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Case Study on Difference between Attitudes of Students in a Science-Mathematics Course and Science Class in an Ordinary Course in a Senior High School

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Abstract: The high school wants to provide the students with many opportunities to come in contact with the research of the universities, in order to nurture an interest in the study of science-mathematics. A high school "A" in Japan established a science-mathematics course comprising two classes and an ordinary course comprising eight classes. The science-mathematics course is run in cooperation with two universities and a research office. We gave questionnaires to third graders in both courses in order to find out whether the science-mathematics course has achieved its goal. Comparisons between the two courses were made and it was revealed that students in the science-mathematics course had more interest in and more knowledge about science and mathematics than those who attended the science class in the ordinary course.

Key words: course of science-mathematics, science class in ordinary course, questionnaire, attitudes

1. Introduction

In order to produce talented people who will be excellent in the fields of science and mathematics, science-mathematics courses are provided in many schools in Japan. The science-mathematics course aims to promote students' interest in the fields of science and mathematics. For this purpose, schools are cooperating with universities and increasing opportunities to meet with more university researchers in accordance with the 15th term Central Council for Education (Ministry of Education, 1999a). Students enrolled in a science-mathematics course may consider majoring in science when they are on the verge of attending a university at their junior high school graduation and are about to enter senior high school.

With regard to the course, characteristic subjects, such as introduction to natural science, problem study, etc., are introduced from the freshman year onward in order to develop independent thinking among individuals and richly expressing self-opinion in sentences or through non-verbal media. Recently, there has been increased cooperation with a university for conducting introduction to natural science and problem study (Suzuki, 2001; Miyaji et al., 2001).

Students in an ordinary course at high school "A" take classes for one year without differentiating liberal arts and science class. Then, they choose any one among the liberal arts and science classes in the beginning of their second year. Students in a science class in the ordinary course include those who chose science in the second year.

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The questionnaire that was conducted four times among the senior students in the science-mathematics course (hereafter referred to as SM class) was analyzed. The findings indicate that students in the SM class are deeply interested in the fields of science and mathematics as the characteristic subject, and they were particularly aware of both the difficulties and the joys of research (Miyaji, 2010).

In order to find out how third-year students in the science-mathematics course are faring, a questionnaire on lessons taught in senior high school “A” was distributed among the students enrolled in the science class in the ordinary course (hereafter referred to as SO class) and among those in the SM class in September. The attitudes of both students were compared on the basis of nine items. Furthermore, we compared the attitudes of students in both the SM and SO classes with regard to their abilities and experiences of their accomplishments. A significant difference would be recognized by the deflection of the number of persons. These results revealed that the SM class met almost all the purposes determined by the school.

The number of credits taken during the SO and SM classes and the characteristic subjects in the SM class are described in Chapter 2. A change of attitudes in the students in SM class through the lesson is described through an analysis of the questionnaires survey conducted in Chapter 3. The difference in the attitudes of the students in both classes is compared in terms of some items in Chapter 4.

2. Features of the SM and SO Classes in High School “A”

2.1 Number of Credits

According to the standard number of credits that the Ministry of Education, Culture, Sports, Science, and Technology have defined, the number of credits in the SO and SM classes in high school “A” are predetermined. As shown in Table 1, the SO class has three more credits for “Japanese language” and “English”. The SM class has four more credits for “mathematics” and “science” (Ministry of Education, 1999b). Although there are three more total credits for the SM class, the ordinary course has one more credit for “geography and history”, “health and physical education”, and “art”. Although not shown in Table 1, the total number of credits for both classes are 96.

Table 1 The Number of Credits of the Main Subjects

Subject	Affiliation	First year	Second year	Third year	Total
Japanese	SO class	5	6	5	16
	SM class	5	4	5	14
English	SO class	6	6	6	18
	SM class	5	6	6	17
Mathematics	SO class	5	6	7	18
	SM class	5	6	8	19
Science	SO class	3	6	8	17
	SM class	6	6	8	20

2.2 Course Subjects

The ordinary course in High School “A” includes experiments and training, while developing content which attaches great importance to the basics and fundamentals. The students are divided into liberal arts and science classes on the basis of the course of study in the second year. Both classes have various elective subjects suitable for the course of study.

The science-mathematics course in high school “A” has the following characteristics:

(1) Taking advantage of the recommendation from the 15th term Central Council for Education (Ministry of Education, 1999a), the interests of students in the science-mathematics course are promoted through the classes in cooperation with the university.

(2) The traditional learning method of “memorizing knowledge” is replaced by the development of a person “who can think with his head and express coherently”, this enables students to subsequently decide on suitable career options.

The subjects in the science-mathematics course are “Introduction to natural science”, “Computer I”, and “Problem Study”. Their contents are explained below. The change in attitudes influenced by each subject is explained.

3. Changes in Science-Mathematics Course

3.1 Lesson Practice of Introduction to Natural Science, and Promoted Interest

“Introduction to natural science” is a one-credit subject from the science-mathematics course, and is conducted during the freshman year. The goal of this subject is to promote development of the basic ability of being able to see and consider nature synthetically and by association, while fostering interest in the development of scientific technology through research activities in fundamental concepts, such as a principle, a law, etc. in natural science and mathematics. The 35 hours of instruction during the year are divided into five parts. Lessons of physics, chemistry, biology, geoscience, and math are performed for seven hours per each subject. Visiting lecturers (e.g., university teachers, etc.) take charge of the content, as shown in Table 2, for the last two hours of each division. The high school teacher who takes charge for five hours of each division makes arrangements with the visiting lecturer beforehand, and draws up a guidance plan so that students may understand the lecture’s contents of the visiting lecturer.

Table 2 Example of Lesson Contents in Introduction to Natural Science

Month	Field	Contents of visiting lecturer
Apr.–May	Physics	Measurement of the muon using a particle telescope
Jun.–Jul.	Biology	Visit of Hayashibara Biochemical Lab.
Sep.–Oct.	Geoscience	Earthquakes and their mechanism
Nov.–Dec.	Mathematics	From plane geometry to spherical surface geometry
Jan.–Feb.	Chemistry	Right and left in the organic compound

Each student’s impressions of the course content are described on one sheet of writing paper, which is scored as a part of an evaluation after they are taught by the high school teachers and a visiting lecturer. For example, the following are comments regarding the physics field conducted during April and Mays: “It was a big surprise to understand that mechanism of spaces could be explained from a small thing called a cosmic ray”; “Although videos of Super-Kamiokande have been viewed before, I only finally realized at length what it was about.”

Students responded to the question “Did the class of introduction to natural science interest you?” through a five-response evaluation (1. Did not change, 3. Was slightly interested, 5. Was interested) (number of respondents, N = 74). It was found that 79% of students responded to ratings 3 to 5 when these were totaled (average value, m = 3.6). For the question “Was the interest in natural science promoted attending the class of introduction to natural science?", students chose from four responses (1. Not at all, 2. Not so much, 3. Promoted, 4. Very much promoted) (N = 74). When ratings 3 to 4 were totaled, it was found that 74% of students answered that the interest in natural science was promoted (m = 2.9).

Forty-eight students (65%) have decided to go on to university studies. Thirty-nine students (53%) hope to enter the faculty and the department of science. Forty students (54%) have decided on their future employment. Twenty-eight students (38%) hoped to obtain employment related to natural science. Two students (3%) have decided to enter the university faculty and department of natural science in the future. No student has decided to take up employment in natural science. This lesson influenced three students (4%) to decide their research themes of the problem study.

Although these figures do not have much influence on the selection of a university or decision of an occupation, they indicate that almost all students developed an interest in natural science through lessons on the subject.

3.2 Contents of Computer I and Promoted Interest

"Computer I" is taught during the freshman year for one credit. While making the meaning and the role of computers in modern society understandable, through operation of a computer, it aims at fostering the usage of various application softwares and the skills and attitude required for processing information appropriately. Major content areas include the role of computers in modern society, the function and composition of a computer, basic operations of a computer, the use of Word, Excel, PowerPoint, and the Internet, etc.

Each student had access to a personal computer. Four tasks were assigned during the year. Students completed these tasks and submitted reports. Based on a team-teaching approach, five teachers in each class instructed students. Since there are considerable differences in individual skills, the computer room was left open for students to address problems after school hours.

Students responded to the question "What do you think about the computer I class?" on a four-point rating scale (1. Not helpful at all, 2. Not helpful, 3. Helpful, 4. Very much helpful). It was found that 80% of students gave a rating of 3 or 4 (N = 74, m = 3.1).

Students responded to the question "Did you take advantage of this class for your problem study?" on the basis of a four-point rating scale (1. Not at all; 2. Not so much; 3. Yes; 4. Absolutely yes). It was found that 87% of students gave a rating of 3 or 4 (N = 74, m = 3.3).

For the question "Which contents of this class were the best?", students responded that the best content was in the order of PowerPoint (47%), Excel (22%), the Internet (20%), and others (13%).

Because of attending this class, one student decided to attend a university, faculty, or a department in the field of natural science. However, none of the students decided to work in the field of natural science in the future. Moreover, none of the students had decided their research theme on the basis of this class.

Although this class has almost no influence on entry into a university nor on the selection of an occupation, almost all the students were satisfied with it. It is actually particularly useful for problem study.

3.3 Details of Problem Study, and Promoted Interest

"Problem study" is conducted during the second-year for two credits. As shown in Table 3, 80 students worked on 23 research themes in a fiscal year. Each group comprised two to six students. Further, 14 mathematics and science teachers took charge of the themes that they were responsible for. A teacher instructed one to four themes for two consecutive fifth and sixth hours on Fridays. Problem study was conducted under the instruction of the teacher in charge. The building for experiment and training was established as a facility for problem study. Each group conducted their study in the building, a computer room, and an experimental laboratory.

Table 3 Themes Classified by the Field of Problem Study

Field	Theme of study
Physics	Superconducting I, II; Sound and vibration; Solar car and a solar battery; Study of electron beam; Wonder of the size of the drop pf water; A bleep; A self-run type robot; Physics robot production; Study of the autonomous type robot
Chemistry	About the property and composition of the soap; A battery; Studying the situation of water pollution of a river
Biology	The reproduction and habits of planarian; Structure and the evolution of eyes; The world of the microbe
Geoscience	Observation of the sunspot
Mathematics	About a cipher I, II; About the golden ration; Truth of the parabola

A briefing session was held during the third term in the first year. The area of research and the research group were then decided. During spring vacation, students conceived of the content of their theme. Survey research began under instruction of the teacher in charge in April of the second year. The interim meeting for the presentation was held during the summer vacation. The students evaluated peer study contents and enumerated questionable aspects. The students continued with additional research after referring to the evaluation and other aspects.

All students studied everything that was expected of them in the second term. The campus trial meeting was held on the basis of the field of study (physics, chemistry, biology, geology, and mathematics) at the end of December. Many students (or groups) stayed up late at night (around 9 pm) to study before the campus trial meeting in December. A manuscript was drawn up and distributed to the students and teachers who listened to the presentation. This presentation involved slides created by PowerPoint. All groups used computers and a projector. The trial presentation time was seven minutes for each group. During this trial meeting, one or two groups were selected as representative for each field. Seven groups were elected on the whole.

The students also studied until late at night before the joint presentations held in February and before the paper deadline in early March. Studying “computer I” during the freshman year helped in the preparation for the summary stage.

The groups that were selected to become the representatives at the campus trial meeting made presentations at the campus presentation workshop for problem study in the SM class in January in the third term. The presentation time was 10 minutes in which a presentation and a question-and-answer session was conducted. A first year student participated in this meeting. These representation groups also attended a joint presentation workshop in the SM class at the prefecture where the school is located. Finally, contents of study among each group was summarized and incorporated into the graduation thesis. This thesis comprises less than eight pages of A4-size paper and was made available by the beginning of March. Then, a second year student exhibited various research subjects by all groups to a panel; the exhibition was held in five rooms in the school in March. This presented an opportunity to explain research work to freshman students. During this time, the first year student, after listening to the talk from a senior second year student, will decide on his theme. The freshman student is thus made to think and decide early on what he wants to do at the presentation meeting for problem study in the SM class.

Six groups, shown in Table 4, went directly to the laboratory of C university, D university, or the research institute. They corresponded via a phone and mail, and received guidance from a teacher in a university or a researcher in a research institute (Miyaji et al., 2001). During the summer vacation, these students visited the university in order to understand what they were expected to do. However, in almost all cases, the direct answer was not obtained from teachers in the university. The students were admonished in the following manner: "It have already been studied so far. You have to propose an idea and turn a paper in the near future." Thus, the students received a hint with respect to what they must study. Their next plans were elaborated and studied.

Table 4 Problem Study Instructed by Staffs in A University

Theme of study	Leader for research
Superconducting	Professor in Dept. Applied Physics, Faculty of Sci. Univ. "D"
Electron beam	Associate Professor in Dept. Physics, Faculty of Sci. Univ. "C"
Physics robot production	Professor in Dept. Sys. Eng., Faculty of Eng. Univ. "C"
Battery	Professor in Dept. Material Applied Chemistry, Faculty of Eng. Univ. "C"
Situation of water pollution and cleansing of a river	Teacher in prefectural technical high school "B"
Observation of the sunspot	Professor in Dept. Earth Sci., Faculty of Sci. Univ. "C"

On the other hand, students responded to the question "How was the problem study class?" through one of four responses (1. Not pleasurable at all; 2. Not pleasurable; 3. Pleasurable; and 4. Very much pleasurable). It was found that 69 students who found the classes pleasurable responded with ratings 3 or 4 (93%, N = 74, x = 3.5). With regard to the reasons why they found the class pleasurable, 8 categories were obtained from 48 students (65%), as shown in Table 5: "I am fulfilling the research that I'm interested in for one year", "Cooperation with others have been carried out", "I could pursue what I had not understood before for one year", "I discovered things that I did not think of before", etc. It was found that 43 students (94%) of those who answered the survey described that interest in science was encouraged by pursuing their research subject.

Table 5 Reasons Given for Why the Problem Study was Pleasurable

Reason	Frequency
It was good to be able to do research continuously for one year	10
We thought independently and were able to study freely	10
My interest in examination and research increased	9
I was able to learn various things	8
I was able to pursue what I did not understand	4
I was able to cooperate	2
Others	5
Total	48

Further, 74 students provided 305 descriptions to the statement "thing learned through the class of problem study". From among these, 11 items were categorized. These were arranged in order of descending frequency, as shown in Table 6. The categories suggest that the students have studied the difficulties and pleasures associated with research. Moreover, they felt and understood that cooperation is also important in conducting the research. It turned out that they became deeply interested in the science and mathematics fields through the problem study.

The ability and attitudes of students that were influenced by the problem study are presented in Table 7; a five-point rating scale was used for this purpose (1. Not appropriate; 2. Not so appropriate; 3. Cannot determine; 4. Appropriate to a certain degree; 5. Appropriate). The mean values of these 11 items ranged from 3.7 to 4.2. It was examined by the t-test whether average rating values deflect to an affirmative side or a negative side in association with “3. Neutral”. As a result, the average rating value for all 11 items deflected significantly to the affirmative side at a 0.1% significant level as shown in the right side of Table 7. It means that students recognized that they have improved in the following abilities: information collection ability (m = 4.2), effective usage of a computer (m = 4.1), popularity of a computer in terms of usage (m = 4.1), knowledge of a computer (m = 4.1), feelings of accomplishment (m = 4.1), and increase of the interest in computers (m = 4.0), etc.

Table 6 Things Learned through the Problem Study

Contents	Frequency
Difficulty of research	62
Pleasure of research	58
Importance of cooperation	41
Method and technical skill of experiments	29
Importance of research	27
Importance of discussion	25
Pleasure of natural science	16
Course determination such as a future target and the purpose	15
Deep understanding of natural science	9
Importance of natural science	8
Others	16
Total	316

Table 7 Ability and Attitudes Promoted by Problem Study

Items	m	SD	t	p
Ability to collect information	4.2	0.9	11.6	***
Expanse of effective use and utilization of computer	4.1	0.9	10.7	***
Expanse of method for computer use	4.1	0.9	10.1	***
Understanding of computers	4.1	1.0	9.7	***
Feeling sense of fulfillment	4.1	1.0	9.1	***
Interest in computers	4.0	1.1	7.5	***
Ability to express self-opinions	3.8	1.0	7.5	***
Ability to create something	3.8	1.0	6.7	***
Ability to complete something perfectly	3.8	1.0	6.7	***
Ability to think	3.7	0.9	6.5	***
Ability to objectively see self problem study	3.7	1.0	5.5	***

3.4 Development of Interests, Except in Section 3

Responses to free descriptions regarding “what kind of change was there through the lesson in the science-mathematics course by now?” was calculated. The response of 53 students (71%) were obtained from among 75 students. These responses were classified into six categories, as shown in Table 8. The following are examples of typical responses: “I became interested in research,” “I came to consider deeply about one thing,” “I became interested in the scientific issue of personal appearances,” “I came to regard science as interesting.” These responses convey that almost all students developed an increased interest in natural science and came to appreciate more deeply the natural and personal phenomena related to the subject. These findings show that the purpose of developing persons who could think and express their thoughts well was achieved.

Table 8 Aspects Developed by Lessons in the SM Class

Contents	Frequency
Interest in and, likes and dislikes for subjects of science and mathematics	17
Interest in natural science	10
Importance of consideration	6
Interest in research	4
Dislike for subjects of science and mathematics	4
Others	9
Total	53

4. Differences between Attitudes of Students in the SO and SM Classes

A questionnaire survey comprising 11 common items was conducted among third-year students in both SO and SM classes in September. The number of students who answered the questionnaire in the SO class was 112 among three classes. Those in the SM class were 75 between two classes. Results on the analysis for eight items were compared in the following manner.

4.1 The Reason Why Affiliation of Students Was Desired and Difference in Developed Ability

Students had a choice of six different reasons for having desired present affiliation. Multiple answers were permitted. The finding of the x^2 test is presented in the upper half of Table 9, based on a 2 × 2 table of (SO class, SM class) × (existence of reaction). Significant difference was recognized for the following four reasons: Students interested in the subjects of science and mathematics want to study deeper into these subjects, and are interested in taking up a job related to science and mathematics, etc. The number of persons providing reasons with regard to why present affiliation was desired was significant. This shows that students in the SM class chose the following reasons: “since they are interested in the subject of science and mathematics”, “since they want to study science and mathematics more deeply”, and “since they want to get a job related to science and mathematics”. The students in the SO class were more likely to choose “the other” reason. A significant difference between students in both classes was clarified through the following two statements: “since they want to go on to universities of science and technology” and “since they want to become engineers in the future”.

The average number of reasons for having the desired present affiliation in the SM and SO classes are 1.37 and 0.97 respectively. Students in the SM class chose more reasons. 32 students in the SO class chose “others”. 16 persons wrote the following two reasons: “since subjects of science and mathematics are my favorites” and “since there are more universities which they can choose from than liberal arts universities”. The rest of the students did not provide a reason. These findings reveal that students in the SM class have a stronger will toward their future purposes.

Students were asked to choose among nine items regarding abilities acquired after entering high school. Multiple answers were permitted. The result of the x^2 test is presented in the lower portion of Table 9. The finding recognized a significant tendency or significant difference for the following four abilities: ability to express oneself, creative ability, ability to solve problems, and others. The number of persons who have improved their abilities in both types of classes was significant as shown in Table 9. For the SM class, there were many students who recognized that their self-expression ability and creative ability have improved. Many students in the SO class recognized that their ability to solve problem and others have improved. Meanwhile, the contents described as others by 14 persons in the SO class were as follows: “ability to understand oneself”, “ability to process information”, “ability to include people within a group”, and “ability to judge the character of persons”. No significant difference was recognized regarding the ability to evaluate oneself, the ability to execute, the ability to express, and the ability to persevere in making efforts.

Table 9 Comparison of Students’ Reasons for Desired Affiliation with the Ability Developed by Both Types of Students

Reason why present affiliation was desired	Interest in subjects of science and mathematics				
	Existence	SO	SM	Sum	x^2
	Yes	26	39	65	16.4
	No	86	36	122	***
	Total	112	75	187	
	Deeply studying their subjects of science and mathematics				
	Existence	SO	SM	Sum	x^2
	Yes	10	18	28	8.0
	No	102	57	159	*
	Total	112	75	187	
	Taking up a job related to science and mathematics				
	Existence	SO	SM	Total	x^2
	Yes	18	21	39	3.9
	No	94	54	148	*
	Total	112	75	187	
	Other reason				
	Existence	SO	SM	Total	x^2
	Yes	32	7	39	10.1
	No	80	68	148	**
	Total	112	75	187	
Ability which is developed and fostered	Ability to collect information				
	Existence	SO	SM	Total	x^2
	Yes	33	31	64	2.8
	No	79	44	123	
	Total	112	75	187	
	Ability to express oneself				
	Existence	SO	SM	Total	x^2
	Yes	25	26	51	3.5
	No	87	49	136	+
	Total	112	75	187	
	Creative ability				
	Existence	SO	SM	Total	x^2
	Yes	18	23	41	5.6
	No	94	52	146	*
	Total	112	75	187	
	Ability to solve problems				
	Existence	SO	SM	Total	x^2
	Yes	50	22	72	4.5
	No	62	53	115	*
	Total	112	75	187	
	Other abilities				
	Existence	SO	SM	Total	x^2
	Yes	14	0	14	10.1
	No	98	75	173	**
	Total	112	75	187	

*** p < .001, ** p < .01, * p < .05, + p < .1

The creative ability acquired by students in the SM class is based on the following activities: to think about and investigate a goal through the problem study, to actually create something, to examine whether the result has been achieved as thought, or to think over how to present one's ideas and findings. The problem solving ability to which the students in the SO class had developed was obtained through the following activities: to logically express problems, such as mathematics and physics, and to find solutions for them. We will investigate how much of these abilities is actually acquired by use of a checklist in order to provide clear evidence through the support of teachers.

The experience of feeling accomplishment for both students during their high school year was examined. The x^2 test result is shown in Table 10. The deflection of frequencies in both groups is significant ($x^2(8) = 21.1$, $p < .001$). Therefore, a residual analysis (Tanaka, 1992) was performed. As shown on the right side of Table 10, students in the SM class responded more to "Yes" and "Some what yes" than those in the SO class. At the same time, students in the SO class responded more to "No", "Some what no", and "Cannot be determined" than those in the SM class.

Students in the SM class felt greater accomplishment while in high school than those in the SO class. This is presumed to be experienced more deeply in "problem study" during the second year, as described in Section 3.3. It appears that they repeatedly experienced their thought processes, confirmation of their results, rounding up the results, and presentation.

Table 10 Comparison of Experience in Feeling of Accomplishment for Both Types of Students

Rating value		Observed frequency			Expected frequency		Difference of proportion		Residual analysis		
		SO	SM	Total	SO	SM	SO	SM	SO	SM	p
1	No	19	4	23	14.1	8.9	1.7	2.7	2.25	-2.25	*
2	Some what no	20	6	26	15.9	10.1	1.0	1.7	1.78	-1.78	+
3	Cannot be determined	24	6	30	18.4	11.6	1.7	2.7	2.31	-2.31	*
4	Some what yes	22	22	44	26.9	17.1	0.9	1.4	-1.76	1.76	+
5	Yes	24	31	55	33.7	21.3	2.8	4.4	-3.22	3.22	***
Total		109	69	178	109.0	69.0	8.2	12.9			
						x^2	21.1	***			

*** p < .001, * p < .05, + p < .1

4.2 T-test for Eagerness and Degree of Comprehension in Both Types of Students

With regard to "the eagerness of learning science and mathematics" and "the degree of comprehension in science and mathematics", the average rating of attitudes, their standard deviations, the number of persons who responded and the result of t test for both types of students are presented in Table 11. T test indicated that the difference in the average value in a commitment to biology was significant at $t(54) = 2.28$, $p < .05$ as shown in the right column of Table 11. The students in the SM class are more eager to learn about biology than students in the SO class. There are no significant differences in the other subjects.

There is a significant difference of average degree of comprehension regarding the contents of a physics textbook ($t(143) = 1.82$, $p < .1$). In biology and geography, both were significant: $t(55) = 2.91$, $p < .01$ and $t(18) = 9.00$, $p < .001$ respectively. The students in the SM class have a higher degree of comprehension about biology and geoscience. There are no significant differences in the other subjects.

Table 11 Results of T-test for Eagerness and the Degree of Comprehension in Students of Both Classes

Item Contents	SO class			SM class			t-test	
	m	SD	N	m	SD	N	Value	p
Eagemess to address mathematics	3.6	1.0	105	3.5	1.2	68	0.52	
Eagemess to address physics	3.2	1.4	48	3.4	1.3	54	0.81	
Eagemess to address chemistry	3.4	1.3	105	3.6	1.3	66	0.99	
Eagemess to address biology	2.8	1.3	42	3.6	1.1	14	2.28	*
Eagemess to address earth science	1.8	1.1	16	2.3	2.3	3	0.43	
Degree of comprehension in mathematics	3.4	0.9	111	3.5	1.0	72	0.84	
Degree of comprehension in physics	3.0	1.2	87	3.3	1.2	58	1.82	+
Degree of comprehension in chemistry	3.2	1.1	111	3.4	1.0	70	1.47	
Degree of comprehension in biology	3.0	1.2	43	3.9	0.9	14	2.91	**
Degree of comprehension in geoscience	2.0	1.4	18	5.0	0.0	2	9.00	***

*** $p < .001$, ** $p < .0001$, * $p < .05$, + $p < .1$

4.3 Relation of Learning Time, Eagerness, and Degree of Comprehension in Both Types of Students

The correlation coefficient among the total amount of study time, the learning time for each subject, the eagerness to address, and degree of comprehension by five-step evaluation is shown in Table 12 for the students in the SO and SM classes. For both types of students, Table 12 shows a strong positive correlation between the study time of each subject, the eagerness to address each subject, and the degree of comprehension for the total amount of study time. In addition, Table 12 shows a strong positive correlation between the eagerness to address each subject and the degree of comprehension in terms of the amount of learning time for each. This implies that there are rather strong positive correlations between the eagerness to address and the degree of comprehension for each subject. As it turns out, both SM class and SO class also have strong positive correlations regarding the total of study time, the study time for each subject, the eagerness to address it, and the degree of comprehension.

The correlation coefficients of the learning time for each subject, the eagerness to address, and the degree of comprehension to the degree of experience of feeling accomplishment are shown in the right column of Table 12. The coefficient of the study time for mathematics and chemistry, the coefficient of the eagerness to address in chemistry, Japanese, and English, and the coefficient of comprehension of Japanese, for the degree of experience in feeling accomplishment is not as strong for students in the SO class. It appears that, as for the degree of experience of feeling accomplishment, there is little correlation in learning time of each subject, an eagerness to address, and degree of comprehension over the SM class. The difference in such a correlation coefficient arises from different reasons such that students in the SO class experience a feeling of accomplishment in the usual face-to-face subjects, while many students in the SM class have obtained such experiences during problem study.

4.4 Impressions after Entering High School

At the end of the questionnaire, students were required to write freely about the things that they found were especially impressive after entering high school. The number of students who described it, the number of items, and the total number of characters for students in the SO class and students in the SM class were 33 (29%) and 34 (45%), 35 and 38, and 190 characters and 846 respectively. When multiple items were described, their descriptions were counted as multiple items.

The average numbers of description characters per item in the SO class and in the SM class were 4.6 and

24.2 respectively in Japanese. The maximum numbers of characters for both classes were 11 and 77 respectively. Since the number of characters for students in the SO class is 4 to 5, only the item name shown in Table 13 is written there, and they are very frank. On the other hand, the students in the SM class richly expressed their feelings by about 24 characters. Descriptions for students in the SO class and in the SM class were classified into the categories as shown in Table 13. The descriptive contents mentioned by the students in the SO class were school festival, course content, school excursion, course activities, etc. Students in the SM class wrote about the problem study, the lesson of the SM class, etc.

Table 12 Correlation Coefficients Among Learning Time, Eagerness toward Learning the Subject, and Degree of Comprehension

SO class		Total of Learning time at home		Eagerness to address the corresponding subject		Degree of comprehension for the corresponding subject		Degree of experience of feeling accomplishment	
		r	p	r	p	r	p	r	p
Learning time at home	Mathematics	0.74	***	0.33	***	0.11		0.28	**
	Physics	0.51	***	0.45	**	0.34	***	0.17	
	Chemistry	0.62	***	0.52	***	0.34	**	0.27	**
	Biology	0.62	***	0.49	**	0.48	*	0.07	
	Japanese	0.42	***	0.41	**	0.15		0.07	
	English	0.66	***	0.28	**	0.26	**	0.05	
	Geography, history and civics	0.41	***	0.30	**	0.13		0.18	+
Eagerness to address	Mathematics	0.41	***	—		0.38	***	0.17	+
	Physics	0.29		—		0.57	***	0.12	
	Chemistry	0.25	*	—		0.60	***	0.20	*
	Biology	0.40	**	—		0.59	***	0.11	
	Japanese	0.31	**	—		0.37	***	0.21	*
	English	0.22	*	—		0.58	***	0.23	*
	Geography, history and civics	0.18	+	—		0.53	***	0.19	+
Degree of comprehension	Mathematics	0.17	+	—		—		0.07	
	Physics	0.22	*	—		—		0.04	
	Chemistry	0.18	+	—		—		0.07	
	Biology	0.33	*	—		—		0.03	
	Japanese	0.22	*	—		—		0.19	*
	English	0.36	***	—		—		0.30	
	Geography, history and civics	0.15		—		—		0.06	
SM class		r	p	r	p	r	p	r	p
Learning time at home	Mathematics	0.63	***	0.30	**	0.34	**	−0.04	
	Physics	0.69	***	0.40	**	0.43	***	−0.05	
	Chemistry	0.57	***	0.44	***	0.24	*	0.13	
	Biology	0.73	***	0.15		0.47	+	0.03	
	Japanese	0.41	***	0.46	***	0.28	*	0.08	
	English	0.68	***	0.60	***	0.37	**	0.12	
	Geography, history and civics	0.27	*	0.46	***	0.27	*	0.12	
Eagerness to address	Mathematics	0.44	**	—		0.31	*	0.11	
	Physics	0.36	**	—		0.67	***	0.09	
	Chemistry	0.44	***	—		0.68	***	0.17	
	Biology	0.38		—		0.08		0.32	
	Japanese	0.29	*	—		0.62	***	0.14	
	English	0.53	***	—		0.50	***	0.15	
	Geography, history and civics	0.24	+	—		0.56	***	0.08	
Degree of comprehension	Mathematics	0.42	***	—		—		0.03	
	Physics	0.45	***	—		—		0.18	
	Chemistry	0.38	**	—		—		0.08	
	Biology	0.38		—		—		0.08	
	Japanese	0.34	**	—		—		0.25	*
	English	0.54	***	—		—		0.07	
	Geography, history and civics	0.27	*	—		—		0.21	+

*** p<.001, ** p<.0001, * p<.05, + p<.1

After morphological analysis about these contents of description, discriminant analysis was carried out on 15 words with more frequent occurrences among nouns and verbs as shown in Table 14. As shown in Table 15, the rate of correct discriminant was 89%. This means that the students in the SO class and those in the SM class are well distinguished.

The cultural festivals and school trips that are often heard from a high school students are written honestly as only the item name. Descriptions of students in the SO class is only seven items about course content. Description examples of students in the SM class are as follows: "problem study remained in my mind. I mastered the ability to which I had to think of what I should do next after one result comes out", "I want the SM class to have even more special feature", "I have studied touching with nature during summer lodging", "I have become more detailed-oriented regarding computers under the guidance of a friend", and "I have begun to get interested in chemistry". There are 27 items of contents related to the problem study and the computer on which are the characteristic subjects of the SM class. This means that students in the SM class were satisfied with the lesson.

Regarding free descriptions, not only do the amount of description but impressive contents also differ acutely according to the two types of classes. In the case of the SM class, there are many striking descriptions related to the problem study, introduction to natural science, and computer I. This also shows that their interests in the field of science and mathematics are encouraged, and many abilities were acquired by nurturing the feeling of accomplishment. The goal of the SM class is fulfilled considerably.

Table 13 Contents of Free Descriptions for Impressions after Entering High School

SO class		SM class	
Contents	Frequency	Contents	Frequency
School festival	16	Problem study	12
Contents of lessons	7	Lessons in SM class	5
School trip	5	Summer lodging learnings	4
Club activities	5	Interest in physics and chemistry	4
Others	2	Interest in computers	3
		Introduction to natural science	3
		Others	5
Total	35	Total	36

Table 14 Frequency Distribution of the 15 Main Words

Word	SO	SM	Total
Research	0	12	12
Assignment	0	12	12
Do	0	11	11
Culture	10	0	10
Science & Math	0	9	9
Lessons	6	3	9
Study	1	5	6
Club	5	1	6
Think	0	6	6
Remain	0	6	6
Ginkgo	6	0	6
Activity	5	1	6
School trip	5	0	5
Capable	0	4	4
Lodgment	0	4	4
Nature	0	4	4
Learning	0	4	4
Total	38	32	120

Table 15 Results of Discriminant Analysis on the 15 Main Words

Affiliation	SO class	SM class	No. of cases	Rate of correct discriminant
SO class	40	1	41	0.98
SM class	7	28	35	0.80
Total	47	29	76	0.89

5. Conclusion

In this paper, the questionnaire of the common items for both SM and SO classes, and the items original to SM class are analyzed in order to understand the educational impact of the characteristic subjects in the SM class and the attitudes of students in both classes of high school "A". The purposes of establishing the SM class, which is to nurture students who can think on their own and promote students' interest in science and mathematics, are fulfilled considerably.

Most of the students in the SM class became more interested and concerned about natural science when attending a lesson of introduction to natural science.

Students in the SM class learned about the difficulties and pleasures of research during lessons of problem study and felt that cooperation was also important when carrying out the research. It turned out that they were deeply interested in the area of science and mathematics through problem study. Many of them believe that creative ability is accrued. The students in the SM class experienced a greater feeling of accomplishment than those in the SO class. It is presumed that this feeling is due to the repetitive experiences of obtaining a result through thought, summarizing, or making presentations during problem study. Through conventional lessons in the SM class, they have come to believe that science is interesting, are interested in the scientific things around them, consider everything in-depth, and are interested in research.

This paper showed that the characteristic subjects, that is, the special feature of the SM class, function quite well.

We hope to continue conducting this survey and take benefit from it as a guideline for the contents of a lesson and the implementation method by grasping the change in the attitudes of the students in the SM class. We hope to conduct surveys using checklists provided by teachers, and investigate qualitative change in reports. We want to grasp students' qualitative change on various variables by analyzing their surveys.

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