingru has two maxims. The first one is Martin Luther King's "I have a dream" (Academician Chen's dream is the "dream of a powerful nation", which he refers to as the "right motivation"), and the second is "As heaven maintains vigor through movements, a gentleman should constantly strive to strengthen himself" from the Book of Changes. Every one of his students memorizes and is deeply impressed by these two sentences. His student Chen Changhua said, "He often teaches us that a person must have a dream, only with a dream can one have motivation and be able to spread their wings and fly. Success requires various conditions, but in the end, it depends on one's own perseverance." He perfectly combines the dreams and actions of scientists. He believes that the "greatest difficulty in the research process is people's thoughts and concepts". He motivates himself with the poem "Seizing Opportunities" by Ye Jianying, which reads "Fear not the strength of the city's walls, nor the difficulty of the books. Science has its obstacles, bitter struggles can seize opportunities". He often uses the words of the Japanese-American scholar Shūji Nakamura after receiving the Nobel Prize, "If you find a meaningful topic, keep working on it until you discover something. If you encounter difficulties, find ways to overcome them, do not be discouraged, there are always difficulties in scientific research", to teach his students.[15] Whenever his students show a fear of challenging subjects, Academician Chen always firmly stands behind them, encouraging, supporting, and helping them conquer each challenge one by one. His fearlessness greatly influences his students and inspires the whole team to forge ahead and overcome obstacles, thus solving a series of world-class problems.

Optics expert Academician Wang Daheng teaches his students to adhere to the eight "whats" principle during the process of scientific research, i.e., "what thing," "what cause," "what time," "what place," "who," "which direction," "what action," and "what effect." In the process of scientific collaboration, scientists should be modest and united. In the pursuit of knowledge and truth, one must be meticulous and always maintain humility and caution. He summarizes these three spirits as "seek truth from facts, assess the situation, inherit and innovate, and strive for excellence." He frequently mentions these 16 characters in public, hoping that the spirit of science can be passed down from generation to generation.[16] In fact, this scientific spirit has not only inspired his own students but also motivated the younger generation in the field of optics. Inorganic chemist Academician Shen Panwen, in his 101 years of life, has spent nearly 70 years standing by the three-foot podium. He said, "If I had to choose between being a scientist and an educator, I would rather be an educator." From 1999 to 2008, Shen Panwen led more than 30 students at the age of over 80 to compile China's first multimedia chemistry textbook software, the "Periodic System of Chemical Elements," which was promoted in major universities nationwide. He also authored 27 volumes of 32 basic chemistry courses and some professional course textbooks, represented by "Introduction to Modern Chemistry." In 2011, his "Chemistry Science Education and Teaching Reform" was formally included in the national education system reform plan.[17] He has vividly interpreted and inherited the spirit of educating people for scientists.

6. Conclusion

The responsibilities of scientist-educators extend beyond personal research and academic instruction, as they embody the spirit of mentorship and guidance in the discovery, nurturing, and fostering of budding talents. Through both formal and informal modes of education, they strive to instill a deep understanding and passion for scientific practice, thereby cultivating the next generation of innovative thinkers. The ideal of fostering talent is consistent, transcending geographic boundaries and differing educational approaches. This task is of historical importance, and, with enthusiasm, proficiency, and courage, scientist-educators continue to pave the way for future scientific endeavors, ensuring the continuation and enrichment of our scientific heritage.

Compliance with ethical standards

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