Literature Review: “Experimental Physics as a University Subject” by James Maxwell

James Clerk Maxwell’s article, “Experimental Physics as a University Subject,” discusses the benefits of experimental physics as a university subject, particularly in regards to the establishment of the Cavendish laboratory at Cambridge University. In 1871, Maxwell was appointed the First Cavendish Professor of Physics at Cambridge University and, indeed, played a leading role in planning and developing the Cavendish laboratory, which opened its doors in 1874. Maxwell characteristically placed emphasis on precise measurements, and his writings inspired Heinrich Hertz in the work that laid the foundations for a new school of physics in Germany. Although not the first physics laboratory, the Cavendish was the first physics laboratory located in a university department for the study of physics. Every single university has experimental science and an experimental laboratory, and it is a crucial part of the scientific course of study at university. Maxwell’s influence, and that of the Cavendish Laboratory, lives on in the scientific course of study for every young scientist.

In “Experimental Physics as a University Subject”, Maxwell argues that experimental physics should be a university subject because (a) it allows for experiments to be used as illustrations in order to teach students about physics and (b) it allows for experiments to be done for research using devices and instruments available in the lab. Maxwell states that while the course of study of physics requires students to maintain in action “all those powers of attention and analysis which have been so long cultivated in university”, it also calls on students to exercise their senses in observation, and their hands in manipulation (Maxwell, 2). An experimental physics laboratory may be employed to either illustrate the phenomena of a particular branch of physics, or for physical research in order to exemplify a particular experimental method (i.e., learning through doing. Furthermore, Maxwell claims that the popularization of scientific doctrines is producing as great an alteration in the mental state of society as the material applications of science are affecting in its outward life (Maxwell, 3). To Maxwell, if society is prepared to receive scientific doctrines, it is the responsibility of scientists to provide for the diffusion and cultivation, not only of true scientific principles, but of a spirit of sound criticism, founded on an examination of the evidences on which statements apparently scientific depend (Maxwell, 3).

Maxwell’s thesis was novel in the sense that it opposed customary practice and belief: that practical laboratory work was to be carried out by every day men in solitary experiments, and not highly educated mathematicians and philosophers. Maxwell is steadfast in his belief that science, particularly measurement, should be shared by men in order to advance scientific doctrine and truths. Maxwell references Bacon’s conception of “experiments in concert” and how it is realized through experimental physics, particularly as a university course, where the scattered forces of science are “converted into a regular army, and emulation and jealousy became out of place, for the results obtained by any one observer were of no value until they were combined with those of the others” (Maxwell, 8). Maxwell further cites the experimental research on terrestrial magnetism as producing lasting effects on the progress of science. The new methods of measuring forces determined in the works by many on terrestrial magnetism were successfully applied by Weber to the numerical determination of all the phenomena of electricity, and very soon afterwards the electric telegraph by conferring a commercial value on exact numerical measurements, which contributed to the advancement of scientific knowledge. In sum, Maxwell argues that it is “therefore natural to expect that the knowledge of physical science obtained by the combined use of mathematical analysis and experimental research will be of a more solid, available, and enduring kind than that possessed by the mere mathematician or the mere experimenter” (Maxwell, 11).

Maxwell addresses two overriding concerns advanced by those who were opposed to the introduction of that experimental physics as a university subject. First, he considers the objection that it would diminish the field of science. Maxwell points out that modern experiments increasingly are exercises in measurement, and that the opinion of the educated seems to be that in a few years all the great physical constants will have been approximately estimated, and that the only occupation that will then be left to men of science will be to carry on these measurements to another place of decimals (Maxwell, 6). Maxwell argues that the labour of careful measurements has been rewarded by the discovery of new fields throughout the entire history of science, and this has allowed for the development of new scientific ideas. Progress in and of itself engenders further progress, particularly through advancements achieved in experimental physics. Second, Maxwell turns to the objection that laboratory studies will withdraw students from more legitimate studies. He counters this worry with Faraday’s ‘mental inertia’ - combining the difficulty of recognizing the abstract relation learned from books with the pain of balancing the mind between what we have learned from books and then from symbols and objects. To Maxwell, this is simply the price that must be paid for new ideas (Maxwell, 12). To Maxwell, this is the principal reason why “a man whose soul is in his work always makes more progress than one whose aim is something not immediately connect with his occupation” (Maxwell, 13).

Not only does Maxwell address the help that science may give to the university in regards to developing the field of scientific research, but he also addresses the help which the university may give to science. With a tip of his hat to Francis Bacon’s suggestion that science is essentially a collaborative endeavour carried out by many individuals over (perhaps) many generations, Maxwell insists that a university laboratory will allow many men who are well trained in mathematics (such as Maxwell himself) to enjoy the considerable advantage of a well-appointed laboratory and thereby unite their efforts and carry out experimental research that no solitary worker could attempt in isolation. Maxwell effectively puts at ease the people who oppose the legitimization of experimental physics as a university subject, particularly through the Cavendish laboratory. Maxwell felt that there was a real place for an experimental physics laboratory at the university, and that it would benefit both physics as a science and the university as an institution of higher learning.

Maxwell’s motivations are clear: to establish experimental physics as a university subject through the establishment of an experimental physics laboratory that will act to further scientific learning at the university level and scientific principles as a whole. Maxwell appeals to his audience’s sense of a greater good: “we recognize these men (physics students) like ourselves, and their actions and thoughts, being more free from the influence of passion, and recorded more accurately than those of other men, and are all the better materials for the study of the calmer parts of human nature” (17). For Maxwell, experimental physics is necessary for the evolution of mankind’s knowledge, for each failure is crucial to the learning of society as a whole and allows for our successes in scientific doctrine. There is no more noble pursuit than that of learning, through which the Cavendish laboratory would be a crucial and illustrative element of free thinking balanced with precise measurement.

References

Maxwell, James C. ‘Experimental Physics as a University Subject’. *The Scientific Papers of James Clerk Maxwell.* Ed. William Davidson Nivin. Vol. 1, New York, Dover Publications, 1890, 2 vols, pp. 241-255.