Paper ID: ICAEE-16-P01

Experimental Physics Textbook Written by the First Physics Professor of Kiryu Technical College

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Abstract
In 1915, Tadaroku Ohtashiro (1881–?) was appointed as the first Professor of Physics at the Kiryu Dyeing and Weaving Vocational School, which was a forerunner of Kiryu Technical College, which itself was later integrated into Gunma University. In the same year, he published a textbook titled "*Quantitative Physics*." Contrary to the title, the book is actually a manual for laboratory physics. The unique features of the textbook are that it contains a large number of real experimental values that were obtained by the Professor's own measurements, and a detailed explanation of experimental error. In this paper, I explore, based on historical documents related to him, Prof. Ohtashiro's thoughts regarding how physics should be taught.

Keywords: Physics Experiments, Physics Education, Measurement Error, Textbook

1. Introduction

In 1915, the Kiryu Dyeing and Weaving Vocational School was established as the eighth Japanese national technical college. However, tuition only began the following year, exactly one hundred years ago from now. The school had two departments; the Department of Dyeing and Weaving and the Department of Spinning and Weaving, and it emphasized both technical education necessary for professionals and fundamental science education. At its founding, freshman students were required to have physics lectures for 3 to 6 h per week, while sophomores attended classes involving physics experiment for 3 h each week (Iwamoto, 1965).

The first physics professor at the school was Prof. Tadaroku Ohtashiro (1881-?) (Fig.1(A)). At the time, Prof. Ohtashiro was studying optical physics and spectroscopy, and he obtained a doctoral degree in 1926 from Tokyo Imperial University for studying the wavelength-dependent blackening phenomena that occur in photographs. He also performed experimental research on electricity. In 1929, he presented a paper in the fourth Kiryu Technical College

(A) (B)

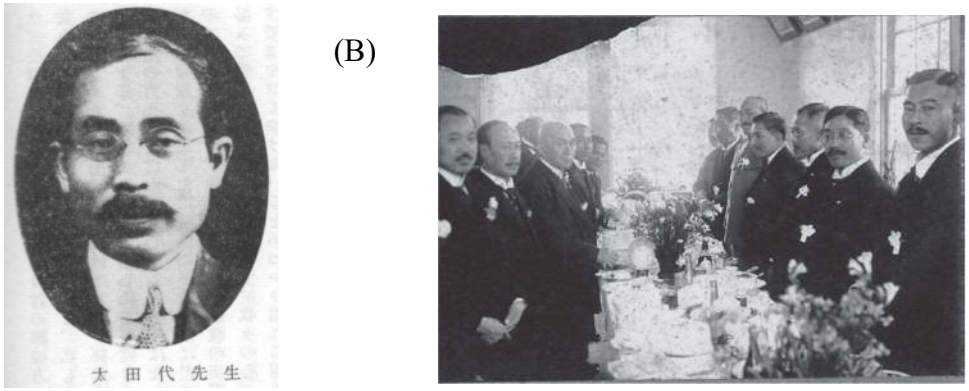
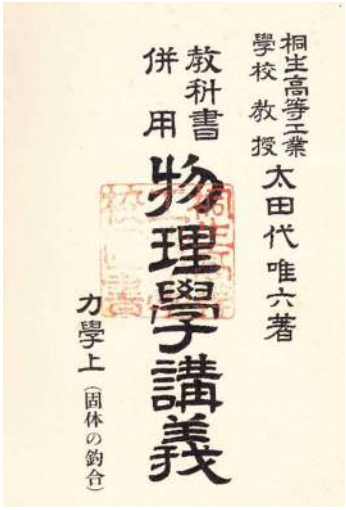


Fig. 1 (A) Photograph of Prof. Tadaroku Ohtashiro taken from the 50th anniversary book (Iwamoto, 1965). (B) Photograph of the opening ceremony of the Kiryu Dyeing and Weaving Vocational School, taken from the 100th anniversary book (School of Science and Technology, Gunma University, 2015). Prof. Ohtashiro is believed to be second from right in the picture.

Bulletin on the properties of electric currents in several kinds of crystal detectors. Kiryu Dyeing and Weaving Vocational School was renamed to Kiryu Technical College in 1920 when a new Department of Applied Chemistry was added.

Prof. Ohtashiro was an avid educator and wrote several textbooks. He not only wrote college and university level textbooks but also, with Prof. Hirotaro Nishida, who was the then-principal of Kiryu Technical College, wrote an entry-level physical and chemical science textbook for students at an all girls' high school (Fig.2 (B)). As of August 2016, six different physics textbooks written by Prof. Ohtashiro can be found on the National Diet Library Digital Collections' website (http://dl.ndl.go.jp/). In this report, I explore Prof. Ohtashiro's thoughts regarding the teaching of physics by looking into the textbooks were written by him and some of the notes he wrote in books donated by him to the Kiryu Technical College Library.

(A)



(B)

Fig. 2 (A) The title page of a physics textbook, "*Lectures on Physics, Mechanics*" (*Butsuri-gaku Kougi*) (1925), written by Prof. Tadaroku Ohtashiro. (B) The front cover of an introductory textbook for students at an all girls' high school, "*Physical and Chemical Science Textbook* (*Rika-Kyoukasyo*)" (1939), written by Profs. T. Ohtashiro and H. Nishida.

2. An analysis of notes left by Prof. Ohtashiro

Prof. Ohtashiro taught at Kiryu Technical College from 1916 until 1937 (Iwamoto, 1965), when he became the Principal of Fukui Technical College (Alumni Association of Engineering, University of Fukui's History Webpage). During his tenure at Kiryu Technical College, he donated some books to its library; these books have a stamp that

(A)

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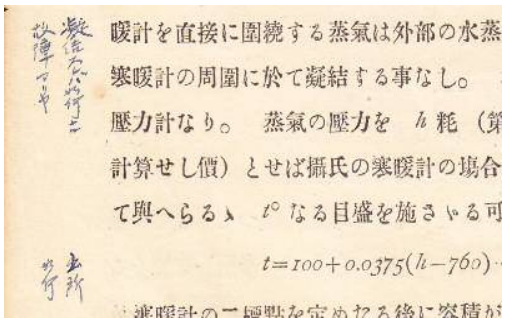


Fig. 3 (A) A stamp showing that the book had been donated by Prof. Ohtashiro. (B) An example of some of the notes left by Prof. Ohtashiro in books he had donated. In the upper section, he asks what kinds of breakdowns occur due to solidification, while in the lower section he asks what the reference for the equation is.

shows this (Fig. 3A). On the margins of some of these books, various notes attributed to Prof. Ohtashiro can be found (Fig. 3B). Some of them seem to be related to questions he may have been looking to ask in his lectures. Others are mainly comments on experimental values or empirical formulae. Judging from these comments, he was interested in the accuracy of these measurements and the validity of their methods. These writings strongly suggest that Prof. Ohtashiro was essentially an experimentalist and that he believed that the most essential part of physics was making quantitative measurements.

3. Prof. Ohtashiro's *"Quantitative Physics"*

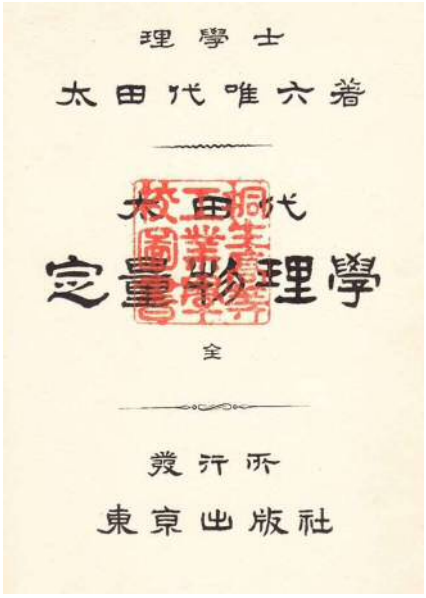
The above-mentioned suggestion regarding Prof. Ohtashiro's thoughts on physics is more clearly apparent in his book, "*Quantitative Physics*" (Fig.4 (A)). This book was published by the Tokyo Publishing Company in 1915, which was just about the time when Prof. Ohtashiro was appointed to Kiryu. This book is evidently not an ordinary physics textbook but rather a manual to be used for physics in the laboratory.

The book contains a total of fifty-five different experimental schema mainly based around the making of quantitative measurements. For example, it advises that the acceleration of gravity should be measured with a simple pendulum, that surface tension can be obtained with a metal ring, and that the index of refraction can be found using a spectrometer. Interestingly, ten of the fifty-five schema are identical to those performed by today's Gunman University freshman in their physics laboratory classes. Aside from the three mentioned just now, three of the ten are electrical experiments (the Kohlrausch Bridge, Wheatstone Bridge, and measurement of electromotive force), two are thermal physics experiments (the measurement of the water equivalent of a calorimeter and mechanical equivalent of heat), and the use of Laurent's saccharimeter to measure the angle of rotation of optically polarized active sugars. It is surprising that the schema physics students use in university and college has not changed much in the past one hundred years.

In my opinion, Prof. Ohtashiro's "*Quantitative Physics*" has two features unique to it when compared to other physics textbooks on experimental procedures written in Japan in those days.

The first is that the book contains a large number of measured values for individual experiments in tabular form (Fig.4 (B)). More than 60% of the schema (35 of 55) have such data tables. According to the preface, these values come from actual experiments performed by Prof. Ohtashiro himself: he was a true experimentalist. In his paper on the history of Japanese physics, Tatsuo Tsuji, a specialist in the area of science history, referred to Emil Warburg's "*The Experimental Physics*," which had been translated by Sheiji Nakamura and was published in Japan in 1902, as the standard experimental textbook used by university and college students during the late Meiji to the early Taisho era (1891–1912) (Tsuji, 2011). In Warburg's book, however, few real experimental values appear, with explanations of the

(A)



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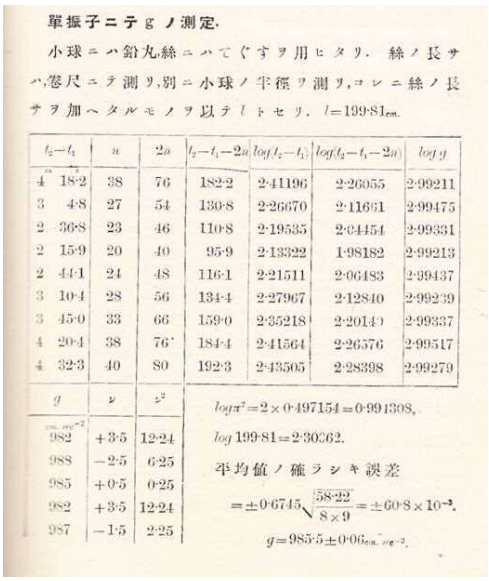

Fig. 4 (A) The title page of the physics textbook, "*Quantitative Physics*" (*Teiryou-Butsuri-Gaku*) (1915). (B) An example of a table containing actual measurement values that appeared in "*Quantitative Physics.*"

principles behind each experiment favored. To the best of my knowledge, Prof. Ohtashiro's "*Quantitative Physics*" is the only textbook out of all of those published between 1890–1915 in Japan that contains a great many real measurements.

The second unique feature is that his explanation of experimental error is based on mathematical theory, i.e., the probability theory. Warburg's book also emphasizes the importance of error in physics experiments, but the basic mathematical theory of error is not explained. In his paper regarding the history of the translation of words related to probability into Japanese, Toshinao Nakata, a specialist in the use of statistical mathematical methods in economics, introduced Prof. Ohtashiro's "*Quantitative Physics*" as one of the earliest Japanese physics textbooks explaining the concept of probability. Prof. Ohtashiro's book contains a relatively detailed explanation of the error function, i.e., the Gaussian distribution function. As with the real experimental values, to the best of my knowledge, his "*Quantitative Physics*" is the only Japanese textbook at the time to explain in detail how to calculate experimental errors using probability theory. In 1916, Rinjiro Segawa published a review paper on the measurement of error in chemical experiments in the Journal of The Pharmaceutical Society of Japan (Segawa, 1916). In it, "*Quantitative Physics*" is listed at the top of the reference list. This indicates that the description of experimental errors in Prof. Ohtashiro's "*Quantitative Physics*" had been evaluated highly by professional researchers at that time.

The terminology used in Prof. Ohtashiro's book is actually quite old-fashioned. Nevertheless, if several of the technical terms in the book were to be updated to today's terminology, Prof. Ohtashiro's description of experimental errors would still be relevant enough for today's classes.

4. Prof. Ohtashiro's complaint to students at the time

Here, I will describe an interesting aside about Prof. Ohtashiro. In the introductory section of "*Quantitative Physics*," he wrote some comments, or more specifically complaints, about the students of his day:

1. Most students do not clearly understand the meaning of the water equivalent in the calorimeter.
2. Most students do not know the unit of frequency of the tuning fork.
3. Some students cannot connect a battery to a circuit.
4. Most students do not understand how to determine the number of significant figures needed.
5. To make the result obey the theory, some students incorrectly eliminate some data.
6. Students understand how to use a Vernier scale and can use it when they hear the explanation at the side of the laboratory bench. However, the next time they attempt to use it they completely forget how it functions, because they do not understand the principle behind it.
   (Approximate English translation by the author).

Many of today's physics teachers would have similar complaints. Although science and technology have advanced in the last hundred years, the main problems in science (and specifically physics) education still remain the same. It is a little bit surprising.

5. Discussion

The aim of this paper is to reveal Prof. Ohtashiro's thoughts on physics education. His notes, found in the margins of his books, indicate that he was strongly interested in the accurate measurement of experimental values. His book on "*Quantitative Physics*" differs from other Japanese physics textbooks on the experimental procedure of the time in that it provides details on how to measure error. These suggest that Prof. Ohtashiro thought that the most fundamental starting point of any physics experiment was the measurement of quantitative data. In fact, he wrote the following in the introductory section of "*Quantitative Physics*:"

> "In my opinion, it is convenient to assume that the teaching of physics at common and technical colleges can be divided into four different parts: qualitatively-derived experimental facts; quantitatively-derived experimental facts; the interpretation of the experimental facts; and the application of physics knowledge for solving real-world problems. The fundamentals of physics are the first and second parts; the third and fourth,

while not essential, are recommended." (English translation by the author)

He also wrote this about teaching at common and technical colleges:

> "To begin with, we should teach how quantitative facts can be derived from qualitative ones, i.e., teach the method needed to perform experiments in order to derive quantitative data. After this, we should teach how to logically explain both quantitative and qualitative facts. Finally, we should teach the application. This way is, I think, the principal way for teaching physics. Lectures in physics and its experimental classes must proceed in parallel." (English translation by the author)

I completely agree with the last sentence above, namely that lectures and experimental classes must proceed in parallel. Unfortunately, the current curriculum of Gunma University does not reflect this. Prof. Ohtashiro's textbook was written one hundred years ago, and yet it seems to be urging us to reconsider how we teach physics today. Do we emphasize the theoretical aspects too much in today's physics lectures? After all, the fundamentals of physics are based on experimental facts.

Acknowledgements

I am grateful to Prof. Akira Akabane (Saitama Medical University), Prof. Jun Shozawa (Tokyo Future University), and Dr Toyomi Tamaki (Mathematical Assist Design Laboratory) for their stimulating discussions and critical reading of an earlier version of the manuscript. This research was supported partly by the JSPS KAKENHI Grants 25282043 (Principal Investigator: Prof. Akira Akabane).

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