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Original Article

The effects of high school curriculum adjustments on physics learning among Taiwanese medical university students

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Currently, the teaching of general physics is not unified among medical universities. Due to changes in the senior high school curriculum guidelines and reduction in physics course hours, there have been difficulties in teaching general physics in medical universities. In the current study, the scores on general physics examinations of 248 medical university students during the period 2015-2017 were analyzed. Moreover, the performances of these students on different units were investigated. From the results, differences in scores on unit 4 (electricity) were relatively large and the performance of female students surpassed that of male students. These results may be related to the following factors: First, natural science content has been reduced in senior high school curricula. Second, some students received early admission to medical university. Third, the examination questions were based on examples and practice tests given in class.

Keywords: General physics, teaching materials, student learning

Introduction

Doctors, medical laboratory technologists, and radiologists need to have a national license to qualify as medical professionals. To pass the national licensing examination, they must finish required courses and internships. Fundamental courses, such as calculus and general physics, are indispensable for advanced courses. In addition, grades and rankings of medical university students are important in the hospital internship selection process. Therefore, medical university students are highly motivated to learn. Yet, for teachers, it is a challenge to provide a general physics course that is understandable and interesting.

Teachers often make adjustments to general physics course curriculum to compliment the focuses of different departments. For example, medical imaging and radiologic science (MIRS) graduates are expected to have clinical expertise in diagnostic imaging, nuclear medicine, and radiation therapy. They also need to study medical ethics, medical English, and other relevant courses. Therefore, in general physics courses, teachers place emphasis on electricity or magnetism in conjunction with subsequent professional courses such as radiation physics, computer tomography, and magnetic resonance imaging. Currently, students need to take 2-4 credits of general physics (see Table 1). General physics courses usually cover mechanics, electricity, magnetism and modern physics. However, the time given to each of these is inadequate. For basic science education, it is necessary to perform a systematic analysis to develop a precise teaching method and choose suitable content to strengthen students' knowledge and logic. Moreover, students who have just entered university usually study the way they did in senior high school. It might be difficult for them to express which area of physics they would like to

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Table 1. Number of required credits in general physics for the department of medical imaging and radiologic science in selected universities from 2015-2017

University	Year 2015	Year 2016	Year 2017
Yang-Ming University	3	3	3
Chang Gung University**	4	4	4
China Medical University	2	2	0
Chung-Shan Medical University	2	2	2
Kaohsiung Medical University	3	3	3
I-Shou University	4	4	4

* Obtained from the course websites of listed universities on March 21, 2018.
**Including general physics laboratory

strengthen. Consequently the course content is decided by the teacher alone.

Recently, in response to senior high school curriculum changes (Ministry of Education 1995, 2010), the number of course hours required for physics and the emphasis on electricity and magnetism have been reduced. Moreover, if senior high school students obtain early admission to a medical university, they might take their coursework less seriously. Hence, students who are just entering a medical university might have different levels of understanding of physics. As such, building a connection between senior high school physics and college physics courses is not easy. Learning general physics provides a foundation for later advanced courses and it is necessary to consider breadth and depth. The contents of general physics courses in selected medical universities, listed in Table 1, include mechanics, atomic physics and electromagnetism (University course information website 2018). Fluid mechanics, optics, and relativity are less often mentioned. The aim of this study was to analyze the performance of medical university students who studied general physics for one semester from 2015-2017 and to discuss the effects of teaching material adjustments on student learning.

Research subjects and methods

During the period 2015-2017, four units composed of key concepts and applications of mechanics, oscillations and electromagnetism were designed and multiple-choice tests were administered after each unit. Students were enrolled in a medical university in central Taiwan and took a general physics course affiliated with MIRS department. There were 40 male and 34 female students in the class of 2015, 38 male and 58 female students in the class of 2016 and 30 male and 48 female students in the class of 2017. Students who were absent from or late for the exams were excluded. Finally, there were 108 male and 140 female students, for a total of 248 students. The teaching materials and handouts were in English but explained in Chinese. The exercises were also in English. The exam questions were based on the exercises. When introducing new concepts, the teacher repeated the examples and gave tests in class. Unit 1 included the concepts of motion in a straight line, motion in two and three dimensions and force; unit 2 included Newtonian mechanics and energy and momentum conservation; unit 3 included static equilibrium, oscillation, and wave function; and unit 4 included electric field, electrical potential energy, and Gauss' law.

Statistical Analysis

All analyses were performed by Student's paired t-test. P value <0.05 was considered statistically significant.

Results

As shown in Figure 1, there were no significant differences in performance on unit 1, 2, and 3 tests among students enrolled in 2015, 2016 and 2017. However, there was a large gap in performance on unit four test, which was on electricity. The class of 2015 received better scores, up to 90 points, on unit four test. In comparison to the class of 2015, the scores on all unit tests in 2016 and 2017 were very close, with the average score between 70 and 80 points. The details are shown in Table 2.

In Table 2, the ratio of male to female students was 1:0.9 in 2015, 1:1.5 in 2016, and 1:1.3 in 2017. In total, the ratio of male to female students was

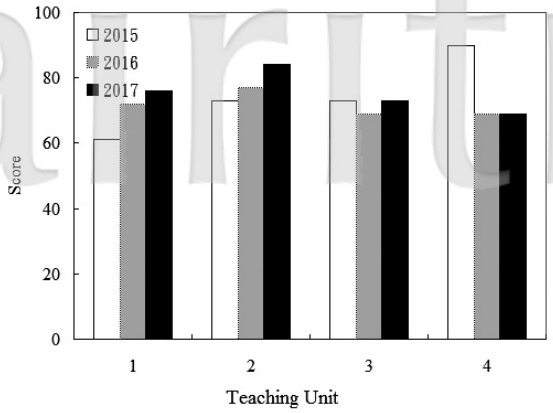

Figure 1. Students' scores on unit 1-4 tests from 2015 to 2017. Unit 1 includes the concepts of motion in a straight line, motion in two and three dimensions and force. Unit 2 covers Newtonian mechanics and energy and momentum conservation. Unit 3 includes static equilibrium, oscillation, and wave function and unit 4 includes electric field, electrical potential energy, and Gauss' law.

1:1.3. The average scores of female students were higher than those of male students from 2015 to 2017. For all units, the test scores of female students in 2015 were slightly higher than those of male students, ranging from 50 to 90 points. However, the scores of female students on unit 2 and 3 tests were better than those of male students and the range was more concentrated, in the interval of 70-90 points. For unit 4 (electricity and magnetism), test scores of female students were comparable with those of male students, but the range was still more concentrated. From statistical analyses, P values (for comparisons of the scores of male and female students) for unit 1, 2 and 3 test scores were less than 0.05 in 2015 (see Table 2). The unit 4 test scores of all students in 2015 were significantly higher than those in 2016 and 2017 (P value < 0.01). In 2016, the scores of female students on each unit test were slightly higher than those of male students and the range was also more concentrated, in the interval of 60-90 points. There was a similar trend in 2017. Comparisons of the scores of male and female students on all individual unit tests in 2016 and 2017 showed no significant differences. However, the scores for unit 2 (mechanics) test were the highest among all unit test scores. P values for all comparisons between unit 2 and other

Table 2. Scores and standard deviations of male and female students for unit 1-4 tests from 2015-2017. Unit 1 includes the concepts of motion in a straight line, motion in two and three dimensions and force. Unit 2 covers Newtonian mechanics and energy and momentum conservation. Unit 3 includes static equilibrium, oscillation, and wave function and unit 4 includes electric field, electrical potential energy, and Gauss' law.

2015	Number of students	Unit 1*	Unit 2*	Unit 3*	Unit 4
Male	40	57±17	70±22	65±23	88±19
Female	34	67±20	89±13	82±12	91±9
Total	74	61±19	73±21	73±21	90±15
2016	Number of students	Unit 1	Unit 2	Unit 3	Unit 4
Male	38	69±21	73±21	72±16	67±24
Female	58	74±14	78±19	72±16	71±19
Total	96	72±17	77±21	69±18	69±21
2017	Number of students	Unit 1	Unit 2	Unit 3	Unit 4
Male	30	79±18	80±19	72±25	63±22
Female	48	79±18	87±13	74±23	72±23
Total	78	76±20	84±16	73±24	69±23

*P-value (comparisons of the scores of male students and female students) is less than 0.05

unit (units 1, 3 and 4) test scores among all students in 2016 and 2017 were less than 0.01.

Discussion

Medical university students have a heavy class schedule and need to start their internships and prepare for national licensing examinations in their senior year. The scores of required courses are closely related to future internship and job opportunities. Therefore, students generally have strong motivation in the learning of basic subjects such as general physics, general biology and calculus. In addition to teaching these subjects, most instructors strengthen some parts of their course according to the focuses of the department. For example, the general physics courses for MIRS students in Kaohsiung and Chung Shan medical universities cover electromagnetism (University course information website 2018), while the general physics course for MIRS students in Yang-Ming University includes basic theories of electromagnetism, electronic circuits, and thermodynamics but bypasses optics and theory of relativity. The purpose of this study was to explore the effects of high school curriculum changes on general physics learning among Taiwanese medical university students and to use the results to develop materials for strengthening their understanding of general physics.

The reasons for the decline in the scores on unit 4 test in 2016 and 2017 (as shown in Figure 1) may be related to the fine-tuning of high school curriculum guidelines (Ministry of Education 1995, 2005, 2010). Among the 138 credits of required courses in senior high school, 4 are in physics. The content of high school physics courses includes mechanics, thermodynamics, optics, electricity and nuclear energy. To provide a 12-year basic education, the curriculum standards for high school were reviewed and revised (Chen 2018). The content related to electromagnetism only includes Coulomb's law, electrical power lines and electric fields, electrical potential and electrical potential energy. Gauss' law and other relevant topics have been excluded. There has been a rising number of applications through multiple admissions channels to colleges and universities. The admissions process is focused not on academic achievement but, rather, on national examination scores. Therefore, it is recommended that general physics lecturers strengthen their courses in the areas of electricity and magnetism. Currently, medical university students must complete 128 credits of required courses, including 2-4 credits in physics. The content includes mechanics, thermodynamics, electricity and magnetism. The time spent on Newtonian mechanics should be reduced, so that it is possible to teach a complete unit on electricity and magnetism.

Another interesting result is the difference in scores between male and female students. In Table 2, the scores of female students were higher than those of male students. This result was not in line with the general opinion that female student performance is inferior to male student performance in science courses (Li 2001). The results of the 2015 international mathematics and science education achievements study released by the Trends in International Mathematics and Science Study and the Progress in International Reading Literacy Study (TIMSS & PIRLS) also showed that the performance of male students in physics is better than that of female students. However, the number of hours female students participate in physics learning is only 20%-50% that of male students (TIMSS & PIRLS International Study Center 2018). In the case of college students, learning is not closely supervised and students can choose courses in different fields. Therefore, it is difficult to evaluate the difference in the level of understanding of physics between male and female students. In addition, the natural science scores on the college entrance exam may be weighted (College Entrance Examination Center 2018). Hence scores may be similar among students. Moreover, the unit test questions were from the practice tests given in class and were easy to predict. Some female students may not be able to accurately locate the knowledge they have learned when they encounter problems. However, if a problem can be solved in a single step, they may be able to find the formula to apply, so that their scores may not be lower than those of male students (Ding and Harskamp 2006).

From the analysis, we also found that the role

of a question bank is debatable. It helps students to understand the concepts and theorems, as well as to remember the physics formulas. This kind of problem-solving technique is especially beneficial for exams in which the format and topics are fixed. However, one may criticize these "boring" problems for reducing student interest and curiosity and not fitting the needs of all students. Few Taiwanese students ask questions in class. They are more inclined to ask questions after class. Therefore, they may need materials to work on to enable them to understand where they need help. Studying general physics trains students to observe the nature of science and improve their logic and reasoning, as well as to prepare for the study of future courses related to their profession. Although the best way to learn is through discussion and debate, Taiwanese students generally hesitate to participate in class.

Conclusions

General physics is regarded as a basic subject, the foundation for future specialized courses. The results of this study suggested that general physics lecturers should reduce the content regarding mechanics and increase the content regarding electricity and magnetism. In addition, the physics scores of female students are higher than those of male students.

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