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” or “responsive constructivist 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 “satisfaction of students” and “educational 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 “fourth-generation evaluation” and “graduate attributes.” This paper proposes the concept for the construction of the models, designs the method for data acquisition, and shows the results of actual analysis by structural equation modeling. Furthermore, for assurance of graduate attributes, students are classified on the basis of their reasons for taking the course and learning outcomes. The paper then proposes a model for improving students’ learning styles and analyzes their ability on the basis of the model.

Key-words: 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

1 Introduction
Currently, the evaluation of educational quality has reached a turning point. As indicated by Kitagata (2008)[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 relationship between 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.

On the other hand, quality assurance in university education is an important research issue. 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 Education Council, 2008[2]).

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 (2005)[3].

This study proposes a model measuring educational effects for assurance of education quality and improvement of student satisfaction, focusing on the concepts of both “fourth-generation evaluation,” as proposed by Guba and Lincoln (1986)[4], and “graduate attributes,” as defined by MEXT. 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. Fig. 2.1 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.

2 Proposed Model Measuring Educational Effects

2.1 Conceptual model measuring educational effects for assurance of education quality and improvement of student satisfaction with lecture quality

Fig. 2.1 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.

The “graduate attributes required by a university” on the right side of the conceptual model in Fig. 2.1 are roughly classified into four items; “Understanding of vector analysis,” “Report submission,” “mid-term examination” and “term-end examination.” 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 roughly classified into six items; “Course positioning,” “How will the lectures contribute to the future,” “Understanding of vector analysis,” “Motivation toward learning and university life,” “Credit certification.”
“Students’ motivation toward their own future” and “Credit certification.”

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. Then, the proposed model is one that can be used for measuring educational effects considering each student’s heterogeneity.

2.2 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 (2007)[5] and Tsubaki (2007)[6], and are listed below.

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 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 is 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
(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, “while 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 (2010)[7] are used for the analysis. For a survey of mathematics learning styles, refer to Tsubaki, Kakuta, and Murata (2009)[8] etc.

### 3 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. 3.1 Students’ reasons for attending the lectures](image-url)
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. Furthermore, as 10 students took the course in order to obtain a wide range of knowledge, teachers must help them to understand how the analysis will contribute to their future and provide various approaches for solving the problems they may encounter.

4 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.

4.1 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 as a trend 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.

< Hypothesis for constructing a structural equation >

- “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 ‘Mid-term examination,’ respectively.

4.2 Construction and discussion of the structural equation model
On the basis of the hypotheses in section 4.1, a structural equation model was constructed and analyzed. The achievements are shown in Fig. 4.1.

![Fig. 4.1 Structural equation model](GFI = 0.691, RMSEA = 0.071)

(Owing to space limitations, error correlations are not displayed in Fig. 4.1)

The left side of Fig. 4.1 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 mid-term 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 ‘Mid-term examination.’ Consequently, it is found that a combination of clear awareness of lectures, good learning strategies, and learning styles produce good learning outcomes.

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. 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.

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 ‘Mid-term 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 mid-term examination. Further, the coefficient of “Learning style” to ‘Mid-term 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 (2008)[9]; refer to Fig. 4.2). 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.

The goodness of fit of the model is now described. The model analyzed in Fig. 4.1 has a goodness-of-fit index (GFI) of 0.691. Concerning the requirement of a GFI of 0.9 or more, Toyota (2000)[10] and Ikemoto, Seki, and Tsubaki (2005)[11] 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 (2000). This model has an RMSEA of 0.071, which falls within the acceptable range. Consequently, this model was employed to verify and discuss hypotheses.

5 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’ awareness (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. 5.1. This classification places credit acquisition and other purposes along the vertical axis and learning outcomes along the horizontal axis.

![Fig. 5.1 Classification of students based on the relation between students’ reasons for taking the course and learning outcomes (Conception)](image)

Actual classification based on students’ reasons and learning outcomes is shown in Fig. 5.2.

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.

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. A two-tailed t test was used in order to analyze the survey items for two groups, the high-level and low-level achievement groups.

![Fig. 5.2 Improvement of the learning methods of students](image)

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) (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 learn about 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 learn about 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 while being aware of the importance and usefulness of lectures in universities.

6 Authenticity Criteria for the Models
This chapter confirms whether the proposed model meets the authenticity criteria of fourth-generation evaluation.

6.1 Fairness
As shown in Fig. 6.1, 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.

6.2 Ontological authenticity
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.

6.3 Educatively authenticity
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.

6.4 Catalytic authenticity
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.

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

7 Conclusion
In this research, models based on the concepts of fourth-generation evaluation, as proposed by Guba and Lincoln (1986)[4], 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) – (6):

(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.

(5) Students did not seek an interest factor in the content of the lectures. However, it is necessary to make known the positioning of lectures to them, or the interest factor of “the effectiveness of vector analysis in 4 years.”

(6) The syllabus could be effectively used to position the lectures. However, it is important to note that it may not always be possible to achieve this objective through the syllabus. Consequently, refining the content of the lectures would prove to be useful.

The model for the improvement of learning styles in order to assure graduate attributes yielded the following results (7) and (8):

(7) 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.

(8) 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.

References:
