A Study on Proposal and Analysis of Models Measuring Educational Effects for Assurance of Education Quality and Improvement of Student Satisfaction

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***Abstract*—** A turning point has been reached in the evaluation of educational quality; universities have also entered the age of "fourth-generation evaluation" in which students and teachers enhance their joint interpretations through lectures and enable more refined lectures. Given this background, many studies have been performed on the enhancement of student satisfaction with educational quality. On the other hand, quality assurance in university education has been researched as an important topic. Therefore, the Central Education Council, an advisory body of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has begun to consider the introduction of the concept of "graduate attributes," which refers to the "minimum ability that students should acquire upon graduation." As a result, great importance has been placed on the achievement of a balance between the "student satisfaction" and "education quality" in order to improve the quality of universities in a comprehensive manner. This study proposes a model measuring educational effects for assurance of education quality and improvement of student satisfaction, focusing on the concepts of both "graduate attributes" and "fourth-generation evaluation." This paper proposes the concept for the construction of the model, designs the method for data acquisition, and shows the results of actual analysis by structural equation modeling. Further, with regard to quality assurance for graduate attributes, this paper classifies students on the basis of their reasons for taking the course and the learning outcomes, then proposes a model for improving students' learning styles and analyzes their ability using the model. Furthermore, in this paper, it is verified that the proposed models meet the authenticity criteria of fourth-generation evaluation.

***Keywords*—**Fourth-generation evaluation, Responsive constructivist evaluation, Graduate attributes, Structural equation model, Heterogeneity, Improvement of learning style according to reason for taking the course, Learning strategies, Metacognition

I. Introduction

CURRENTLY, the evaluation of educational quality has reached a turning point. As indicated by Kitagawa [1], great importance has been placed on the validity and reliability of qualitative evaluations in traditional education assessments. However, universities have entered the age of "fourth-generation evaluation" or "responsive constructivist evaluation," wherein students are also required to do evaluations. Given this background, many studies have been performed on the enhancement of student satisfaction with educational quality. A dominant concept of "fourth-generation evaluation" is to produce joint interpretations by students and teachers, enhance such joint interpretations through lectures and enable more refined lectures. Joint interpretations in this context mean to hold what students expect and what teachers assume in common. Fourth-generation evaluation consists of methods for emphasizing the focal points in responsive evaluations and methodologies based on constructivist paradigms. In other words, analyses as well as criticisms are taken into account repeatedly under an anti-preordinate focus that "focal points, needs and problems in a disputer to be evaluated by a stakeholder vary with the progress of interactions among them and cannot be accordingly determined in advance" and a precondition that "any truth does not exist objectively and is socially made up through interaction with people." Then, sophisticated constitutions using inputs from both surveys and respondents will be developed. "Fourth-generation evaluation" is based on this methodology. Also, Paladini and Carvalho[2] shows how Expert Systems support can be used in active and interactive learning processes. A. Lazakidous, G. Lazakidou-Kafetzi and K. Siassiakos[3] stressed the potentiality of facilitating students' evaluation through Adaptive Education Systems by proposing such one with an emphasis on its pedagogic model.

On the other hand, quality assurance in university education is an important research problem. In the context of a falling birthrate, quality assurance in the form of entrance examinations has fewer practical functions. Through deregulation and incorporation, universities in Japan have made efforts to improve their educational quality by introducing market principles. However, quality assurance is said to be essential at the higher end of the educational level. Therefore, the Central Education Council, an advisory body to the MEXT is considering the introduction of the concept of "graduate attributes," which refers to the "minimum ability that students must acquire upon graduation" (refer to the Central

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Education Council[4]).Also, Mahmud and Zainol[5] examined postgraduate students' competency in statistical data analysis and their attitudes toward statistics. Kostagiolas and Zimeras [6] stated that quality is indeed a multifaceted concept entailing multiple consequences for the overall management of healthcare services, and provided a Library and Information Services framework for the development of a professional-centered e-support system for learning quality methods and tools.

Tremendous importance has been placed on the achievement of a balance between "satisfaction of students" and "quality of university education," which is considered to be the improvement of the educational quality of universities in a comprehensive manner. The approach of defining universities' missions in the form of students' learning outcomes and evaluating their achievements has been becoming widespread among universities in developed countries. For an international comparison of quality assurance in higher education, refer to the report edited by the Research Institute for Higher Education, Hiroshima University[7].

This study proposes a model measuring educational effects for assurance of education quality and improvement of student satisfaction, focusing on the concepts of both "graduate attributes," as defined by MEXT and "fourth-generation evaluation," as proposed by Guba and Lincoln[8]. The lectures of "Mathematics for System Engineering B course", which has been introduced in the second grade of the Department of Systems Engineering, Faculty of Electro-Communications, University of Electro- Communications was taken as a model in this study. This paper proposes the concept for the construction of the model, designs the method for data acquisition, and shows the results of actual analysis by structural equation modeling based on this proposed method, and examines the results.

Chapter 2 proposes a conceptual model measuring educational effects for assurance of education quality and improvement of student satisfaction with lecture quality on the basis of graduate attributes and fourth-generation evaluation. It also proposes the survey items for measuring the educational effects. Chapter 3 identifies goals of students using survey data. Chapter 4 then constructs and examines a structural equation model for improving both learning outcomes and student satisfaction. With regard to quality assurance for graduate attributes, Chapter 5 classifies students on the basis of their reasons for taking the course and the learning outcomes; it then proposes a model for improving students' learning styles and analyzes their ability using the model. Furthermore, in Chapter 6, it is verified that the proposed models meet the authenticity criteria of fourth-generation evaluation.

II. Proposed Model Measuring Educational Effects

A. Conceptual Model Measuring Educational Effects For Assurance of Education Quality and Improvement of Student Satisfaction with Lecture Quality

Fig. 1 shows a proposed conceptual model measuring educational effects for assurance of education quality and improvement of student satisfaction using the Mathematics for System Engineering B course as an example. The model focuses on both the proposed items - "satisfaction level of university expected by students" and "graduate attributes required by a university." The Mathematics for System Engineering B is a course that aims to teach students vector analysis, which is calculus for vector-functions and used for analyzing spatial variations.

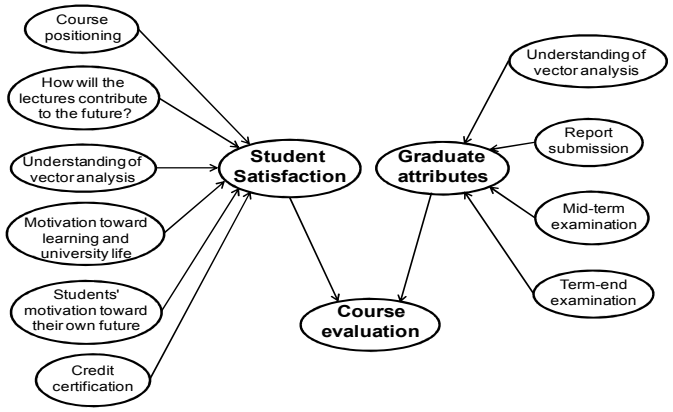


Fig. 1 Conceptual model measuring educational effects for assurance of education quality and improvement of student satisfaction

The "graduate attributes required by a university" on the right side of the conceptual model in Fig.1 are classified into four items.

" Understanding of vector analysis" is an achievement standard that is defined by a teacher in charge on the students' level of understanding of vector analysis which is the focal point of the course. It can be regarded as the main item for the evaluation of the graduate attributes of students on this subject. When this model is applied to another subject, the content can be accordingly adapted.

"Report submission," "mid-term examination," and "term-end examination" are items for the measurement of academic ability at each stage that leads to an understanding of vector analysis. These items evaluate how students establish ways of thinking, calculation methods, formulas, and other techniques that are fundamental to their learning.

"Student satisfaction" on the left side of the model is classified into six items.

"Course positioning" is an item that measures the attitudes of individual students toward the course. These attitudes depend on the students. Whereas some students may take the course "to ensure the number of credits necessary for graduation," others may do so to "lay the foundation for their academic goals." It is important for teachers to understand the course positioning by students in order to obtain joint interpretations by teachers and students.

"How will the lectures contribute to the future" is an item that measures students' understanding of the usefulness of education in society and how it is fundamental to future learning, in order to link courses with students' needs.

"Understanding of vector analysis" is an item that measures students' understanding of vector analysis, which is the same as the item in the "gradate attributes."

"Motivation toward learning and university life" is an item that measures the degree of students' motivation toward learning and university life after completing the course and being stimulated by it.

"Students' motivation toward their own future" is an item that measures the degree of students' motivation toward their own future after completing the course and being stimulated by it.

"Credit certification" is an item that measures whether students meet the criteria of graduate attributes and acquire knowledge and skills required for earning credits.

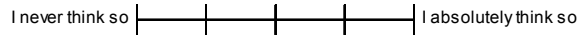
In the above conceptual model, the educational effects of the lectures are measured by evaluating the degree of students' level with the items under "graduate attributes required by university" and the degree of students' satisfaction with the items under "student satisfaction." It should be noted that "graduate attributes required by university" are preliminarily determined to some extent by the characteristics of courses and by concepts defined by the teachers in charge of the courses (aspects on which special emphasis should be placed); however, the items under "student satisfaction" are influenced by each student's concepts. Hence, it is important to arrive at a joint interpretation by students and teachers. For instance, even if a student gives a low rating to the item "understanding of vector analysis" because he or she considers the course to be necessary only for the acquisition of the number of credits required for graduation in "course positioning," his or her satisfaction may be enhanced by credit acquisition. However, the criterion for graduate attributes that is specified by teachers must be met.

In order to evaluate students' graduate attributes, teachers judge whether students' academic abilities are worthy of credit certification independent of the students' views on their abilities. The students may rate their degrees of satisfaction with other items differently. Consequently, the proposed model is one that can be used for measuring educational effects considering each student's heterogeneity.

B. Proposal of Survey Items for Measuring Educational Effects

This section proposes survey items for the measurement of student satisfaction in the model for measuring educational effects. The survey items were based on Torii[9] , Tsubaki [10] and Sahari, *et al.*[11], and are listed below. The survey was conducted in the Mathematics for System Engineering B class.

Example of Responses



1) Describe the influence of your parents on you.

(1) Did you select the University of Electro-Communications after consulting your parents ?

(2) Who made you select the university ?

(3) Are your parents aware of what you are studying at the university ?

(4) Do you consult your parents about general university life ?

2) Rate your reasons for selecting the university.

(5) Was your current department of the university of Electro-Communications your first choice ?

(6) What factors did you consider important in selecting the university ?

(7) Does your future goal motivate you to study hard at the university ?

(8) Do you want to find a suitable job by taking the current courses and gaining experience at the university ?

(9) Is your main reason for studying at the university is to acquire a high-paying job ?

(10) Is your main reason for studying at the university to acquire a challenging job ?

(11) Is your main reason for studying at the university to undertake valuable research and develop superior skills ?

3) Answer some questions on your views on your courses and classes (not limited to Mathematics for System Engineering B) at the university.

(12) Do you feel satisfied after solving a difficult question in the courses and classes ?

(13) Is it fulfilling to study at the university because you can judge your own improvement ?

(14) Are you not concerned about your achievements so long as you earn a credit ?

(15) When you take a course, do you think about how it will contribute to research in the fourth grade and future job opportunities ?

(16) Do you give greater importance to your interest in a subject or the easy acquisition of a credit ?

4) Answer some questions on your views on the Mathematics for System Engineering B course.

(17) Do you feel satisfied after solving a difficult question in the course ?

(18) Is the course an interesting course because it helps you to judge your own improvement ?

(19) Are you not concerned about your achievements so long as you earn a credit ?

(20) When you took the course, did you think about how it would contribute to research in the fourth grade and future job opportunities ?

(21) Did you give a greater importance to your interest in this subject or to the easy acquisition of a credit in this subject?

(22) How important do you consider learning the content of the course for your future university life and job?

(23) Did you read the syllabus of the course before opting for the course?

(24) Do you remember the content of the syllabus?

(25) The course is aimed at enabling students to learn about vector analysis. Has the course been successful for you in doing this?

(26) Do you know about the future potential of vector analysis?

(27) Was your motivation toward learning and university life

enhanced by the course?

(28) What is your primary reason for taking the course? (Circle only one)

・Credit ・Getting good achievements

・Acquisition of a wide variety of knowledge

・Understanding the principles of vector analysis

・Other ( )

(29) Is your decision to take the course influenced by the teacher who is in charge of the course? What are your criteria for selecting the course on the basis of the teachers? (Mark all the criteria that apply.)

・Friendly and kind ・Rigorous ・Careful teaching

・Seemingly easy acquisition of a credit

・Teacher's knowledge ・Clear writing on the blackboard ・Approachability

・Other ( )

(30) Are you generally content with your learning experience (attending lectures) in the course?

(31) What is your current grade point average (GPA)?

The design of the survey items from (1) to (31) is described below.

Items (1) to (4) examine whether the satisfaction level of students' parents can be incorporated into the model by considering parents as stakeholders. If parents are more involved in their children's lives, speak to them regularly, and understand their reasons for taking courses at universities, they may derive more satisfaction. Although it is considered to be difficult to obtain details about the levels of lectures from these items, they were employed in this research because they were required for extending this model to the evaluation of universities in the future.

Items (5) to (6) aim to capture the reasons for students selecting the university. A student who has gained admission to a first-choice university is able to express his academic objectives more clearly than one who has gained admission to a second-choice university. Furthermore, a student who places more importance on the learning contents of a subject also expresses his academic objectives more clearly than one who focuses on the reputation of a university.

Items (7) to (11) aim to examine how students consider the positioning of a university. In other words, the items attempt to determine whether students want to gain the knowledge they require at the university, whether they attend school in order to define their future visions, or whether they wish to conduct research and develop superior skills with an eye toward the future.

Items (12) to (16) aim to understand the positioning of classes and lectures. From (12), it can be determined whether students attend lectures in the university to acquire specialized and in-depth knowledge. From items (13) and (15), it can be seen whether they positively attempt to gain the knowledge that is assumed to be necessary for the future. Further, items (14) and (16) reveal whether students attend lectures to earn the number of credits required for graduation or whether they attend lectures both to satisfy their own interests and to earn credits. As long as they are enrolled at the university, they must obtain the predetermined number of credits. They may take up a course out of no personal interest. Even if their purpose is only to earn a credit in the course, some students attend lectures after understanding the positioning of the course as a joint interpretation by students and teachers. This setup clearly offers an advantage to those students in terms of allocation of their time to various lectures and learning efficiency, compared to the other students who attend lectures without understanding the positioning of the course.

Items (17) to (30) aim to determine the positioning of the Mathematics for System Engineering B course. Items (23) and (24), which deal with the syllabus, are important for the development of a joint interpretation by the students and a teacher before the class. A comparison between the values of items (12) to (16) and (17) to (21) enables us to determine the positioning of the course among all the lectures. For instance, "whereas students give greater importance to the acquisition of a credit in other courses, in the case of Mathematics for System Engineering B, interest takes precedence."

In this research, the results of surveys on metacognition and learning styles conducted by Tsubaki, Kikuchi, and Endo [12] are used for the analysis. For a survey of mathematics learning styles, refer to Tsubaki, Kakuta, and Murata [13] etc.

III. Understanding Students' Reasons for Taking the Course

The survey items include items for understanding students' reasons for taking the course. The items are as follows: "What is your primary reason for taking the course ?"; "Are you not concerned about your achievements so long as you earn a credit."; "Did you give a greater importance to your interest in this subject or to the easy acquisition of a credit in this subject?" On the basis of the results, students' reasons for taking the course can be classified into four types.

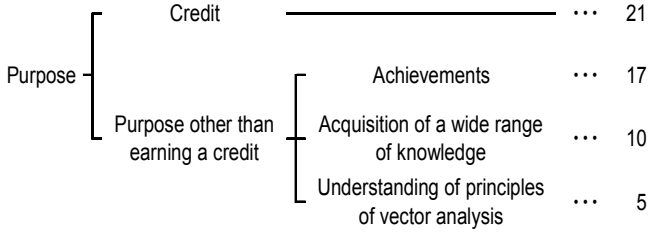


Fig. 2 Students' reasons for attending the lectures

As shown in Fig.2, 21 students wished to earn a credit. Among students who had other reasons for taking the course, 17, 10, and 5 of them gave importance to achievements, acquisition of a wide range of knowledge, and understanding of the principles of vector analysis, respectively.

The purpose of the lectures is to teach students the principles of vector analysis. It is understood that 15 students aim to gain an understanding of the principles of vector analysis and a wide range of knowledge. It is necessary to convey the importance of vector analysis and the future use of the analysis in a manner that is easy to understand and to help other students to

understand the principles of the analysis.

On the other hand, teachers have to understand that about 40% of the students select the course in order to acquire a credit. The points for improvement with regard to this class include further clarification of the criterion for granting a credit. Because 17 students placed an emphasis on their achievements, it is necessary to specify criteria for evaluation.

IV. Construction of and Discussion on the Structural Equation Model for Improving Learning Outcomes and Student Satisfaction

This chapter provides an overview of the lectures and constructs a structural equation model for improving students' satisfaction and graduate attributes.

A. Examination of Hypotheses

In this section, hypotheses for constructing a structural equation model were formulated for examination. Structural equation modeling, a multivariate analysis technique, was used; stochastic cause-and-effect relationships were analyzed using observation data. These relationships can be divided into a structural equation describing a relationship between latent variables and a measurement equation describing relationships between a latent and observation variables. ' ' are used to denote an observation variable that can be directly observed, and " " a latent variable that cannot be directly observed.

< Hypotheses for constructing a structural equation>

A structural equation describes the relationship between latent variables.

・When a student attends lectures, he or she considers the positioning of the lectures in the four-year learning period of his/her university.

・"Positioning of lectures" affects "Awareness of lecture content" and "Learning interest."

・"Awareness of lecture content" also affects "Learning interest" and "Learning strategies."

・"Metacognition" also affects "Learning strategies."

・"Learning strategies" affects "Learning style."

・"Learning interest" and "Learning style" affect 'Satisfaction derived from lectures' and 'Examination,' respectively.

B. Construction and Discussion of the Structural Equation Model

On the basis of the hypotheses in section 4.A, a structural equation model was constructed and analyzed. The achievements are shown in Fig. 3.

The left side of Fig. 3 shows the relationship between latent variables that mainly affect the degree of satisfaction with lectures. The relationship is a model based on fourth-generation evaluation; the model enables us to understand students' needs for lectures and clarify ways of improving lectures in order to enhance satisfaction levels. The relationship between latent variables that mainly affect scores in the examination on the right side of the figure is a model based on assurance of graduate attributes. This model enables us to define the learning flow that leads to actual learning outcomes.

In general, it is understood that 'Satisfaction with lectures' will be improved if "Positioning of lectures" is high and "Learning interest" is increased. The improvement in "Learning strategies" results from "Metacognition" and "Awareness of lecture content." "Learning strategies" has a positive influence on "Learning style," and "Learning style" has a positive effect on 'Examination.' Consequently, it is found that a combination of clear awareness of lectures, good learning strategies and learning styles produce good learning outcomes.

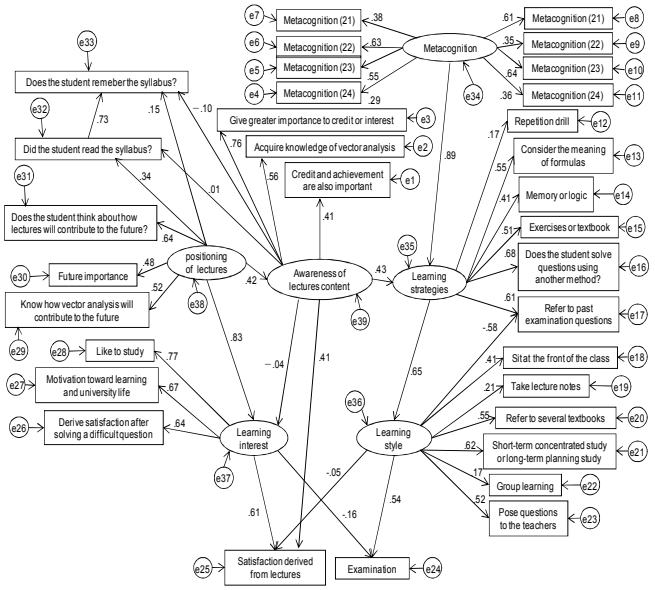


Fig. 3 Structural equation model
(GFI = 0.691, RMSEA = 0.071)

Table 1 Error correlation in Fig. 3
(Owing to space limitations, they are not displayed in Fig. 3)

	Correlation coefficient		Correlation coefficient		Correlation coefficient
e17 <--> e22	0.397	e15 <--> e12	-0.244	e24 <--> e32	-0.396
e9 <--> e19	0.306	e15 <--> e16	-0.289	e25 <--> e32	-0.400
e19 <--> e12	0.445	e4 <--> e35	0.640	e19 <--> e28	-0.304
e9 <--> e20	-0.364	e1 <--> e28	0.573	e11 <--> e28	-0.327
e9 <--> e22	0.203	e27 <--> e29	0.561	e23 <--> e12	0.288
e13 <--> e14	0.321	e26 <--> e3	0.389	e9 <--> e26	0.325
e26 <--> e28	0.002	e4 <--> e29	-0.280	e2 <--> e22	-0.304
e31 <--> e32	0.380	e6 <--> e28	-0.411	e7 <--> e10	0.354
e30 <--> e18	0.493	e8 <--> e31	-0.359	e7 <--> e33	0.316
e23 <--> e3	-0.654	e27 <--> e21	-0.322	e8 <--> e2	-0.277

The coefficient of "Positioning of lectures" to "Learning interest" (0.83) shows that the former has a significant impact on the latter. They wish to take the course because of its usefulness in specialized subjects and studies. Consequently, it is necessary to emphasize how vector analysis can contribute to the students' future. The coefficient of "Awareness of lecture content" to "Learning interest" (-0.04) shows that the former rarely affects the latter. This is attributed to the fact that students fail to develop an interest in the content of Mathematics for System Engineering B.

Although "Positioning of lectures" and "Awareness of lecture content" were considered to have an effect on the syllabus, it was found that the latter did not have a significant effect. It is

indicated that syllabus was used effectively when students decide where the lectures of the course should be placed during the four years of university but that syllabus was not used effectively when students consider the content of the lectures. The distribution of the data shows that the learning outcomes of students who had read the syllabus well were poor. Hence, it is possible that there are problems not only with the content of the syllabus but also with students' clear sense of purpose.

The coefficient of "Learning interest" to 'Satisfaction with lectures' (0.61) shows that students who appreciate the usefulness of vector analysis and have an interest in learning exhibit an increased level of satisfaction. However, the coefficient of "Learning interest" to 'Examination' (-0.16) indicates that the former does not have a significant effect on the latter. Consequently, it was found that students' interest in the course is not closely related to their achievements in the examination. Further, the coefficient of "Learning style" to 'Examination' (0.54) shows that unestablished learning styles did not produce good learning outcomes. On the other hand, the coefficient of "Learning style" to 'Satisfaction with lectures' (-0.05) indicates that it cannot be said that good learning styles enhance satisfaction levels. Therefore, it appears to be difficult to enhance satisfaction with lectures and learning outcomes at the same time; balancing these two elements is thus an important future challenge.

Owing to the fact that learning outcomes are affected by "Learning style," learning style is an element that is closer to students than to teachers (Tsubaki, Kikuchi, and Kobayashi [14]; refer to Fig. 4). In conclusion, in order to improve learning outcomes, it is useful to analyze students' learning styles, propose concrete learning styles that are aimed at the different goals they have for taking the course, and promote their study methods in the next chapter.

Table 2 Estimated value, standard error, test statistic, and p-value of Fig. 3
(*** indicates 1% significance and **, 5% significance)

			Estimated value	Standard error	Test statistic	P-value
Awareness of lecture content	<---	Positioning of lectures	0.355	0.180	1.974	**
Learning strategies	<---	Metacognition	0.403	0.340	1.185	0.236
Learning strategies	<---	Awareness of lecture content	0.185	0.161	1.151	0.250
Learning style	<---	Learning strategies	1.899	1.510	1.257	0.209
Did the student read the syllabus?	<---	Awareness of lecture content	0.016	0.388	0.042	0.967
Learning interest	<---	Positioning of lectures	0.804	0.278	2.889	***
Learning interest	<---	Awareness of lecture content	-0.043	0.190	-0.227	0.821
Did the student read the syllabus?	<---	Positioning of lectures	0.808	0.372	2.175	**
Metacognition(16)	<---	Metacognition	1.662	0.654	2.541	**
Exercises or textbook	<---	Learning strategies	3.116	2.709	1.150	0.250
Like to study	<---	Learning interest	1.296	0.243	5.327	***
Examination	<---	Learning interest	-5.676	4.719	-1.203	0.229
Acquired knowledge of vector analysis	<---	Awareness of lecture content	1.358	0.419	3.245	***
Give greater importance to credit or interest	<---	Awareness of lecture content	0.772	0.280	2.760	***
Credit and results are important	<---	Awareness of lecture content	1.000			
Derive satisfaction after solving a difficult question	<---	Learning interest	1.275	0.311	4.100	***
Does the student remember the syllabus?	<---	Awareness of lecture content	-0.216	0.230	-0.940	0.347
Does the student remember the syllabus?	<---	Positioning of lectures	0.275	0.217	1.270	0.204
Satisfaction with the lectures	<---	Learning style	-0.066	0.152	-0.435	0.664
Satisfaction with the lectures	<---	Learning interest	0.924	0.203	4.548	***
Satisfaction with the lectures	<---	Awareness of lecture content	0.723	0.323	2.236	**
Motivation toward learning and university life	<---	Learning interest	1.000			
Does the student remember the syllabus?	<---	Did the student read the syllabus?	0.551	0.069	7.978	***
Metacognition (24)	<---	Metacognition	0.751	0.386	1.945	0.052
Metacognition (13)	<---	Metacognition	0.701	0.360	1.946	0.052
Metacognition (14)	<---	Metacognition	1.224	0.515	2.375	**
Metacognition (17)	<---	Metacognition	1.000			
Metacognition (21)	<---	Metacognition	1.261	0.498	2.535	**
Metacognition (22)	<---	Metacognition	0.870	0.430	2.023	**
Metacognition (23)	<---	Metacognition	1.260	0.415	3.035	***
Think about the meaning of formulas	<---	Learning strategies	3.918	3.074	1.275	0.202
Memory or logic	<---	Learning strategies	1.937	1.613	1.201	0.230
Does the student solve a question using another method?	<---	Learning strategies	3.975	3.109	1.279	0.201
Take lecture notes	<---	Learning style	0.428	0.270	1.586	0.113
Refer to several textbook	<---	Learning style	1.161	0.349	3.324	***
Pose questions to the teachers	<---	Learning style	0.661	0.195	3.396	***
Group learning	<---	Learning style	0.356	0.307	1.157	0.247
Repetition drill	<---	Learning strategies	1.000			
Short-term concentrated study or long-term planning study	<---	Learning style				
Examination	<---	Learning style	17.627	5.317	3.315	***
Refer to past examination questions	<---	Learning style	-1.229	0.539	-2.279	**
Refer to past examination questions	<---	Learning strategies	3.812	3.103	1.229	0.219
Sit at the front of the class	<---	Learning style	0.859	0.310	2.768	***
Think about how the lectures will contribute to the future	<---	Positioning of lectures	1.000			
Know how vector analysis will contribute to the future	<---	Positioning of lectures	0.840	0.271	3.100	***
Future importance	<---	Positioning of lectures	0.729	0.242	3.011	***

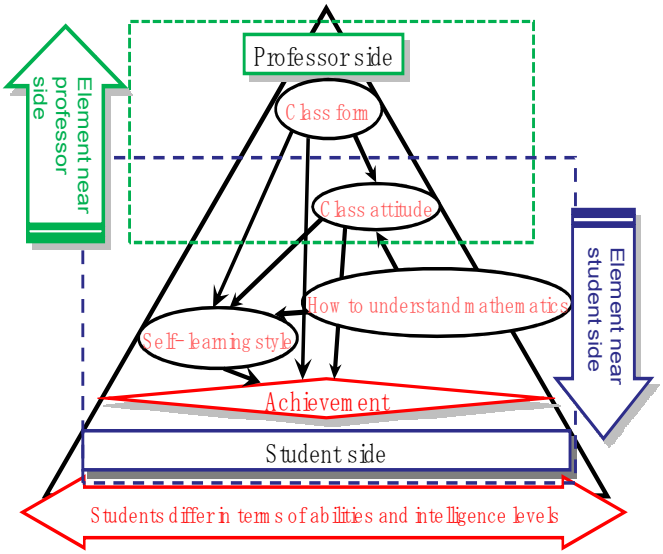


Fig. 4 Lecture model with a simultaneous and heterogeneous structure

The goodness of fit of the model is now described. The model analyzed in Fig. 3 has a goodness-of-fit index (GFI) of 0.691. Concerning the requirement of a GFI of 0.9 or more, Toyota[15] and Ikemoto, Seki, and Tsubaki [16] asserted that a point to be noted for a measure of model fit was that "the criterion of GFI > 0.9 must not be used if the total number of observation variables exceed 30."

Considering that it is not appropriate to use GFI as a fit index because the sum of the observation variables in this paper is 33, we determined the use of RMSEA, which is an index per degree of freedom, as indicated by Toyota[15]. This model has an RMSEA of 0.071, which falls within the acceptable range. Consequently, this model was employed to verify and discuss hypotheses.

V. Proposal of a Model and Analysis for Improving Students' Learning Styles Based on Their Reasons for Taking the Course to Improve Assurance of Graduate Attributes

Chapter 5 analyzes the relationship between students' positioning of lectures /learning outcomes and learning styles, discusses the types of learning strategies and learning styles that can accomplish the level of academic ability required by teachers, and puts forward concrete suggestions for students' learning methods.

This research suggests the matrix classification of students shown in Fig. 5. This classification places credit acquisition and other purposes along the vertical axis and learning outcomes along the horizontal axis.

Actual classification based on students' reasons and learning outcomes is shown in Fig. 6.

In this research, it is considered preferable to classify middle-level students into (2) or (3). Students who take the course for purposes other than credit acquisition are preferably classified as (2) because their needs are only met if they enter the upper level of achievement. On the other hand, students who take the course for credit acquisition are preferably classified as (3) because their needs are only met if they enter the middle level of achievement.

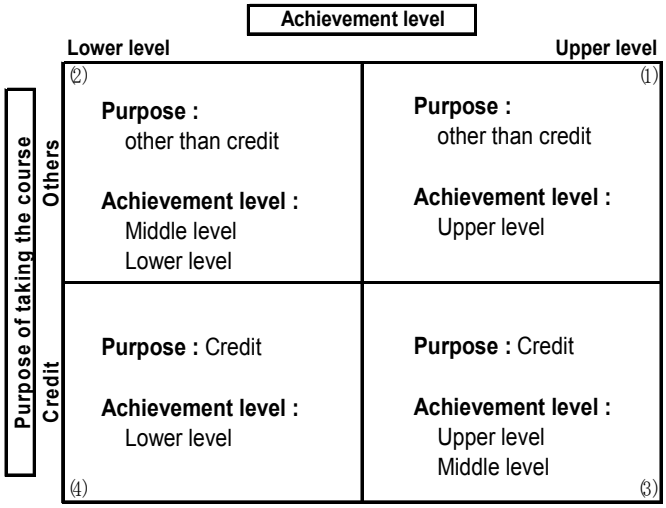


Fig. 5 Classification of students based on the relation between students' reasons for taking the course and learning outcomes (Conception)

Here, the significance of the survey items in the proposed classification is tested in order to offer concrete suggestions on learning methods to different types of students. Two-tailed t tests were used in order to analyze the survey items for two groups, the high-level and low-level achievement groups.

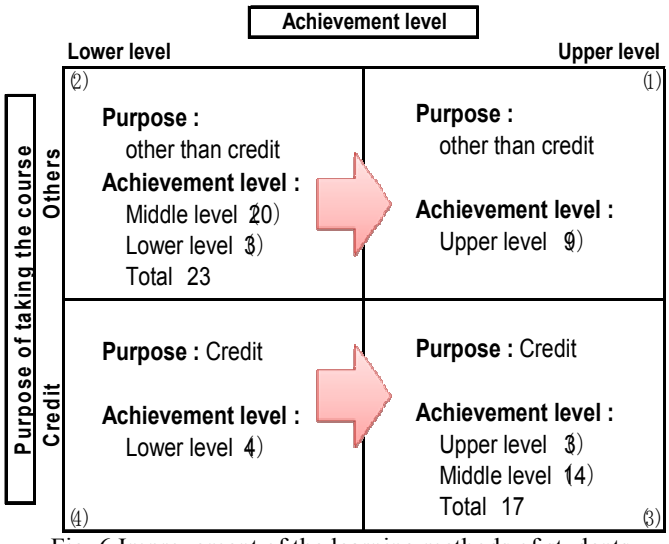


Fig. 6 Improvement of the learning methods of students

First, students classified as (1) and (2) are examined to discuss suggestions for the students classified as (2).

Students classified as (1) take the course for purposes other than credit acquisition and accomplish the level of graduate attributes defined by teachers. They have no problems in terms of education quality assurance. However, because the quality of lectures required by these students is high, their levels of satisfaction with the course may decrease. The average satisfaction level of 9 students actually classified as (1) was

3.1. It is not high. It is desirable to provide additional works and developmental materials to these students and to create a lecture structure that allows them to obtain higher-level knowledge.

"Middle-level and lower-level students who take the course for purposes other than credit acquisition in (2)" are compared with "upper-level students who take the course for purposes other than credit acquisition in (1)" in order to offer suggestions on concrete learning styles. The achievements obtained for these students were used to a t test, which revealed that survey items with 5% significance include "12. Do you feel a sense of accomplishment after solving a difficult question (commonly for all subjects) ? (more students in (1) than in (2))"; "34. Metacognition (13) (Can you explain the learned unit to others ?) (more students in (1) than in (2))"; and "51. Do you pose questions to the teachers ? (more students in (1) than in (2))." Hence, detailed learning styles for improvement include "Try to understand a unit so that you can explain the learned unit to others" and "Actively ask questions to the teachers about things you do not understand."

Next, students in (3) and (4) are examined to discuss suggestions for students classified as (4).

Students classified as (3) take the course for credit acquisition but can surely accomplish the level of graduate attributes defined by teachers. They can successfully acquire the credit, their levels of satisfaction with the course will increase.

Students classified as (4) take the course for credit acquisition but cannot surely accomplish the level of graduate attributes defined by teachers. "Upper-level and middle-level students who take the course for credit acquisition in (3)" are compared with "lower-level students who take the course for credit acquisition in (4)" in order to obtain suggestions on concrete learning styles. The following survey items had 5% significance: "5. Was your current department of the university of Electro-Communications your first choice? (more students in (4) than in (3))"; "13. Do you like to study (for all subjects) ? (more students in (3) than in (4), in other words, students in (4) is low.)"; and "25. Did you acquire knowledge of vector analysis ? (more students in (3) than in (4), in other words, students in (4) is low.)." The students in (4) gave excessively low ratings to item 25. That is, they realized that they did not acquire knowledge of vector analysis even though they attended the lectures. In addition, the students classified as (4) also gave excessively low ratings to item 13. This indicates that they did not find the lectures interesting and that their motivation toward learning did not increase because they could not understand the course. That is, they were unable to improve on these aspects even if they were aware of this fact. Hence, they should make efforts to enhance their motivation toward the course and acquire learning methods that deepen their understanding of the content whereas being aware of the importance and usefulness of lectures in universities.

Also, Ayub *et al.*[17] aimed to identify the factors that influencing students using POLCA (Portal of Learning Calculus) in teaching and learning of calculus at the university.

Table 3 Results of the t test

	Items for which the significance of learning styles were confirmed	Results of t test (p-value)
Comparison of (1) and (2)	12. Do you feel a sense of accomplishment after solving a difficult question? (commonly for all subjects) (more students in (1) than in (2))	0.004
	34. Metacognition (13) (Can you explain the learned unit to others ?) (more students in (1) than in (2))	0.001
	51. Do you pose questions to the teachers ? (more students in (1) than in (2))	0.050
Comparison of (3) and (4)	5. Was your current department of the university of Electro-Communications your first choice? (more students in (4) than in (3))	0.015
	13. Do you like to study? (for all subjects) (more students in (3) than in (4), in other words, students in (4) is low.)	0.000
	25. Did you acquire knowledge of vector analysis ? (more students in (3) than in (4), in other words, students in (4) is low.)	0.000

VI. Uthenticity Criteria for the Models

This chapter confirms whether the proposed model meets the authenticity criteria of fourth-generation evaluation.

A. Fairness

Fairness is defined by Guba and Lincoln[8] as follows.
Fairness; Fairness refers to the extent to which different constructions and their underlying value structures are solicited and honored within the evaluation process.

As shown in Fig. 7, there are different constituents such as "Human and Social Subject, Specialized Foundation Subject, Specialized Subject and Free Subject," and value structures of "Basic Knowledge for Studies, Required Learning for Graduation, and Development of Graduate Abilities for Succeeding in the Real World" are at the root of these constituents and are accepted by students. This is considered to satisfy the criterion for fairness.

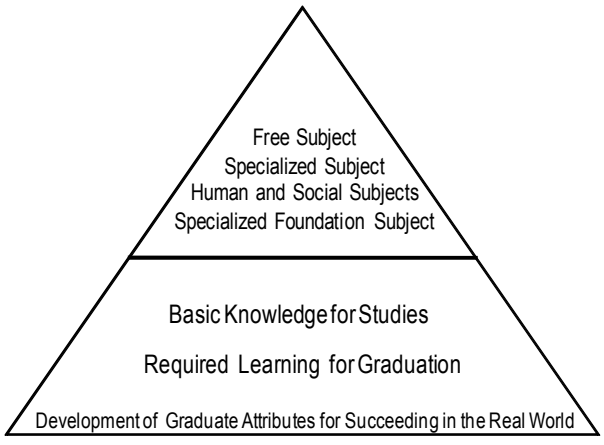


Fig. 7 Value structure in university lectures

B. Ontological Authenticity

Ontological authenticity is defined by Guba and Lincoln[8] as follows.

Ontological authenticity; This criterion refers to the extent to which individual respondents' own emic constructions are improved, matured, expanded, and elaborated, in that they now possess more information and have become more sophisticated in its use. It is, literally, "improvement in the individual's (or group's) conscious experiencing of the world" Insofar as the evaluator can make available examples, cases, or other material that aids participants to reassess their own experience - seeing how it is the same as or different from the experience of others - it may serve to enhance their own awareness of the context in which they find themselves.

Courses created by students and teachers and a university with a cluster of courses and classes are improved through joint interpretations and on an ongoing basis every year. The growth of the university to a more sophisticated organization is considered to assure ontological authenticity. Furthermore, the enhancement of individual student's awareness through these lectures is measured using an evaluation survey, thereby ensuring ontological authenticity.

C. Educative Authenticity

Educative authenticity is defined by Guba and Lincoln[8] as follows.

Educative authenticity; Educative authenticity represents the extent to which individual respondents' understanding of and appreciation for the constructions of others outside their stakeholding group are enhanced.

It is not enough that the actors in some contexts achieve, individually, more sophisticated or mature constructions, or those that are more ontologically authentic. It is also essential that they come to appreciate (apprehend, discern, understand) - not necessarily like or agree with - the constructions that are made by others and to understand how those constructions are rooted in the different values systems of those others.

The survey items are used to evaluate how the lectures contribute to research and future jobs.

Furthermore, the items give students an opportunity to recognize the usefulness of the lectures in the research and future jobs. Consequently, educative authenticity is considered to be accomplished.

D. Catalytic Authenticity

Catalytic authenticity is defined by Guba and Lincoln[8] as follows.

Catalytic authenticity; This criterion may be defined as the extent to which action is stimulated and facilitated by the evaluation processes.

The survey items include an item that evaluates whether university education enhances the motivation toward learning and university life, thereby enabling the measurement of catalytic authenticity.

However, all lectures do not have to meet catalytic authenticity. If authenticity is satisfied for any lectures students find interesting, all the conditions for authenticity may be met.

E. Tactical Authenticity

Tactical authenticity is defined by Guba and Lincoln[8] as follows.

Tactical authenticity; It is not enough to be stimulated to action. It is quite possible to want, and even to need, to act, but to lack the power to do so in any meaningful way. Thus tactical authenticity refers to the degree to which stakeholders and participants are empowered to act.

Students' opinions are taken into consideration for realizing the development of lectures. Consequently, tactical authenticity is considered to be achieved.

VII. Conclusion

In this research, models based on the concepts of fourth-generation evaluation, as proposed by Guba and Lincoln[8], and graduate attributes, as defined by MEXT, were constructed. Using the model, the relationship between fourth-generation evaluation and graduate attributes were analyzed on the basis of the learning outcomes and learning survey data.

First, joint interpretation by students and teachers based on analyzing survey data revealed the following results (1) and (2):

(1) Because more than half the students give importance to credits and achievements, teachers must convey the criterion for the certification of credits and achievements to students in a more explicit manner through the syllabus and other means.

(2) There are students who take the course in order to understand the principles of vector analysis or obtain a wide range of knowledge. Thus, the contribution of the course to the students' future must be made known to such students in a more concrete manner.

Structural equation modeling provided the following results (3) and (4):

(3) The following hypotheses are reasonable. One hypothesis is that students first determine the positioning of lectures during the four years of university; they then become conscious of the content of the lectures. At the same time, their satisfaction with the course is enhanced after they develop an interest in learning. Another hypothesis is that the content of the lectures and students' metacognition bring about learning strategies and good learning styles, resulting in improved learning outcomes.

(4) Our analysis showed it was difficult to improve both students' satisfaction levels and learning outcomes at the same time through teachers' instructions. As for the learning styles of students' which were close to students' area, students themselves should improve them based on the reasons for taking the course. By students enhancing their learning outcomes, it is expected to improve the overall quality of lectures.

The model for the improvement of learning styles in order to assure graduate attributes yielded the following results (5) and (6):

(5) It was shown that students with a purpose other than credit acquisition improved their learning outcomes by gaining an in-depth understanding which was deep enough to be able to explain the learned units to others.

(6) Students who take the course in order to earn a credit realized that they did not obtain enough knowledge of vector

analysis, but did not improve their learning styles. However, they had learned about the course. Consequently, it was suggested that they could enhance their learning outcomes by checking important points with their friends.

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