JOURNAL OF CHEMICAL EDUCATION

Article

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The Heuristic Method, Precursor of Guided Inquiry: Henry Armstrong and British Girls' Schools, 1890−1920

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ABSTRACT: Though guided-inquiry learning, discovery learning, student-centered learning, and problem-based learning are commonly believed to be recent new approaches to the teaching of chemistry, in fact, the concept dates back to the late 19th century. Here, we will show that it was the British chemist, Henry Armstrong, who pioneered this technique, calling it the heuristic method of instruction. It became widely used in Britain (and Japan), especially in British girls' schools. Here, we trace the origin, success, and later decline of the application of heurism to chemistry laboratory teaching in Britain and highlight the role of women chemistry teachers. Finally, we briefly review the independent development of the guided-inquiry method for chemistry laboratory work in the United States.

KEYWORDS: *General Public, History/Philosophy, Laboratory Instruction, Hands-On Learning/Manipulatives, Inquiry-Based/Discovery Learning, Student-Centered Learning, Women in Chemistry, Elementary/Middle School Science, High School/Introductory Chemistry*

In the current chemistry education literature, there are many references to guided-inquiry learning, discovery-learning, student-centered learning, and problem-based learning. Some of these articles contrast "modern methods" with previous pedagogies making such comments as "Traditional chemistry labs are expository in nature and have sometimes been described as cookbook type recipes".[1] Another article refers to "[M]any traditional general chemistry labs are modeled after "cookbook"-type activities... Many universities are still using 19th-century technology and manuals that show step-by-step instruction."[2] Even the common original citation for guided inquiry fails to mention its antecedent.[3] Though it is certainly true that in recent times, "cookbook" experiments have become the norm, it has been long forgotten that, to the contrary, the concept of discovery-based laboratory learning dates back to the late 19th and early 20th centuries.

HENRY ARMSTRONG AND THE HEURISTIC METHOD

It was the British chemist, Henry Edward Armstrong (1848−1937), who first proposed teaching chemistry through discovery laboratory work. His first academic appointment had been as Lecturer in chemistry at St. Bartholomew's Hospital, London, in 1870.[4] There, he was dismayed by the passivity of students. They simply wanted to memorize facts and definitions and whatever else was needed to pass the course. At the hospital, he had to teach to the defined syllabus, but upon moving to a position at the London Institution at the end of 1870, he had much more freedom. It was there that he encouraged students to explore chemistry through experiments in the institution's laboratory.[5]

Over the next decade, he developed his ideas and tested them out on a boys' middle school in 1880. He named his teaching approach the heuristic method; "heuristic" comes from the Greek "find" or "discover", and his personal definition of the term was, "... methods which involve our placing the students as far as possible in the attitude of the discoverer-methods, which involve their finding out instead of being merely told about things."[6] Though Armstrong was not the originator of the term, he was the first to apply it to the teaching of chemistry.

In 1894, Armstrong commented:[4]

> *For the ideal school of the future I picture the teacher no longer giving lessons but quietly moving about among the pupils, all earnestly at work and deeply interested, aiding each to accomplish the allotted task, as far as possible alone.*

He was very clear that heurism was the principle of guided inquiry, not simply letting students loose in the laboratory in the hope that they might discover all the basic principles of chemistry by themselves.

Armstrong continued to refine his heuristic method over the years, including giving Saturday morning sessions on teaching chemistry through the heuristic laboratory experience to London science teachers in 1896. His book, *Teaching of Scientific Method*, published in 1903, was reviewed in the British literary magazine, *The Spectator*, to a rave review: "Professor Armstrong is a well-known and enthusiastic advocate of what he happily christened the "Heuristic" method of teaching... there can be no question that this plan is the only one that should be used in science education."[7] The wide acceptance of the heuristic method of chemistry teaching resulted in the number of British school chemistry laboratories increasing from fewer 150 in the 1870s to over 1000 by the 1900s.[8]

A CASE STUDY IN ARMSTRONG'S HEURISTIC METHOD

To illustrate the use of the heuristic method, Armstrong[6] described a study of the process of rusting:

dx.doi.org/10.1021/ed500724d | J. Chem. Educ. XXXX, XXX, XXX−XXX

Young children are delighted to be so regarded, to be told that they are to act as a band of young detectives. For example, in studying the rusting of iron, they at once fall in with the idea that a crime, as it were, is committed when the valuable strong iron is changed into useless, brittle rust; with the greatest interest they set about finding out whether it is a case of murder or suicide, as it were—whether something outside the iron is concerned in the change or whether it changes of its own accord.

A lady teacher who had thus presented the case to a class of young girls told me recently that she had been greatly amused and pleased to hear one of the girls, who was sitting at the balance, weighing some iron that had been allowed to rust, suddenly and excitedly cry out, "Murder!" This is the very attitude we desire to engender; we wish to create lively interest in the work and to encourage it to come to expression as often, as emphatically, as freely as possible.

It is of no use for the teacher merely to follow an imaginary research path: the object must ever be to train children to work out problems themselves and to acquire the utmost facility in doing so. ...but do not let us spoil them by telling them definitely in advance what to look for and how to look for it: such action is simply criminal.

HEURISTIC TEACHING OF CHEMISTRY AND BRITISH GIRLS' SCHOOLS

It was the British private girls' schools who embraced heuristic teaching of chemistry with enthusiasm. Ironically, Armstrong was antagonistic to women in science, for example, he was the single greatest impediment to the admission of women chemists to the Chemical Society[9] at a time when the large majority of British chemists were supportive of the women's cause.[10] Armstrong did not keep secret his very strong opinions on the topic of girls and women. For example, he stated[5] that "Those who have taught women students are one and all in agreement that, although close workers and most faithful and accurate observers, yet, with the rarest exceptions, they are incapable of doing independent original work." While his opinion of women teachers was even more critical[5], contending it was essential for them to be married, because the single women teachers were: "the sexless creatures who too often engage in the vain task of training our daughters... are a real danger to society."

However, this same Armstrong was delighted to present his heuristic approach at meetings of girls' school science teachers.[11] We can perhaps comprehend this apparent contradiction by a statement[6] that he made to the Educational Science Section of the British Association for the Advancement of Science in 1902: "Experimental teaching is of even greater value to them [girls] than to boys, as boys have more opportunities of doing work which is akin to it in the world. The work done by girls should of course bear directly on their domestic occupations."

Armstrong also lauded the contribution of two of his former women research students who had become high school chemistry teachers:[5]

Miss Grace Heath—a teacher of the very greatest promise, whose premature death is deeply to be deplored—early obtained most promising results at the North London Collegiate for Girls, where, in such consequence, such work is gradually becoming regarded as of importance. But the most systematic trial given to the method in a girls' school has been that carried out at the Central Foundation School in Bishopsgate, London by Miss Edna Walter, B.S. This lady has embodied her experiences in an interesting paper read at the Liverpool meeting of the British Association in 1896, which was afterward printed in Education.

In fact, it was Heath who had the more influential account published. Her letter, to the journal *Nature*, gained a wide readership:[12]

By this new [heuristic] method the pupils themselves are put into the position of discoverers, they know why they are at work, what it is they want to discover, and as one experiment after another adds a new link to the chain of evidence which is solving their problem, their interest grows so rapidly, that I have seen at a demonstration lesson a whole class rise to their feet with excitement when the final touch was being put to the problem which it had taken them three or four lessons to solve.

Heath's successor as chemistry teacher at the North London Collegiate School for Girls, Rose Stern, together with her friend, A. M. Hughes, of the London County Council Secondary School, Eltham, wrote a laboratory manual along heuristic principles: *A Method of Teaching Chemistry in Schools*. In the Introduction, they state:[13]

[I]t is intended that every experiment should be suggested and carried out by the pupils, the part of the teacher being only to guide and supervise. At the same time the teacher must reserve the right of selecting the experiment to be done by the class when several have been suggested, and, in this way, preventing time being wasted in trying experiments which would be of little value to the children and which would break the sequence of their work.

The use of the heuristic method at British girls' schools became accepted practice. For example, in a history of Bedford High School for Girls, it is commented:[14]

[W]hen Professor Armstrong and his heuristic method... had caused a good deal of fluttering in the scientific dove-cote, it became absolutely necessary to make some provision for individual practical work.

It is not surprising that Blackheath School for Girls was another of the many girls' schools to adopt the heuristic method as Armstrong had sent his daughters to that school. The compilers of the history of the school remarked:[15]

The method employed in the laboratory was based on the so-called heuristic method. It appealed to many science teachers as providing a very sound basis for elementary work in science, although not altogether suitable for the more specialized work of older students.

THE DECLINE OF THE HEURISTIC METHOD

The heuristic method of teaching chemistry even spread to Japan.[16] However, there were voices of dissent. The famous British chemist, Sir William Ramsey, was one of those who vociferously espoused the lecture method and expressed a dismissive hostility toward the heuristic approach.[17]

To use guided inquiry required considerable skill on behalf of the teacher: to guide toward the goal, not to leave the students aimless. However, as Armstrong's heuristic devotees retired, the

dx.doi.org/10.1021/ed500724d | J. Chem. Educ. XXXX, XXX, XXX–XXX

new generation lacked the training in the proper context and application of the method. As a result, by the 1920s, the heuristic approach was in decline. Turner described in *History of Science Teaching in England*:[18]

> *Unfortunately the disciples of Armstrong went too far. They regarded practical work in the school laboratory as an end in itself. ... They were afraid to tell their pupils anything, and the unfortunate young investigators often gained nothing from their work in the laboratory but a marked distaste for the subject. The over emphasis on method and the ignorance of the importance of the content has done much to bring heuristic teaching into disrepute.*

In fact, many later British science educators contended that the lecture method, interspersed by demonstrations, was a far more effective use of the teaching time and resulted in better learning outcomes.[19]

A BRIEF HISTORY OF INQUIRY-TYPE CHEMISTRY LABORATORY ACTIVITIES IN THE UNITED STATES

Though Armstrong gave speaking tours in the United States,[5] the heuristic method seems to have made no impact. A 2006 review of the history of laboratory work in U.S. high schools and colleges makes no mention of heurism.[20] Even a 1918 article on methods of teaching high school chemistry makes no mention of Armstrong's approach.[21] In fact, it was whether laboratory instruction of itself was superior to demonstrations that provided the debate in the United States during the 1920s and 1930s.[22−26]

The first U.S. reference that we could find to anything similar to heurism or guided inquiry dated from 1929. Horton[27] described what he named the "problem method" in which high school students were given a question, and then they planned their own experiments and devised their own methods to solve the problem. The next step in the saga came in 1955 when Blick[28] categorized "cookbook" laboratory work as "deductive−descriptive" and instead, he argued for "inductive−deductive" laboratories. He noted that such experimentation required more effort on the part of the instructor and students, and he added a caution:[28]

> *It is not to be inferred that all laboratory work should be inductive. There is not time to rediscover all that has been discovered in the past; but a proper balance in the use of inductive and deductive procedures is needed.*

Independently, McClure applied the discovery method at the kindergarten level in 1964.[29] Then in 1970, the "inquiry−discovery" method of laboratory instruction appears in the literature.[30] And finally, in 1979, the key article in the development of contemporary guided-inquiry experimentation was published.[31]

Thus, those current American authors who claim guided-inquiry type laboratory work to be a recent idea are ignoring the rich history of the methodology, even in the context of American chemistry education. In fact, before this contribution, only one reviewer of U.S. chemistry laboratory instruction styles had, in passing, traced the concept all the way back to Armstrong and heurism.[32]

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Notes

The authors declare no competing financial interest.

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