

ANALYZING THE CAUSAL RELATIONSHIP FOR AN EFFECTIVE REMEDIAL EDUCATION BASED ON BAYESIAN NETWORK: A CASE STUDY

TOSHIYA ARAKAWA

Department of Information Technology and Media Design
Faculty of Advanced Engineering
Nippon Institute of Technology
4-1 Gakuendai, Miyashiro-machi, Minamisaitama-gun, Saitama 345-8501, Japan
arakawa.toshiya@nit.ac.jp

Received February 2021; revised May 2021

ABSTRACT. *The purpose of remedial education is to equip students with the key skills required to undertake university education; thus, remedial education has an important role. At the author's university, the questionnaire, which aims to research students' satisfaction with the lecture, is completed half-yearly. If the questionnaires are well surveyed and analyzed, an effective and efficient way to improve students' study skills could be found, and this could also help lecturers improve their teaching skills. Thus, the causal relationship of these questionnaires is analyzed using a Bayesian network. Considering the results of the analysis, it was found that for students with relatively low academic skills, lecturers should clarify what they do not know and instruct them so that they can actively inquire the lecturers. On the other hand, for students with high academic skills, groupworks satisfy and improve the three essential and fundamental skills because they respect, listen to, and understand other students' opinions through groupworks.*

Keywords: University education, Remedial education, Student's study skill, Bayesian network, Causal relationship

1. Introduction. The primary purpose of this paper is to introduce the causal relationship of satisfaction questionnaire data for the remedial education class for an effective remedial education using a Gaussian Bayesian network, and to propose a method for achieving effective education, or present suitable teaching methods for remedial education. Remedial education (also referred to in the literature as developmental education for imparting developmental or basic skills) refers to courses taken on a college campus that are below the college's academic level. The courses enroll students who were initially underprepared for college level education in writing and math, and guide them until they reach the threshold for registration into credit-bearing courses [1]. Therefore, the purpose of remedial education is to equip students with the key skills required to undertake university education [2].

The university where the author enrolled previously specialized in human resource development for manufacturing and related research. Thus, remedial education is aimed at improving the fundamental skills for manufacturing, such as basic mathematics and physics, writing, and presentation skills. In addition, the author's university focuses on improving three essential and fundamental skills that are needed for engineering: "motivation", "humanity", and "ability". Students are expected to acquire "design skill" and "create skill" for manufacturing based on these skills [3] (Figure 1). The improvement process of these skills is explained as follows [3]:

1) Improving “motivation”

Being aware of “learning” and “connection to society” at the university, students’ motivation to learn and their sense of vocation are fostered. The basis of the class is to approach various issues with one’s own ideas, summarize them through group investigation and discussion, and present them. We raise students’ awareness of their work’s importance and improve their “motivation” by acting.

2) Improving “humanity”

Groupwork is introduced into several classes. There are various styles of groupwork, such as group discussion about a problem or theme to set a direction and work on it, teaching to exercises each other that students are taking in, and so on. “Humanity” is improved by taking initiative, respecting each other, and working together.

3) Improving “ability”

In every class, not only acquiring knowledge but also cultivating the ability to solve problems is emphasized. Students’ ability will be improved by studying with interest via processes such as preparation, lecture, and exercise.

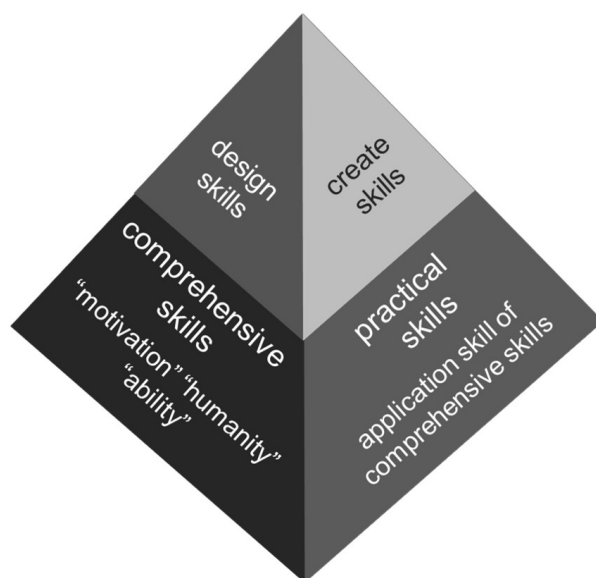


FIGURE 1. Three essential and fundamental skills defined by Aichi University of Technology [3]

For effective and efficient acquisition of the above-mentioned skills, students must realize the importance of acquiring these skills, following enrollment in the university. Thus, remedial education plays an important role in educating first-year university students.

The author’s university has a questionnaire for the half-yearly evaluation of the lecture. The questionnaire aims to research students’ satisfaction with the lecture, the teaching method, whether the previously mentioned three skills required improvement, etc. If these questionnaires are surveyed and analyzed, an effective and efficient way to improve the three skills could be found, and this could help lecturers improve their teaching skills.

In this study, causal relationships are analyzed using a Bayesian network, a probabilistic graphical structure model, based on the results of a questionnaire survey conducted over the last seven years. Considering the results of the analysis, an effective and efficient way to improve the essential and fundamental skills of the first-year students is proposed.

Bayesian network is not especially a unique method for analyzing the causal relation, and there are many previous studies using Bayesian network. As an example of such

previous studies, Zhang et al. adapted Bayesian network to estimate risk for adapting to driving environment changing [4]. As for application Bayesian network to education, there are some previous studies. For example, a study shows an application of Bayesian networks to educational testing [5]. Another study predicts student's performance based on Bayesian networks [6]. A study also describes visualization using Bayesian network and analysis methods using e-book logs collected by research project at university [7]. There is also a previous study proposing the use of Bayesian networks to predict student grades, given past performance in prerequisite courses [8]. These previous studies are for analyzing or estimation student ability, and not for analyzing the lecturer's skill. The main point of manuscript is focusing on analyzing the lecturer's skill for remedial education at industrial university. We think the contribution of this manuscript is showing the characteristics of the students whose academic skill is different and some guideline how to teach such students through the analysis in this manuscript.

The remainder of this paper is organized as follows. Section 2 describes the preparation for analysis, particularly the data used for constructing the Bayesian network model, and instructions related to the network. Section 3 explains the constructed model using the network and presents a summary for this analysis. Finally, Section 4 summarizes this paper.

2. Materials and Methods.

2.1. The dataset. The satisfaction questionnaire data for the remedial education class during the seven years, from 2013 to 2019, were used in this study. Students answered the questionnaire during the final term of the class. At the author's university, questionnaires (Scantron sheets) are distributed immediately after the last semester of classes begins. Students are instructed to answer the questionnaire during the class. At the end of the class, the lecturer arbitrarily appoints a student to collect the questionnaires of all the students who attended the class and bring them to the Academic Affairs Division, where the staff of the Academic Affairs Division compiles the questionnaire data. The data will be fed back to the instructors approximately two to three months after the last semester of the class. The instructors are supposed to take a close look at the feedback data and comment on the data results, including reflections on the class and future initiatives. These questionnaires consist of the following questions.

- Q1: Are you totally satisfied with the class?
- Q2: Did you take the class with motivation?
- Q3: How long did you study for the class on an average?
- Q4: Did the lecturer explain the planning, aim, and goal of the class?
- Q5: Did the lecturer explain the standard of grade evaluation?
- Q6: Did the curriculum or the class go per the syllabus?
- Q7: Were the way of talking and the volume of the lecturer's voice clear?
- Q8: Was the way of presentation or writing on the blackboard understandable for you?
- Q9: Did you feel the lecturer's enthusiasm?
- Q10: Did the class incorporate groupwork and did the students teach each other in class?
- Q11: Were worksheets used and did the class progress based on the cycle like preparation for the lecture, lecture itself, and review of the lecture?
- Q12: How was the response of the lecturer to questions?
- Q13: How well did you understand the class?
- Q14: Were textbooks useful for your understanding of the class?
- Q15: Do you think the goal of the class was achieved?
- Q16: To what extent do you think this class has improved your motivation?

Q17: To what extent do you think this class has improved your humanity?

Q18: To what extent do you think this class has improved your ability?

Each questionnaire was scored on the following basis: do not think (feel) at all = 1 point; average (neither yes or no) = 3 points; and think (feel) strongly = 5 points. In addition to the above questionnaires, students may optionally enter comments about the class. The results of the questionnaires were omitted if the scores of each questionnaire were all the same, e.g., if all the answers from Q1 to Q18 were 1 or 5.

The remedial education classes are divided into five categories: languages, mathematics, physics, computers, and general education, which are based on the genre, and five classes, which are based on each student's score in the achievement examination taken during the admission at the university. Examples of a class name belonging to each category are shown below:

- Language categories:
Basic English, TOEIC Basic, Chinese, English communication, English reading, Practical Japanese
- Mathematics categories:
Fundamental Mathematics, Vectors and Matrices, Statistics and Probability, Differentials, and Integrals
- Physics categories:
Elementary Mechanics, Physics, Method of Thinking, and Use of Physics: Exercise
- Computer categories:
Information Literacy, Fundamental Programming
- General education categories:
Psychology, Chemistry, Law and Politics, Life Science, Environment Conservation, Engineering Ethics

Students' classes are categorized per their individual score in the achievement examination taken during admission at the university. Classes are categorized into class A to class E. Class A is the lowest level class for students who are not good at language or mathematics. On the contrary, class E is the highest-level class for students who are good at language or mathematics. Apart from this, there is a special class, LA class (Less than A class) for students who had not studied mathematics sufficiently until their high school days, and whose academic ability of mathematics is not enough to take the university's class. However, the class held for 2nd-year students is not categorized by students' academic ability. Even though students are categorized into classes according to their score at the achievement examination, it is considered that in the author's university, students of A and B classes are lower-ability students, whereas students of C and D classes are higher-ability students. Thus, the curricula of A and B classes are almost the same. This is also the same in the case of classes C and D. Moreover, in this paper, the data of classes A and B are summed up while those of C and D classes are the same.

Each category of the remedial education classes and the number of classes that are involved in each category from 2014 to 2019 are shown in Tables 1 and 2. Table 1 shows the number of classes for each remedial education category, and Table 2 shows the number of classes according to students' individual levels of academic achievement. As noted above, the classes held for 2nd year students are not categorized by students' academic ability; thus, class number in Tables 1 and 2 is that of only the 1st year students.

In this study, the causal relationship of each class was analyzed because it would be effective to find the most important factor for each class level. However, the causal relationship of each category of remedial education was not analyzed because, in this manuscript, we would like to analyze the point or the method how the student of each

TABLE 1. The number of classes in each remedial education categories

Category	Number of classes
Language	268
Mathematics	282
Physics	69
Computer	76
General education	180

TABLE 2. The number of classes in each remedial education classes

Class	Number of classes
LA	62
AB	209
CD	90
E	21

TABLE 3. The minimum, 1st quartile, mean, 3rd quartile and maximum Q1 score of each class

Class	Minimum	1st quartile	Mean	3rd quartile	Maximum
LA	2.780	3.655	3.887	4.140	5.000
AB	2.500	3.640	3.827	4.050	4.700
CD	2.710	3.533	3.761	4.015	4.820
E	3.260	3.960	4.045	4.250	4.670

TABLE 4. The minimum, 1st quartile, mean, 3rd quartile and maximum students number of each class

Class	Minimum	1st quartile	Mean	3rd quartile	Maximum
LA	2.00	12.25	17.87	24.00	33.00
AB	6.00	17.00	23.68	27.00	65.00
CD	10.00	23.00	31.54	37.75	85.00
E	5.00	25.00	27.08	31.00	66.70

class can improve their ability. Here, in Table 3, the minimum, 1st quartile, mean, 3rd quartile and maximum Q1 score of each class are shown. As a reference, the minimum, 1st quartile, mean, 3rd quartile and maximum students number are also shown in Table 4. In author's university, all questionnaire despite the number of students is subject to be analyzed, thus, in this manuscript, all result of questionnaire were used for analysis.

Next, an analysis method is introduced. Considering our motivation to find an effective and efficient way to improve three essential and fundamental skills and help lecturers improve their teaching skills, it is desirable to find the relationship between the students' satisfaction for the class and the three skills, for instance, the points of Q1, Q16, Q17, and Q18 in the questionnaire, and other factors concerning the teaching method, that is, the points of other questions besides Q1, Q16, Q17, and Q18 in the questionnaire. To find these relationships, we applied the Gaussian Bayesian network for the analysis of the questionnaire.

2.2. Bayesian network. Bayesian networks [9], also known as “belief network” or “causal networks”, are a type of probabilistic graphical model that uses Bayesian inference for

probability computations. Bayesian networks aim to model conditional dependence, and therefore causation, by representing conditional dependence by edges in a directed acyclic graph (DAG). Through these relationships, one can efficiently infer the random variables in the graph using factors [10]. The nodes are random variables, and the edges give dependencies between the variables. A set of conditional distributions of each variable, given its parents, completes the joint description of the variables [10,11].

Random variables, $X = X_1, \dots, X_n$, are called nodes, and dependencies between each node are expressed by connecting an arrow called an arc. For example, in Figure 2, dependencies between each random variable can be expressed by conditional probability, that is, X_2 and X_3 are defined as $P(X_2|X_1)$ and $P(X_3|X_1, X_2)$, respectively. Thus, the joint probability distribution of the Bayesian network in Figure 2 is defined as follows:

$$P(X_1, X_2, X_3) = P(X_3|X_1, X_2)P(X_2|X_1)P(X_1)$$

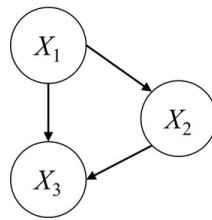


FIGURE 2. An example of a Bayesian network

As for constructing the Bayesian network model, there are two types of models: knowledge-driven and data-driven. In this study, the Bayesian network model was constructed based on a data-driven type. In addition, to construct a Bayesian network model based on a data-driven type, there are three algorithms: constraint-based, score-based, and hybrid algorithms. In this study, a score-based approach was applied.

A score-based algorithm is one in which DAG is explored to maximize the score function, and the score is distributed to DAGs, which are candidates for correct DAG based on the score function. In this study, Bayesian information criterion (BIC) was applied as a score function [12]. This is an algorithm that G^* , which satisfies the following equation, and it is explored when the score of graph structure g constructed by dataset D is defined as $Score(g|D)$:

$$G^* = \arg \max Score(g|D)$$

The greedy hill climbing algorithm is known as a typical score-based algorithm, and has been applied in this study. A Bayesian network can incorporate the causal knowledge of professionals and relationships that are clarified previously into the model as previous information when the model structure is learned.

In this study, the score is a continuous value; thus, a Gaussian Bayesian network was applied for the analysis of causal relationships based on the results of a questionnaire survey conducted over the last seven years.

2.3. Analysis. R version 3.6.0 was used for analysis, and the bnlearn package was used for constructing the Gaussian Bayesian network. For constructing a Gaussian Bayesian network, the pass that should not be connected logically was set as a blacklist. The following was considered as an improper directed path.

- 1) Q1, Q16, Q17, and Q18 are not causes but results because students' satisfaction and three skills, "motivation", "humanity", and "ability" are the results of the instruction.
- 2) Q4, Q5, and Q6 are not results but causes because class operation is based on syllabus.

- 3) Q10 and Q11 are not results but causes because students' satisfaction and motivation may be brought about by the groupwork and their study with the work sheet.
- 4) The causal relationship between Q14 and other questionnaires is unclear; however, Q14 may be the cause of Q1, Q2, Q3, Q6, Q7, Q8, Q9, and Q15 because students may get to increase their motivation and understanding of the class because of the textbook. Additionally, they may get to understand lecturers' lessons due to the textbook. In addition, the textbook used in the class may help achieve the class goal. On the other hand, Q14 may not be the cause of the other questionnaire besides Q1, Q2, Q3, Q6, Q7, Q8, Q9, and Q15.
- 5) Q14 may be the result of Q2, Q3, Q4, Q5, Q6, Q7, and Q8 because students realize the usefulness of the textbook, after they feel that they get to increase their motivation and understand the lecturer's lesson well. On the other hand, Q14 may not be the result of the other questionnaire besides Q2, Q3, Q4, Q5, Q6, Q7, and Q8.
- 6) As in the case of Q14, the causal relation between Q15 and other questionnaires is also unclear; however, Q15 may be the cause of Q1 because students feel satisfied with the class, if they feel that the class goal was achieved. On the other hand, Q15 may not be the cause of the other questionnaire besides Q1.
- 7) Q15 may be the result of Q2, Q3, Q6, and Q15 because the class goal is to improve students' motivation and make them study. On the other hand, Q15 may not be the result of the other questionnaire besides Q2, Q3, Q6, and Q15.

3. Results and Considerations. In this section, Figure 3 shows the results of the Gaussian Bayesian network for the questionnaire responses of each student's class. In Figure 3, (a) to (d) show the result of classes LA, AB, CD, and E, respectively.

3.1. Causal relation in class LA. As for class LA, the following characteristics were found.

- 1) Q10 has no relation with other questionnaires.
- 2) Q2 and Q7 are causes of Q1.
- 3) Q2, Q12, and Q13 are causes of Q16.
- 4) Q2, Q9, and Q13 are causes of Q17.
- 5) Q2 and Q14 are causes of Q18.

Considering this, regarding class LA students, groupwork does not affect items such as satisfaction to study. In other words, it is suggested that doing groupwork is useless for class LA students.

In addition, considering from 2) to 5), Q2 may be the common item for satisfaction with the class and improvement of three essential and fundamental skills. It is suggested that it is important for class LA students to first take a class with motivation. Next, Q13 is an item to improve Q16 and Q17, and Q7 and Q9 are the causes of Q13. Thus, it seems important that the lecturers should consider the loudness of their voice and the readability of the materials, and show their enthusiasm to the students. In case of students with a relatively low academic ability, students may be inspired by the faculty members' enthusiasm for teaching the students, rather than teaching the essential content of the discipline, by first showing them that he or she is teaching with enthusiasm.

3.2. Causal relation in class AB. As for class AB, the following characteristics were found.

- 1) Q2, Q7, Q12, and Q13 are causes of Q1.
- 2) Q3 and Q12 are causes of Q16.
- 3) Q2, Q10, Q12, and Q14 are causes of Q17.

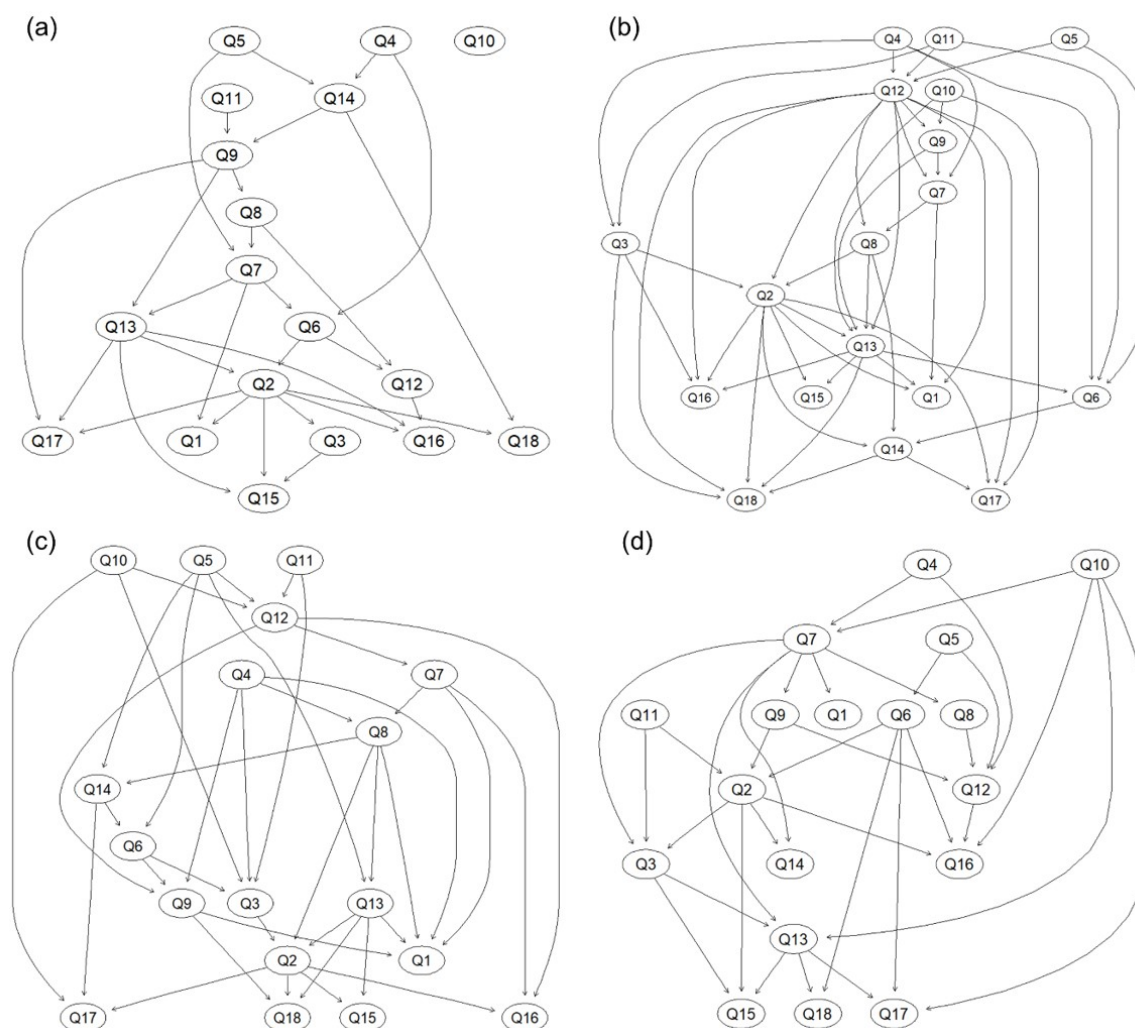


FIGURE 3. The result of constructed model by Bayesian network: (a) class LA, (b) class AB, (c) class CD, and (d) class E

4) Q2, Q3, Q12, Q13, and Q14 are causes of Q18.

It was found that taking classes with motivation leads to students' satisfaction with the class, and this was the same as the case of class LA. On the other hand, Q12, Q13, and Q14 are common items for improvement of satisfaction with the class and three essential and fundamental skills. This differs from the case of the class LA.

Q10 is a cause of Q17, and it suggests that, for class AB, groupworks contribute to improve "humanity" in three essential and fundamental skills. In addition, interestingly, Q12 is a cause of Q17 and Q18. The difference from the case of the class LA seems to exist at the point of "students realize what they do not understand, and they ask the lecturers about it", and consequently, their communication ability improved. Moreover, they can also cultivate their "humanity", which leads to the improvement of "ability" because they get to solve their question. Further, Q14 causes Q17 and Q18. Some students, and the number seems to be less than that of class LA, do not have a good grasp of the study points. Thus, for the class AB, reading the textbooks thoroughly might lead to the improvement of "ability" of three essential and fundamental skills. However, the reason that Q17, "humanity" of three essential and fundamental skills, was improved is unclear. We will continue to consider this issue.

3.3. Causal relation in class CD. As for class CD, the following characteristics were found.

- 1) Q4, Q7, Q8, Q9, and Q13 are causes of Q1.
- 2) Q2, Q7, and Q12 are causes of Q16.
- 3) Q2, Q10, and Q14 are causes of Q17.
- 4) Q2, Q9, and Q13 are causes of Q18.

Interestingly, Q4 is a cause of Q1, which is different from the case of classes LA and AB. Students in the classes CD and E are defined as excellent students in the author's university, and excellent students are considered to emphasize the learning process after they are explained that what, how much, and how they study at the class. Considering this, it is suggested that the planning, aim, and goal of the class, which is the content of Q4, leads to satisfaction with the class. In addition, Q12 is a cause of Q16; however, it is not a cause of Q17. This differs from the case of the class AB. It seems that the excellent students have some ability to communicate, and it is just a normal thing to ask the lecturers. Thus, they seem to increase their motivation for study because they get adequate answers to their questions from the lecturers.

3.4. Causal relation in class E. As for class E, the following characteristics were found.

- 1) Q7 is a cause of Q1.
- 2) Q2, Q6, Q10, and Q12 are causes of Q7.
- 3) Q6, Q10, and Q13 are causes of Q17.
- 4) Q6 and Q13 are causes of Q18.

The class E consists of excellent students, and most of them understand how to study at the university. Thus, they already have the habit of studying themselves, and they expect easy explanations from their lecturers for their better understanding. Overall, it is suggested that Q6, Q10, and Q13 affect the three essential and fundamental skills. First, regarding the effect of Q10, the students can verify their ability and progress in their study with other students through groupwork. Moreover, the excellent students seem to benefit from groupworks. As for Q13, it also needs to be considered that Q7 and Q10 are also causes of Q13. Doing groupwork and the explanation method helps improve students' understanding; thus, it is suggested that the students improve their "humanity" and "ability" because they respect, listen to, and understand other students' opinions. As for Q6, it is suggested that Q6 improves students' motivation (Q16) because Q6 means that the students can study in line with the goal of the syllabus. However, the reason that Q6 brings the improvement of Q16 is still unclear. We will continue to consider this issue.

3.5. Summary of consideration. The discussion in Sections 3.1 to 3.4 can be summarized as follows.

- 1) Groupworks do not affect satisfaction and improvement of the three essential and fundamental skills for students with low academic ability. On the other hand, there is a tendency for groupworks to affect satisfaction and improvement of the three essential and fundamental skills for students with high academic ability.
- 2) The way the lecturers speak and the volume of their voice have a significant impact on students' satisfaction with the class. Figure 4 shows the scattering plot between Q7 (the way of talking and the volume of the lecturer's voice) and Q1 (student's satisfaction to the class) of each class. Considering this and the result of analysis by Bayesian network, there are strong correlation between Q7 and Q1. The correlation coefficient between Q7 and Q1 of each class is also shown in Table 5. Considering Figure 4 and Table 5, we can insist, as far as in this manuscript, that the louder and

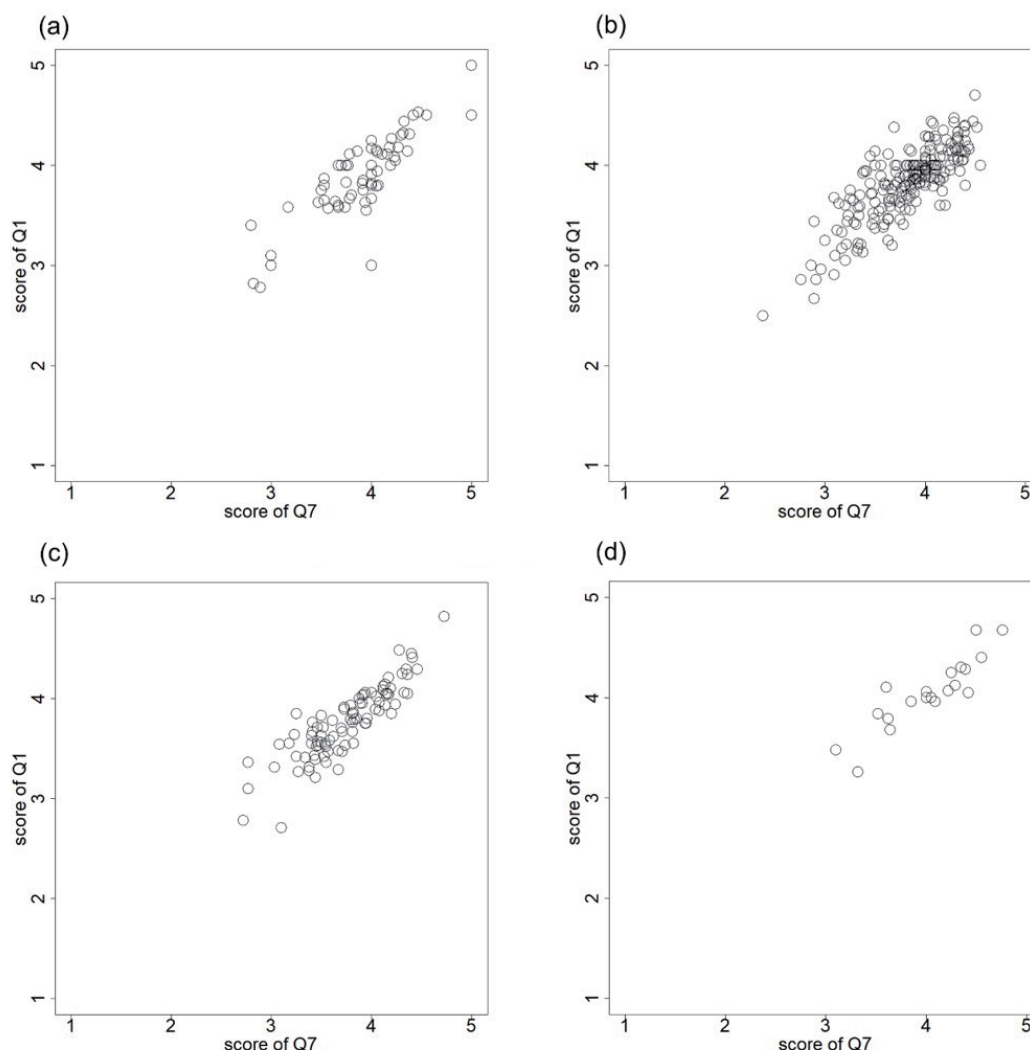


FIGURE 4. The scattering plot between Q7 and Q1 of each class: (a) class LA, (b) class AB, (c) class CD, and (d) class E

TABLE 5. The correlation coefficient between Q7 and Q1 of each class

LA	AB	CD	E
0.840	0.807	0.872	0.890

clearer the lecturer speaks, the more the lecturer satisfies the students. These results confirm the result of Bayesian network.

- 3) The students of the class AB, who have a relatively low academic ability, can cultivate the three essential and fundamental skills, if they ask questions to the lecturers and the lecturers answer properly. Even though their academic ability is relatively low, they are conscious about the point they cannot understand; thus, they can ask lecturers to solve their questions, which would cultivate their three essential and fundamental skills.
- 4) It is suggested that explanation of the planning, aim, and goal of the class, and making the class based on the syllabus, have a large influence on the three essential and fundamental skills for the students of the class CD and E, with relatively high academic abilities. The motivation of the students with high academic abilities may lead them

to understand what, to what extent, and how they study in the class, despite having an attitude toward self-study. For considering this, the results of student's comment of the class, whose satisfaction is lower than 1st quantile in Table 3, are shown in from Tables 6 to 9. Tables 6, 7, 8, and 9, respectively, present comments from students in classes LA, AB, CD, and E.

TABLE 6. Comments of students in class LA

LA	<ul style="list-style-type: none"> • The lecturer's voice is low, and it is hard to hear him. He is too harsh on students when they make mistakes. • I have not studied calculus; therefore, the lecture is hard to understand. • At first, the contents of the class were not suitable for class LA; the equation exercise especially is not adequate for class LA. • The lecturer's responses were bad. • The contents of the class are too easy. • The lecturer's explanations are long.
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TABLE 7. Comments of students in class AB

AB	<ul style="list-style-type: none"> • The lecturer was gloomy. • The contents that were projected were hard to see. • I could not feel the lecturer's enthusiasm. • The lecturer's explanations were not understandable. • I wish the lecturer would explain the solution for the exercise in more detail. • The lecturer should write more clearly. • The voice of the lecturer was too low. • I wish the lecturer would stop sighing. • I want the lecturer to proceed with classes more smoothly. • The lecturer is annoying. • The voice tone of the lecturer is hard to listen to. • I want to concentrate on solving the exercise without the lecturer speaking. • The class should proceed according to the syllabus. • The textbook used in the class should be changed. • There were a lot of mistakes when the lecturer wrote on the blackboard. • The text that the lecturer wrote on the blackboard was too small. • There were instances of classes being short in terms of time.
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Considering 1), 2), and 3) and Tables 6-9, the comments from students in classes LA and AB (which include many students having relatively low study skills) are mainly in response to the lecturer's way of speaking and teaching. Figure 4 shows that the lecturer's way of speaking affected the satisfaction of the students in the class. This is also evident in the students' comments in classes LA and AB. However, for classes CD and E, the comments are mainly concerned with the progression of the class or the lecturer's response to questions from the students, and there are fewer comments about the lecturer's way of speaking or poor handwriting than there are from classes LA and AB. In other words, the students of classes CD and E, which are higher level classes than LA and AB, are more motivated to understand the class and improve their study skills than those in classes LA and AB. Therefore, the students from classes CD and E feel dissatisfaction if the lecturer responds inadequately to the students. This consideration coincides with the results of the analysis of a Bayesian network, shown in

TABLE 8. Comments of students in class CD

CD	<ul style="list-style-type: none"> • The lecturer told me to transcribe the answer, which I did understand. He reiterated his previous statement when responding to a question I asked him. • The lecturer did not prepare for commentary prints for topics that he could not explain in class. He explained in the same way he did during the class when I asked him questions after class. • The handwriting on the corrective prints was too bad to understand. • The homework problems are so difficult. • For this class, the lecturer does not need to spend three hours. If he can finish the class in half an hour, it may be effective. • The attitude of other students in the class was quite bad. • I wanted the lecturer to speak clearly. • I think the lecturer took too much time to check and explain the solutions of homework. • The lecturer's voice was too low to understand. I want him to speak clearly. • I want the lecturer to explain more and speak louder. His writing on the blackboard was illegible.
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TABLE 9. Comments of students in class E

E	<ul style="list-style-type: none"> • Google Classroom was not utilized adequately. • I wanted an explanation regarding grammar. • I would have liked a detailed explanation. • I would like to be taught how to solve a proof problem. • The lecturer should give us homework for every class. • The lecturer's voice was low. • Ninety minutes seemed too long a time period to solve a few problems.
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the previous section. Therefore, it can be said that the result of the Bayesian network confirms the comments of the students.

4. **Conclusions.** In this study, models were constructed using a Bayesian network based on the results of the class evaluation questionnaire about remedial education from 2013 to 2019, and the constructed model was analyzed. Considering the analysis, we can say the effective method for each level of students to improve their academic skills is as follows.

- 1) For class LA students, whose academic skills are relatively low, lecturers should make them understand what they do not know and instruct them so that they can actively ask questions to the lecturers. Class AB students, whose academic skills are higher than those of class LA students, already have such skills.
- 2) For class AB students, lecturers should instill the attitude to self-study, which class CD students already have. In addition, the lecturers should educate them on how 15 classes proceed and what kind of knowledge the students are desired to have, and they should educate students so that they can fully grasp the flow of the class.
- 3) For class CD students, they satisfy the class if the planning, aim, and goal of the class are adequate. In addition, it seems that they seem to increase their motivation for study because they get adequate answers to their questions from the lecturers.
- 4) For class E students, they already have the habit of studying themselves, and they expect easy explanations from their lecturers for their better understanding. In addition,

it is suggested that the students improve their “humanity” and “ability” because they respect, listen to, and understand other students’ opinions through groupworks.

For future research, the results of the questionnaire of each remedial class will be analyzed. Furthermore, in view of the results of this study, the essence for improving students’ satisfaction and their three essential and fundamental skills will be considered.

Acknowledgment. The author gratefully acknowledges Mr. Ruyta Kawai and Mrs. Kazumi Sugiura for helping the author input the data.

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