

Measuring academic achievement using selected exam subjects: The exam scores of medical technologist students

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Abstract

Background: It is necessary to conduct classes effectively for new medical technologist students. To develop effective lectures for university students, academic achievement based on selected exam subjects and the exam scores of medical technology students were analyzed.

Methods: This study is a prospective cohort study. This study focused on 99 students who entered university in 2015 as medical technology students, and the exam results of the 99 students over four years were analyzed. We examined the following: 1) The subjects selected for the university entrance exam; 2) the grades from all four years of university; 3) the graduation exam results at the end of the senior year; and 4) the medical technology national exam scores. Statistical analyses were performed using IBM SPSS version 22 that included t-tests and a Pearson correlation analysis.

Results: The subjects selected for the entrance examination affected the average score of the national exam (which is held in February), and the scores of the graduation test (held before the national exam) and the national exam were highly correlated ($r=0.79$, $p=0.00$)

Conclusion: Student study support should be provided immediately after enrollment, especially for students who have not taken the biology exam. We identified a high correlation between the scores for the graduation exam, which is held in December of the senior year, and the national exam, which takes place the following February. Those who failed the graduation exam at this university cannot take the national exam, which is required for the students to be able to graduate.

Keywords: Admission, higher education, medical technology, university

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1. Introduction

Modern universities were established in Japan in the second half of the 1800s. Their role was to train the leaders of society by teaching them about culture and different areas of expertise [1]. In 1949, the old system of higher education was abolished, and a new one was set up based on “the school education law” [2], which stipulated that the purpose of universities was to drive research on specialized arts and crafts, teach applied skills, and impart scientific knowledge.

At present, Japan is experiencing a decrease in the population of 18-year-olds. However, the number of universities is increasing because, according to the Amendment of the Standards for the Establishment of Universities developed in 1991, there is no limit to the number of universities that can be established [3]. This amendment classified the role of universities as follows:

1. Global research and education centers.
2. Highly specialized training for craftspeople.
3. A wide range of professional training.
4. Comprehensive liberal arts education.
5. Education and research in specialized fields (for example, art and physical education).
6. A foundation for lifelong learning.

7. Social contributions (for example, international exchanges, at the local level, and between industry, academia, and government).

As the number of universities and their student capacity has expanded compared to the number of candidates, their quality has become questionable. Until recently, university life has been left to the students, and the educational content was created by the universities and managed according to certification and accreditation criteria (in relation to maintenance, the appropriate operation of the student service system, and the admissions policy). Now that the university is available for all students, universities are required to ensure that attendance is managed and students' motivation is increased.

In addition, the number of medical technology training courses is rising. Approximately 5,000 students from 117 universities, including vocational schools, took the national exam for medical technologists in 2018. The law determines the subjects that qualify, and there is no difference in the amount and content of the classes taken across the different universities. However, the pass rate ranged from 0 to 100%, depending on each university. Increasing pass rates for the national exam are important for universities to acquire students following year, and all universities and vocational schools are working on this issue. For example, upon being admitted, first-year students can take introductory classes to supplement the subjects that they took in high school, and students in their senior year can attend lectures to prepare for the national exam.

These efforts are often based on the past experiences of the department staff. However, while there has been some degree of success, experience-based education has some challenges in terms of continuity. The numerical analysis of data related to the development of educational policies to increase the pass rate can overcome these drawbacks. In this paper, we analyzed exam results data from university medical technologist students to provide evidence that can be used to develop new policies that address these problems.

2. Materials and methods

We examined the following data from medical technology students:

1. The subjects selected for the university entrance exam;
2. The grades from all four years of university;
3. The graduation exam results at the end of the senior year; and
4. The national exam scores.

1. *Participants:* We observed 98 students enrolled in a private medical university in Tokyo from 2015, for four years. Ten students were admitted through the recommended admissions (RA) process, for which a written exam is not required; instead, the applicants need to go through an interview and submit the grades they earned in high school. Eighty-nine students took the written exam (WE), and they were allowed to choose two subjects for this exam from English, Japanese, biology, chemistry, physics, or mathematics; however, choosing English and Japanese at the same time is not permitted. Out of the 89 WE students, 23 selected English for their

university entrance exam, 22 opted for Japanese, 43 chose biology, 18 decided on chemistry, two chose physics, and 70 opted for mathematics. Figure 1 displays the chosen subjects.

2. *Curriculum requirements*: The following is a list of the subjects within the medical technology degree.

- First-year (1st): Medical outline, chemistry I and II, life sciences I and II, clinical physiology I, the human body and its functions [1st and 2nd semesters], information science, basic medical theory, medical mathematics, English I and II, human communication, life morals, and medical sociology.
- Sophomore (2nd) year: Tissue cytology, biochemistry, clinical pathology I, clinical physiology II, testing equipment science, microbiology overview, blood information analysis, immunology I and II, clinical examination overview, medical English, pathology [1st and 2nd semesters], clinical microbiology I, and clinical chemistry I.
- Junior (3rd) year: Clinical cytology, clinical microbiology II, genetic testing, hematology, parasitology, clinical chemistry II, medical electronics, radiology, public health, clinical exam I, human error/risk management, clinical pathology II, inspection management, clinical physiology III, team medical practices, related laws and regulations, and clinical chemistry.
- Senior (4th) year: Graduation exam and national examination.

3. Exam items:

1. The relationships between the subjects chosen by WE students for the entrance exam, the grades they earned after being admitted, their scores on the graduation exam, and their scores on the national exam. These components were compared to the RA students' grades after this group was admitted.
2. A regression analysis was used to examine the total scores of the subjects by year, in addition to the national exam scores.

4. We performed statistical analyses using the software IBM SPSS version 22, and a t-test and Pearson correlation analysis were performed. We assumed that the significant probability p-value, at less than 0.05, was significant.

3. Results

1. We compared the scores of the RA and WE students, after they were admitted to the program.

- We looked at the RA students' scores regarding the two subjects assigned to the first-year students (chemistry I and medical mathematics). They (RA; n=10) had lower scores than the WE students (n=89). For chemistry I, the RA and WE students earned 52.6 ± 19.8 and 66.2 ± 12.6 per 100 points, respectively ($P=0.00$). For medical mathematics, the two groups earned 44.5 ± 35.2 and 68.2 ± 31.0 per 100 points, respectively ($P=0.02$).
- We scrutinized the scores for three subjects (clinical pathology I, microbiology overview, and pathology 2nd semester) assigned to sophomores. The WE

students (n=77) obtained higher scores than the RA students (n=8). For clinical pathology I, the RA and WE students earned 69.4 ± 16.4 and 81.6 ± 11.0 per 100 points, respectively (P=0.01). For microbiology overview, they got 54.4 ± 17.3 and 69.9 ± 16.7 , respectively (P=0.02). For pathology (2nd semester), they earned 34.9 ± 31.6 and 55.9 ± 21.6 per 100 points, respectively (P=0.01). After the end of the sophomore year, in terms of the total scores (1,400 points) from the tests conducted that year, the RA students earned 779.3 ± 282.7 , and the WE students obtained 957.8 ± 225.5 . Subsequently, the WE students scored significantly higher than RA students (p=0.04).

- In relation to the scores for the team medical assignments assigned to juniors, the RA (n=4) and WE (n=61) students earned 72.3 ± 1.5 and 69.2 ± 10.2 per 100 points, respectively. The RA students scored significantly higher than the WE students (P=0.05).
 - On the graduation exam, the RA students (150.8 ± 19.5 ; n=4) scored significantly higher than the WE students (133.3 ± 15.5 per 200 points; n=53) (p=0.04). However, both groups' scores on the national exam did not reveal any differences (150.8 ± 14.2 and 141.1 ± 11.2 , respectively; P=0.11).
2. For the entrance exam, we compared the post-admissions scores between the students who chose English (ES) and those who did not select it (NE).
- Between the ES (n=23) and NE (n=66) students, the scores for three subjects (medical outline, chemistry I, and English II) assigned to first-year students were 70.4 ± 7.6 and 63.2 ± 13.6 , 70.7 ± 10.0 and 64.6 ± 13.1 , and 77.6 ± 13.6 and 70.1 ± 12.7 per 100 points, respectively. The ES students scored significantly higher than the NE students (P=0.02, P=0.04, and P=0.04, respectively).
 - Between the ES (n=18) and NE (n=59) students, the scores for three subjects (clinical physiology II, microbiology overview, and medical English) assigned to sophomores were 67.6 ± 10.5 and 61.0 ± 10.7 , 76.8 ± 14.0 and 67.6 ± 17.0 , and 84.7 ± 8.8 and 76.0 ± 12.5 per 100 points, respectively. The ES students scored significantly higher than NE students (P=0.02, P=0.04, and P=0.00, respectively).
 - Between the ES (n=16) and NE (n=45) students, the scores of three subjects (radiology, clinical physiology III, and clinical chemistry) assigned to juniors were 86.1 ± 9.7 and 80.3 ± 8.6 , 70.5 ± 8.8 and 65.0 ± 8.5 , and 88.3 ± 4.8 and 83.5 ± 8.4 per 100 points, respectively. The ES students scored significantly higher than the NE students (P=0.03, P=0.032, and P=0.03, respectively).
 - There was no difference between ES (n=14) and NE students (n=39) in subjects (graduation exam and national exam) assigned during the senior year (P=0.07 and P=0.58, respectively).
3. For the entrance exam, we compared the post-admissions scores of students who opted for Japanese (JS) and those who did not choose it (non-selected, NJ).
- Between the JS (n=22) and NJ (n=67) students, the scores for seven subjects (medical outline, chemistry I and II, life sciences I, clinical physiology I, medical mathematics and English II) assigned to first-year students were

60.6±1.48 and 66.8±11.3, 60.1±16.5 and 68.1±10.5, 56.7±22.8 and 66.9±15.6, 64.1±26.7 and 76.9±11.0, 69.4±26.4 and 80.5±20.2, 53.6±34.1 and 72.9±28.6, and 67.4±1.6 and 74.4±10.5 per 100 points, respectively. The JS students scored significantly lower than the NJ students (P=0.04, P=0.01, P=0.02, P=0.04, P=0.04, P=0.01 and P=0.03, respectively). Regarding the total scores of the subjects, the JS students scored lower (1075.2±305.6 per 1,600 points) than the NJ students (1200.9±198.6 per 1,600 points; p=0.03).

- Between the JS (n=18) and NJ (n=59) students, the scores for three subjects (biochemistry, clinical physiology II, and blood information analysis) assigned to sophomores were 60.0±10.1 and 66.7±15.1, 57.1±10.0 and 64.2±10.8, and 60.1±22.1 and 73.3±17.2 per 100 points, respectively. The JS students scored significantly lower than the NJ students (P=0.04, P=0.02, and P=0.01, respectively).
- Between the JS (n=12) and NJ (n=49) students, the scores for three subjects (radiology, human error/risk management, and team medical practices) assigned to juniors were 76.6±10.4 and 83.0±8.5, and 72.0±7.7 and 78.1±8.3, and 63.1±12.8 and 70.7±9.0 per 100 points, respectively. The JS students scored significantly lower than NJ students (P=0.04, P=0.03, and P=0.02, respectively).
- There was no difference between the JS (n=8) and NJ (n=45) students for the subjects (graduation exam and national exam) assigned to seniors (P=0.79 and P=0.39, respectively).

4. For the entrance exam, we compared the post-admissions scores between students who opted for biology (BS) and those who did not (non-selected, NB).

- Between the BS (n=43) and NB (n=46) students, the scores for six subjects (the human body and its functions [1st and 2nd semesters], life sciences I and II, clinical physiology I, and basic medical theory) assigned to first-year students were 76.1±14.9 and 69.1±15.3, 72.5±18.2 and 62.5±21.3, 78.0±17.8 and 69.8±15.5, 81.0±15.2 and 72.3±21.6, 84.1±17.8 and 71.9±24.5, and 82.5±15.6 and 71.8 and 22.1 per 100 points, respectively. The BS students scored significantly higher than the NB students (P=0.03, P=0.02, P=0.025, P=0.03, P=0.01 and P=0.01, respectively).
- Between the BS (n=39) and NB (n=38) students, the scores for seven subjects (tissue cytology, clinical pathology I, microbiology overview, blood information analysis, immunology I and II, and clinical examination overview) assigned to sophomores were 74.3±14.1 and 63.0±15.7, 85.9±9.3 and 77.4±11.1, 74.8±15.2 and 64.9±16.8, 75.7±17.4 and 64.8±19.4, 58.1±14.1 and 49.1±15.6, 66.4±19.7 and 55.9±24.4, and 59.4±19.5 and 47.1±17.6 per 100 points, respectively. The BS students scored significantly higher than the NB students (P=0.00, P=0.00, P=0.01, P=0.01, P=0.01, P=0.04 and P=0.00, respectively).

After the end of the sophomore year, in terms of the total scores (1,400 points) from the tests conducted that year, BS students earned 1007.1±234.1, and NB

students obtained 886.5 ± 224.3 , and the BS students scored significantly higher than NB students ($p=0.02$).

- Regarding the scores for two subjects (clinical microbiology II and public health) assigned to juniors, the BS ($n=33$) students (82.1 ± 11.4 and 71.9 ± 17.3 , and 72.8 ± 6.8 and 68.6 ± 9.2 per 100 points, respectively) scored significantly higher than the NB ($n=28$) students ($P=0.01$ and $P=0.05$, respectively).
- There was no difference in scores on the graduation and national exams between the BS ($n=28$) and NB ($n=25$) students ($P=0.85$ and $P=0.34$, respectively).

5. For the entrance exam, we compared the post-admissions scores between students who selected chemistry (CS) and those who did not (non-selected, NC).

- Between the CS ($n=18$) and NC ($n=71$) students, the scores for two subjects (chemistry I and medical mathematics) assigned to first-year students were 71.8 ± 8.0 and 64.7 ± 13.2 , and 81.4 ± 23.1 and 64.8 ± 32.0 per 100 points, respectively. The CS students scored significantly higher than the NC students ($P=0.03$ and $P=0.04$, respectively).
- Regarding the scores for the microbiology overview course assigned to sophomores, the CS students scored significantly lower (62.1 ± 15.1 per 100 points; $n=17$) than the NC students (72.0 ± 16.6 per 100 points; $n=60$) ($P=0.03$).
- Regarding the scores for two subjects (clinical microbiology II and parasitology) assigned to juniors, the CS students ($n=14$) obtained 69.6 ± 18.4 and 79.7 ± 13.5 , while the NC students ($n=47$) earned 68.8 ± 11.8 and 76.5 ± 11.7 per 100 points, respectively. The CS students scored significantly lower than the NC students ($P=0.03$ and $P=0.03$, respectively).
- There was no difference between the scores of the CS ($n=14$) and NC ($n=39$) students for the graduation and national exams ($P=0.27$ and $P=0.09$, respectively).

6. For the entrance exam, we compared the post-admissions scores between students who chose mathematics (MS) and those who did not (NM).

- There was no difference in scores for all subjects assigned to first-year students between the MS ($n=70$) and NM ($n=19$) students ($P>0.05$).
- Between the MS ($n=60$) and NM ($n=17$) students, the scores for six subjects (pathology [1st semester], clinical pathology I, immunology I, clinical examination overview, medical English and clinical chemistry) assigned to sophomores were 59.9 ± 15.5 and 71.1 ± 11.4 , 79.7 ± 11.1 and 88.5 ± 8.0 , 51.7 ± 15.7 and 60.4 ± 13.1 , 50.3 ± 19.1 and 63.5 ± 17.6 , 76.9 ± 13.4 and 82.4 ± 5.3 , and 59.1 ± 24.3 and 71.5 ± 12.6 per 100 points, respectively. The MS students scored significantly lower than the NM students ($P=0.01$, $P=0.00$, $P=0.04$, $P=0.01$, $P=0.02$ and $P=0.05$, respectively).
- There was no difference between the MS ($n=45$) and NM ($n=16$) students for the subjects assigned to juniors ($P>0.05$).
- There was no difference in the scores for the graduation and national exams between the MS ($n=41$) and NM ($n=12$) students ($P>0.05$).

7. We did not show the post-admission scores between students that chose physics and those who did not choose due to the small target number (n=2)

8. We compared the total scores of the subjects conducted annually in addition to the scores for the national exam. Figures 2 to 5 display the results.

- The regression equation, which examines the difference between the total score of the tests carried out in the first year and the scores for the national exam held at the end of senior year, is the score on the national exam = 0.05×total score of tests in the first year + 84.3, R²=0.303 (P=0.00)
- The regression equation, which examines the difference between the total score of the tests carried out in the sophomore year and the scores for the national exam held at the end of senior year, is the score of national exam = 0.05×total score of tests in the sophomore year + 91.9, R²=0.510 (P=0.00)
- The regression equation, which examines the difference between the total score of the tests conducted in the junior year and the scores for the national exam held at the end of the senior year is the score of the national exam = 0.03×total score of the tests in the first year + 98.3, R²=0.297 (P=0.00)
- The scores for the graduation and national exams, carried out at the end of the senior year, is the score of the national exam = 0.6×score of graduation exam + 60.1, R²=0.986 (P=0.00)

4. Discussion

1. From this study, we conclude that the admission system exerts an influence on the students' grades after admission. Grades during the first two years depended on the subjects the applicants chose for the entrance exam. In particular, the results demonstrate that it is necessary to provide additional lectures to students early after university admission who do not take biology in high school, or who choose Japanese on the entrance exam so that they can respond quickly to university lectures.

The role of higher education in Japan has diversified. Medical universities specialize in training health professionals, and the role of medical universities does not include training the leaders of society by teaching them about culture and the different areas of expertise in liberal arts education. In particular, the role of private colleges is to assist their students with obtaining licenses as medical personnel such as medical doctors, nurses, and medical technologists. It is important for universities to train their students so that they can pass university exams throughout their studies and obtain medical licenses after university. However, the admission system, including recommendation entrance and entrance by written examination, has also diversified, and subsequently, it is important to consider the education of students enrolled in different ways. In addition, some research has demonstrated that there is a difference in students grades after admission depending on the admission system [4, 5, 6].

2. In this study, with the aim of improving post-admission education in a medical technology training course, we analyzed the relationship between the type of exam subject upon being admitted, the grades earned in the subjects studied at university

(from the first year to the senior years), and the scores of the national exam for medical technologists. The target students were RA and WE students, and the results for the RA students are announced in October, before the announcement of the entrance exam that is based on a choice of two subjects.

The problem is that once the RA students pass the entrance exam, they do not study again until they are admitted to the university, and they spend less time studying than WE students. Subsequently, the scores of the RA students tend to be lower in several subjects during the first and sophomore years. However, some research has demonstrated that opposite results. Nishimura et al. (2017) found no difference between the grades of RA and WE students and concluded that this is due to the efforts of the students after being admitted [7]. In this study, the RA students scored lower than the WE students in the post-admissions exams. During the first year, the scores for two subjects (chemistry I and medical mathematics) were lower, and during the sophomore year, the scores for three subjects (clinical pathology I, microbiology overview, and pathology) were lower. However, in the second half of the four-year period, the RA students were able to recover their grades. The RA students were selected based on documents from their high schools and an interview screening. They had the top grades in high school and are considered academically talented. With regard to teaching after RA students are admitted, it is necessary to create supplementary classes that focus on chemistry-related subjects.

In terms of the subjects taken after the sophomore year, ES students scored significantly higher than the NE students for three years after being admitted. However, for many subjects, the JS students scored lower than the NJ students. The option of English and science (such as biology and chemistry) for the entrance exam seemed comprehensible compared to other choices. It is necessary to examine students who select Japanese as well as RA students and to provide post-admissions guidance to these students. For subjects such as mathematics, chemistry, and biology, the latter has had the greatest impact on post-admission results. In particular, the BS students earned high scores for six subjects during the first year and eight subjects in the sophomore year.

For students who chose mathematics, interestingly, the scores for six subjects assigned to the sophomores decreased considerably. The total score of 70 students who opted for mathematics included 27 that chose biology and nine students who chose Japanese as a second subject. There was no difference in the scores of these six subjects between the students who chose biology and those who selected Japanese (data not shown).

Generally speaking, the differences in the scores were eliminated in the senior year, and the students were able to improve their academic ability over the 4-year period. During this time, a total of 42 out of 99 students dropped out of university. In order to eliminate these students, it is necessary to strengthen basic academic ability by using supplementary classes, and an awareness of the study's purpose should be encouraged at an early stage post-admissions.

The importance of these results provides a basis for understanding when to focus on student education. This indicates that it is necessary to provide additional lectures to

students who do not take biology in high school, or who choose Japanese for the entrance exam early after university admission so that they can respond quickly to university lectures. These results also demonstrate that this study supports previously reported results [4, 5].

We identified a high correlation between the scores for the graduation exam, which is held in December senior year, and the national exam, which takes place the following February. Those who failed the graduation exam at this university cannot take the national exam to graduate. The results of the graduation exam were discovered to be effective in judging whether the students have passed. To increase the national exam pass rate, education on how to pass graduation exams is necessary. At the same time, learning effort from students is required, and a mechanism for encouraging their effort is also required.

3. The results were obtained from four years of research, and a study that followed a single group produced highly reliable results. In comparison to previous reports, these results seem to be generalizable. As university entrance exam results are not disclosed, a comparison between the entrance exam results and scores after admission could not be completed. If these data were clear, a more detailed conclusion could be drawn

5. Conclusion

There was a difference in the student grades, depending on their entrance examination system. However, the difference was resolved by the second year, and we identified a high correlation between the scores for the graduation exam, which is held in December in the senior year, and the national exam, which takes place the following February.

In this study, we aimed to formulate an education policy, and we conclude that, first, in the first year of admission, it is necessary to ensure that high school subjects are thoroughly studied. Second, those who failed the graduation exam at this university cannot take the national exam to graduate.

The purpose of higher education is to give students the ability to think for themselves as effective members of society, and to provide them with the knowledge to pass the national exam.

6. Declaration of conflicts

There are no conflicts to declare.

7. Authors' Biography

Dr Kazuo Goto: is a Professor at Teikyo University in Tokyo, Japan. He obtained his Doctor in Health Science (2000), and has contributed at levels of teaching and research in the area of Laboratory Medicine, Medical Technology and Laboratory 5animal Medicine. His research interest includes creation of human disease model

animals using genetic modification, search of infectious diseases of mouse and human, and education of medical technologist. He has served as a reviewer of international journals and conferences: as well as session chair at conferences.

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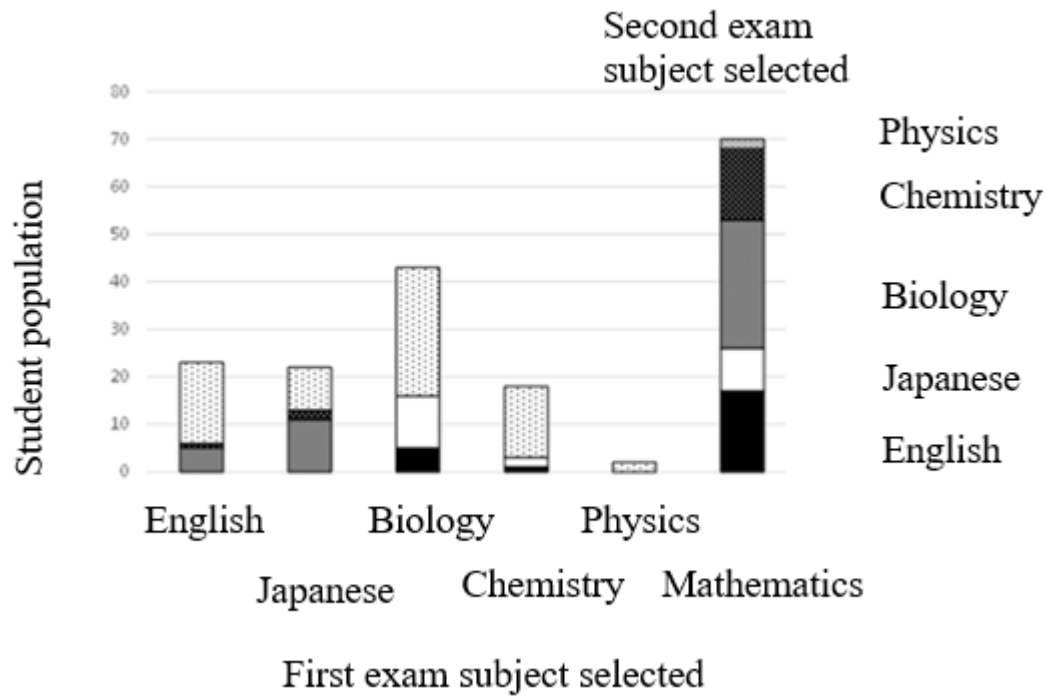


Fig. 1. Two subject choices and student population.

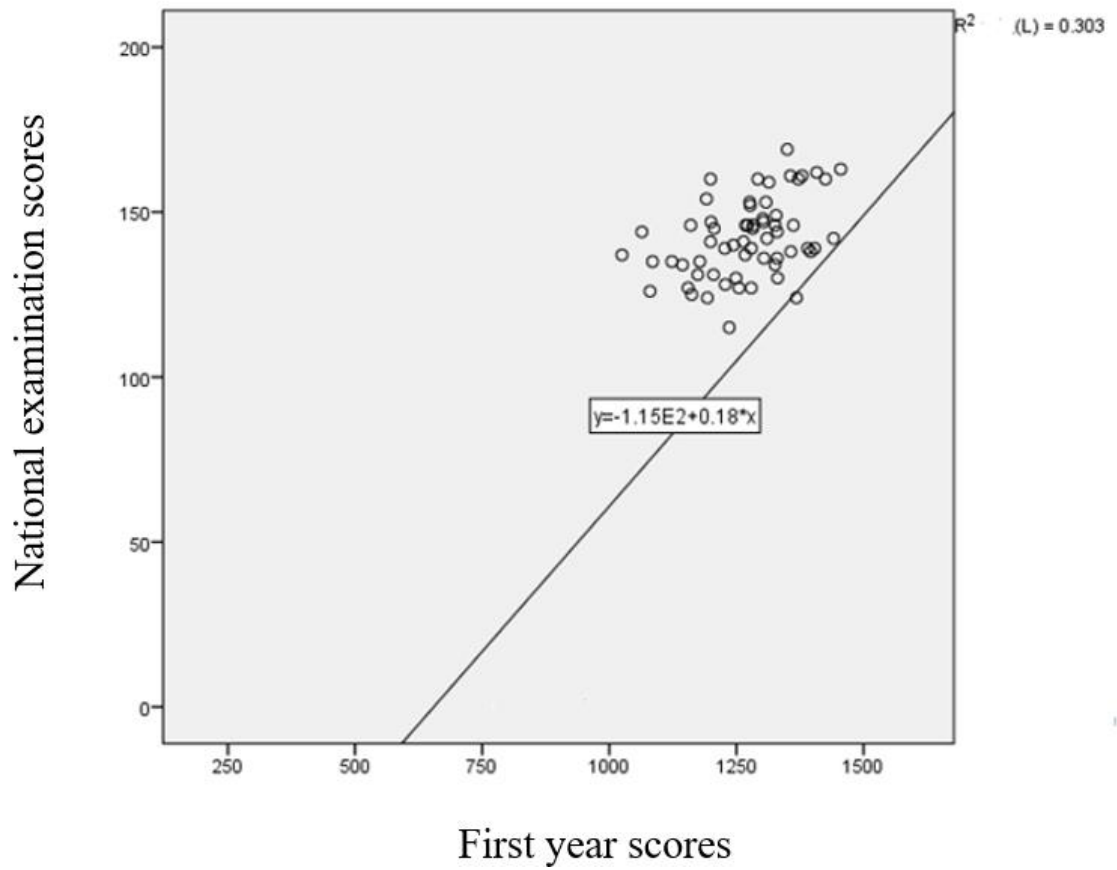


Fig. 2. Comparison of the average score from the first year and the scores for the national exam for medical technologists.

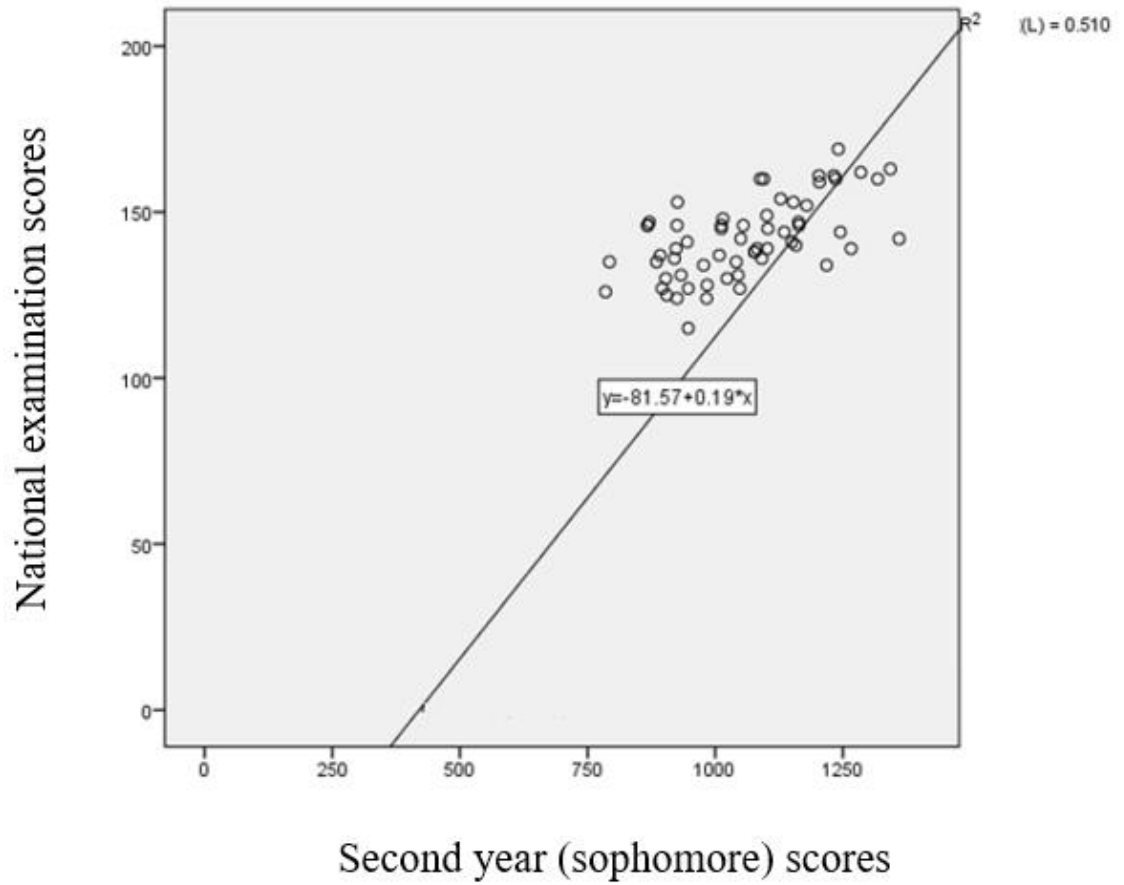


Fig. 3. Comparison of the average score in the sophomore year and the scores for the national exam for medical technologists.

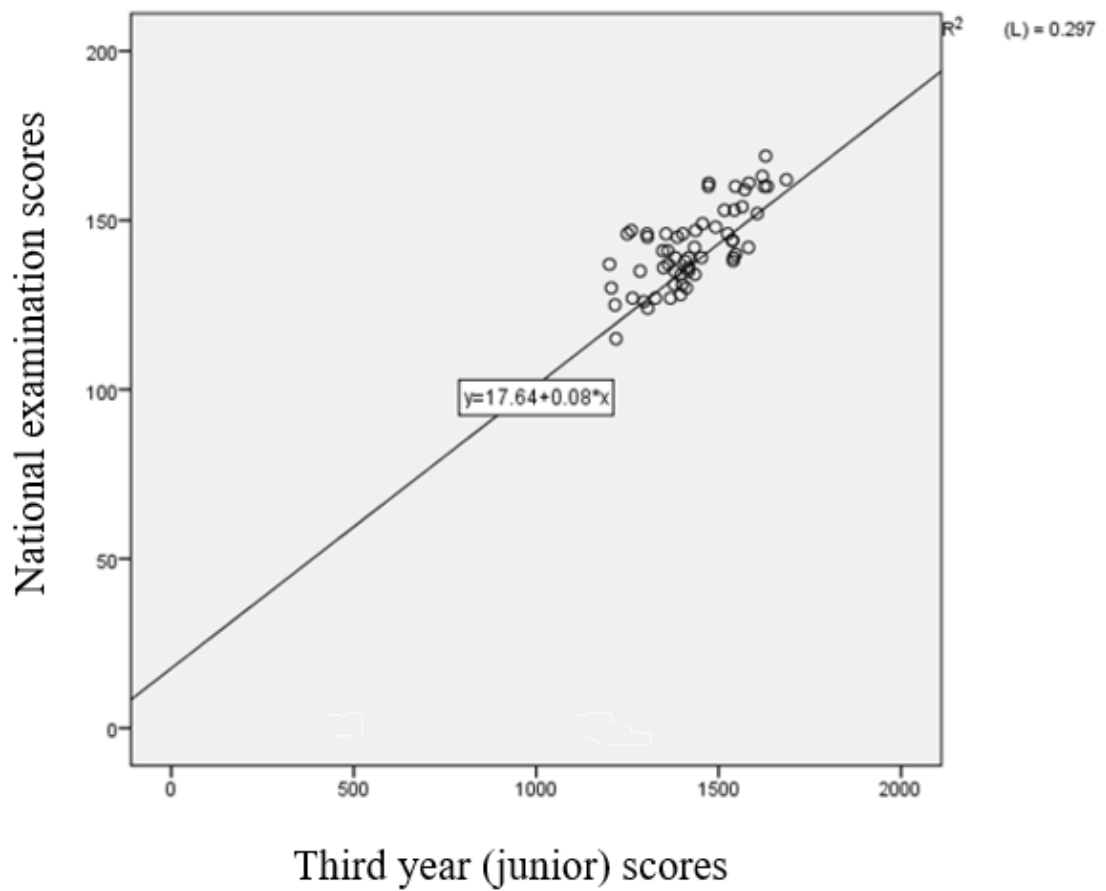


Fig. 4. Comparison of the average score from the junior year and the scores for the national exam for medical technologists.

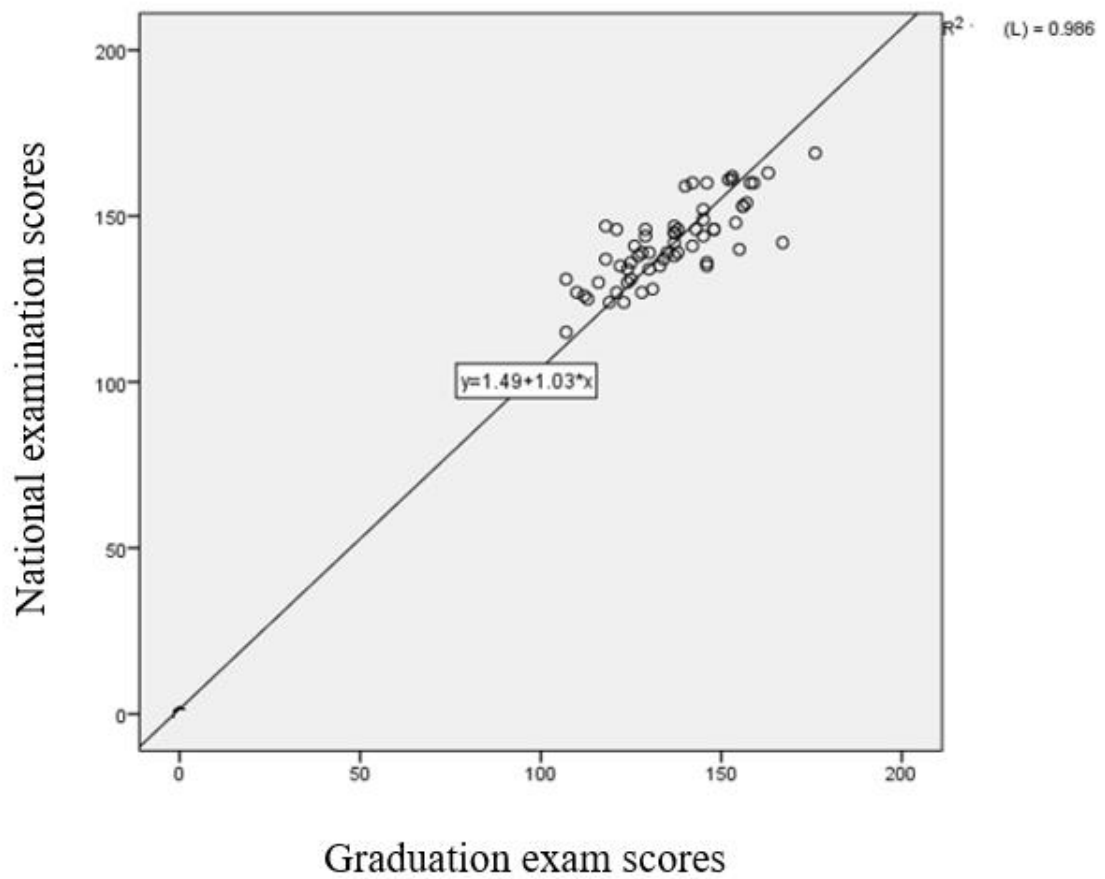


Fig. 5. Comparison of the scores for the graduation exam (senior year) and the national exam for medical technologists.

Table 1. Significant difference in RA* and WE** scores, or selected or non-selected students.

Years after being admitted	Number of subjects observed	RA	Selected subjects (WE students)				
			Engl ish	Japa nese	Biolo gy	Chem istry	Mathe matics
First year	16	2 L*** (n=10)	3 H (n=23)	7 L (n=22)	6 H (n=43)	2 H (n=18)	0 (n=70)
Sophomore	15	3 L (n=8)	3 H (n=18)	3 L (n=18)	7 H (n=39)	1 H (n=17)	6 L (n=60)
Junior	17	1 H (n=4)	3 H (n=16)	3 L (n=12)	2 H (n=33)	2 H (n=14)	0 (n=45)
Senior	2	1 H (n=4)	0 (n=14)	0 (n=8)	0 (n=28)	0 (n=14)	0 (n=41)

*RA: Students enrolled through recommended admissions

**WE: Students enrolled through the written exam.

***L: Score of RA students were lower than WE students.

****H: The score of RA students were higher than WE students.

For example, 2L suggests that the scores for two subjects taken by RA students were lower than the scores of WE students