Analysis of Blended Classes on Operations Research Focusing on Practice

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Abstract— **Operations Research classes are held focusing on practice. Following the textbook, slides are shown, there are lectures on problems and their formularization and solutions are explained using examples. After classes, as practice, a sheet with blank boxes for answers to similar problems in the same format as the examples was distributed and students were asked to complete it. The next week, after giving the answers to the practice problems, a sheet with problems similar to examples and practice was distributed as a challenge in the same format as practice problems and students were asked to complete it. E-learning that makes it possible to study with lecture slides and to browse answers to practice problems was provided for lesson preparation and revision in and outside of classes. At the beginning and the end of the course, students were questioned about their level of term recognition and awareness in the classes. This study analyses this information and reports on changes in level of term recognition and awareness.**

Keywords- Operations Research, Recognition level of technical terms, Survey about attitude, Blended learning, Exercise, Assignment

I. INTRODUCTION

In Operations Research (OR) classes as one type of information science lectures, we believed that the contents of classes would not be well understood with only explanations of and solutions to problems. Therefore, we incorporated practice into these classes. The contents of the textbook were explained. During practice, worksheets that made it possible to practice by filling in the blanks were distributed. As a result, almost all students did the practice sheets and handed them in. For the practice portions of all chapters, the calculation method was explained so that it was possible for students to obtain solutions if they filled in the appropriate figures in each box of the calculation formula. It was made clear to students that if they had a calculator, they would be able to solve OR problems themselves. This method was adopted with the expectation of understanding the nature of OR and fostering people who can solve problems that they come up against in society through the experience of solving problems. The contents of these lectures have been made into an Operations Research textbook [1].

Following the textbook, slides are shown, there are lectures on problems and their formularization, and solutions are explained using examples in these classes. After these classes, a sheet with blank boxes for answers to similar problems in the same format as the examples was distributed and students were asked to complete it as practice. After giving the answers to the practice problems at the next week, a sheet with problems similar to examples and practice was distributed in the same format as practice and students were asked to complete it. In this way, OR classes were conducted focusing on practice [2].

How to learn is different for each student. A perfect media for all students does not exist. It is possible to support many and various student learning styles and to deepen understanding by using more than one media [3][4]. The use of e-learning, which cooperates with and expands the class, in the classroom is a useful means to improve the traditional class [5][6]. Reading class content on the web increases opportunities to review and prepare. It is tied with settlement of the contents to learn many times until a learner is convinced. Even if a learner is absent from a class, the class content can be reviewed at his/her convenience.

Approximately 80% of classes using e-learning in Japanese higher education are blended learning [7]. In Japan, the number of blended classes coordinating lectures and e-learning is particularly high. These are producing effects on studying through reciprocal complementation of lectures and e-learning [8]. There are expectations for this type of blended classes [9]. The authors have been implementing blended learning for the past ten years or so and have produced good results [10]. The authors are implementing blended classes for an introduction to computers. We can report that there were positive results from the development of classes with integrated media such as organized lecture notes, e-learning and short tests. In addition, we reported that it was possible to even further boost effects due to an increase in interaction with teachers through a questionnaire about the level of understanding [11]. The results of a comparison of the use of e-learning in and outside of classes showed that almost the same effects could be obtained with both methods [12][13].

The structure of the classes can be roughly divided into lecture, practice and experiment. Blended classes for which we have made reports up until now have been lecture-type classes. Accordingly, in Operations Research classes that are practice-type, in order to produce results by implementing blended classes, preparing e-learning that makes it possible to study with the lecture slides and to browse answers to practice problems made it possible to use e-learning in lesson preparation and revision in and outside of classes.

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This paper sets out to discover the effects of blended practice-type classes, by analyzing the answer to questionnaire survey about their level of recognition of terms used in the classes and awareness at the beginning and end of the course. This paper explains class contents and methods, analyses the information obtained from questionnaires, and reports on changes in level of recognition of terms and awareness.

II. CLASS DESIGN AND CONTENTS

Class contents are shown in TABLE I. The textbook [1] is composed of 14 chapters with representative OR techniques and in classes, the 7 problems shown in TABLE I from these 14 chapters were taken up. The target was an elective course for the latter period of the 3rd year of university information studies. There were 20 students in the 2012 class. There were a total of 15 classes of 90 minutes each.

The textbook is composed of goals, definitions of problems, solutions to problems, practice and challenges for each technique. It was assumed that they would be used in lectures, but at the beginning of each chapter, the goal was explained so that they could also be used in practice and experiments. Next, the problems in the chapter were explained and defined so that the students understood the content. Actual examples were used and there were no omissions, giving a detailed explanation of techniques and methods or the solution to the problem. After this, practice problem sheets were distributed and practice in actually calculating and solving problems similar to the examples was conducted. These problems can be solved with either a calculator or a pen and paper. At this time, the practice problems sheet is prepared with the required tables and text and is in a framework in which the problem can be solved by filling in figures and results in the blanks. Furthermore, two challenges are also in the textbook to offer an opportunity for practice for those who wish to further cultivate their understanding. This is a feature that does not exist in similar books.

If the problems could not be completed within the time limit, students were instructed to finish and hand it in by the next week. The answers to practice questions were explained the following week. One of the ways of using these challenges is to distribute challenge sheets with the same format as for practice and have the students solve them. Students were made to hand these practice and challenge sheets in as many times as it took until they got the correct answers. Furthermore, final exams were implemented. In any case, understanding of each technique is improved by repeatedly solving three types of problems: the example problem that shows the solution method, the practice problem and the challenge.

From the actual experience [2] of giving lectures, the explanation of goals, problem definition and problem solution took between 15 and 40 minutes so it was possible to use between 35 and 60 minutes for practice, ensuring plenty of time. Lectures, practice and challenges for one chapter were completed every two weeks.

At the beginning of the class, the answers to the previous week's practice are given. Then, after explaining the goal of that day's problem technique, the formulization and method for solving the problem are explained. Lecture contents are explained through slides projected on the screen. After that, a practice sheet with blanks is distributed in order to implement practice for the chapter that has been explained. Then the students are asked to solve the problems. When the problems are solved, the students hand them in.

A. Class Goals and Aims

OR is a mathematical model for decision-making. Many mathematical models are proposed. The goal of this class is to explain these techniques, to actually practice these techniques after the lecture, to cultivate understanding and to be useful in problem solving in society. In addition, through various activities in these lectures, the ability to think and solve problems is cultivated.

TABLE I. PLANS AND DESIGN ON OPERATIONS RESEARCH.

Week	Lecture Contents	During the Class							Outside the Class			
		Lecture Slides	Practice Slides	Practice Sheets	Challenge Sheets	Instruction for Class Plan and Method	Awareness Survey	Recognition Survey	Lecture Slides	Practice Slide Study	Evaluation Sheets	Report Framework
1	Chapter 4 Transportation	Chapter 4		Practice 1		Distribution of Materials	Survey prior to course	Survey prior to course	Chapter 4		Submit prior to course	
2	Challenge 1		Practice Answer 1		Challenge 1					Practice Answer 1		
3	Chapter 5 Assignment	Chapter 5		Practice 2					Chapter 5			
4	Challenge 2		Practice Answer 2		Challenge 2					Practice Answer 2		
5	Chapter 6 Travelling Salesman	Chapter 6		Practice 3					Chapter 6			
6	Challenge 3		Practice Answer 3		Challenge 3					Practice Answer 3		
7	Chapter 7 Sequencing	Chapter 7		Practice 4					Chapter 7			
8	Challenge 4		Practice Answer 4		Challenge 4					Practice Answer 4		No.1 (Chapters 4,5,6,7)
9	Chapter 8 Shortest Path	Chapter 8		Practice 5					Chapter 8			
10	Challenge 5		Practice Answer 5		Challenge 5					Practice Answer 5		
11	Chapter 9 Schedule Planning	Chapter 9		Practice 6					Chapter 9			
12	Challenge 6		Practice Answer 6		Challenge 6					Practice Answer 6		
13	Chapter 10 Replacement	Chapter 10		Practice 7					Chapter 10			
14	Challenge 7		Practice Answer 7		Challenge 7					Practice Answer 7		No.2 (Chapters 8,9,10)
15	Overall Practice						Survey after course	Survey after course			Submit after course	

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The aims of this class are to understand the selected mathematical models in OR and the algorithms of these techniques so that students can solve the problems according to these algorithms.

B. Class Design

Explanations were given based on the class planning and design in TABLE I. In the first week, class plan explanations were distributed and class planning was explained. After that, an initial survey of term recognition and awareness was conducted. Based on the textbook, the goals, problem definition and solution method for the example were explained for Chapter 4 Transportation. Next, practice sheets were distributed and students were asked to solve the practice problems referring to the explanation of the solution method for the example. At that time, students were given advice to browse the e-learning lecture slides and refer to them. During practice, the teacher went around the classroom and accepted a question. Students were observed helping each other. Those who came up with the answers were asked to submit their practice sheets. Those who didn't come up with the answers were asked to bring their completed practice sheets to the professor's office before the next class.

The next week, the answers to the practice problems were given. After that, sheets were handed back to those who had made mistakes in the answers or the calculations. Next, challenge sheets were distributed and students were asked to solve the problems. At that time, the students were advised to browse the e-learning lecture slides and refer to them. Those who came up with the answers were asked to submit their challenge sheets. Those who didn't come up with the answers were asked to bring their completed challenge sheets to the professor's office before the next class.

In the 3rd week, the goals, problem definition and solution method for the example were explained for Chapter 5 Allocation. Next, the students were asked to solve practice problems in the same way as for Chapter 4 and submit them. In the 4th week, the students were asked to solve challenge problems in the same way as for Chapter 5 and submit them. In this way, the class got through one chapter every 2 weeks.

The submission of practice and challenge problems was repeated until the answer was correct. If a problem sheet was to be given back, mistakes on the sheet were marked with a colored pencil. There were some students who took a long time to get the right answers even though they were able to browse e-learning documents after the answers were explained in class. In the end, 7 practice and challenge problems were completed in 15 weeks. Post surveys of term recognition and awareness were taken in the 15th week.

Students were asked to fill in the goals, problem definition and discussion for each chapter after downloading framework files and were asked to submit these two reports in the 8th and the 14th weeks.

C. Contents of E-learning

To intensify the effect of this lecture and to enable the students to make a peer assessment, e-learning functions were added as follows: (1) learning with 254 lecture slides; (2) learning with downloadable documents and templates of seven kinds; (3) submitting and uploading exercises of seven kinds; (4) uploading opinions to a bulletin board and browsing them; and (5) sending question mail.

III. Analysis Results and Discussion

For this paper, in order to understand the level of understanding of terms that came up in class contents, term recognition surveys were conducted before and after the course. By conducting study activities related to the classes, an awareness study related to ability was implemented before and after the course in order to understand the changes in awareness related to ability. In order to understand which activities are useful in improving this awareness, students were asked to fill in activities that help to improve awareness in the right-hand column beside the awareness evaluation number in the post-project awareness survey.

Below, we state that significant differences were observed in the significance testing with a significance level of 5%. The symbols m, SD, F, t and p refer to mean, standard deviation, F value, t value for test statistics and probability respectively. The results of the tests show that symbols ***, ** and * are significant with significance levels of 0.1, 1 and 5% respectively. The + symbol shows the significance trend with a significance level of 10%.

A. Changes in Term Recognition

In order to find out whether students have understood the OR related terms that came up in class lectures, the term recognition level survey method [14] developed by Nakamura et al. was used. The 33 terms listed in TABLE II were surveyed twice for recognition (R) before (April) and after (July) the course (N=19). 19 people gave valid responses to this survey. Evaluations were made on three levels of recognition: 3. I understand it, 2. I don't fully understand it but I have heard of it, and 1. I don't understand it. H-check terms for which there is a high likelihood of respondents understanding them were: PC, queue and network and an L-check term for which there is a low likelihood of respondents understanding it was: simulation. These 4 terms were expected and set to be terms that did not change throughout the class.

Results of paired significance tests for recognition of the above-mentioned terms are shown in TABLE II. The results of pre- and post- paired significance tests for the development of average recognition of the 33 terms showed a significant difference with a significance level of 0.1%. It was observed that post-course recognition was higher.

The results of a paired significance tests for average growth of recognition of each term before and after the course showed a significance level of 0.1% for 22 terms, a significance level of 1% for 6 terms and a significance level of 5% for 1 term. This means that recognition levels for these 29 terms had risen after the course. However, through the significance test, 4 terms were observed not to have significant differences. These were all the check terms. PC,

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queue and network were H-check terms. These had high recognition of R=3.0, R=2.6 and R=2.5 before the course and of R=3.0, R=2.8 and R=2.7 after the course respectively with almost no change. It is for this reason that these terms, having had high recognition from the beginning, did not change much due to the classes. In addition, the L-check term 'simulation' was not explained in the classes and the pre-course survey showed low recognition of R=2.1 whereas the post-course survey showed a value of R=2.4 with almost no change. In this way, the 4 check terms that were set to show the validity of the survey were stable and there was no significant difference in the significance test. This can be considered to show the validity of the survey. Due to this fact, it can be said that understanding of the 29 terms that appeared in relation to class contents was improved.

B. Changes in Evaluation Values of Awareness related to Ability

The 35 categories listed in TABLE III were surveyed twice for awareness before (April) and after (July) the course. There were 9 evaluation values: 1. Not at all, 3. Slight, 5. A little, 7. Fairly and 9. Extremely. 19 people responded to this before and after the course.

TABLE II. SIGNIFICANCE TEST FOR TERM RECOGNITION.

Contents	No.	Term	Before		After		Significance Test	
			m	SD	m	SD	t−value	p
Transportation	2	Transportation	1.2	0.4	2.9	0.2	16.7	***
	3	Objective Function	1.4	0.5	2.8	0.4	9.2	***
	4	Restrictions	1.6	0.6	2.8	0.4	9.9	***
	5	Optimal Solution	1.6	0.7	2.7	0.4	5.5	***
	6	Typical Constant	1.3	0.4	2.5	0.7	6.7	***
	7	Optimal Decision	1.3	0.4	2.5	0.6	7.5	***
Allocation	8	Allocation	1.3	0.4	2.8	0.4	10.9	***
Travelling Salespeople	9	Travelling Salespeople	1.2	0.4	2.7	0.4	13.6	***
	10	Setup Fees	1.2	0.4	2.5	0.5	8.5	***
Ordering	13	Ordering	1.4	0.6	2.7	0.4	8.7	***
	14	Johnson Method	1.2	0.4	2.2	0.6	6.5	***
Shortest Route	15	Shortest Route	1.6	0.6	2.7	0.5	8.4	***
	12	Distance Matrix	1.3	0.4	2.6	0.5	9.8	***
	16	Node	1.8	0.6	2.6	0.6	3.5	**
	17	Arc	1.5	0.6	2.4	0.6	4.5	***
	18	Diagraph	1.3	0.5	2.4	0.7	7.4	***
	19	Shortest Route	1.7	0.7	2.6	0.7	4.5	***
Schedule Control Planning	21	Schedule Control Planning	1.6	0.7	2.5	0.6	5.3	***
	22	PERT	1.3	0.4	2.3	0.7	6.5	***
	23	Arrow Diagram	1.6	0.7	2.5	0.6	3.9	**
	24	Critical Path	2.2	0.7	2.8	0.4	3.0	**
Exchange	25	Exchange	1.2	0.4	2.7	0.4	13.0	***
	26	Discounted Value	1.4	0.5	2.3	0.6	5.3	***
	27	Malfunction Probability	1.7	0.7	2.5	0.5	3.7	**
	28	Average Lifespan	1.9	0.8	2.5	0.6	2.2	*
Inventory Control	29	Inventory Control	1.5	0.5	2.3	0.7	6.4	***
	30	Order Point Method	1.4	0.5	2.3	0.5	6.9	***
	32	Storage Costs	1.5	0.6	2.2	0.7	3.6	**
	33	No. of Orders	1.6	0.6	2.3	0.5	3.6	**
Check Terms	31	Simulation	2.1	0.6	2.4	0.7	1.6	
	20	Network	2.5	0.5	2.7	0.4	1.2	
	11	Queue	2.5	0.5	2.6	0.5	0.3	
	1	PC	2.9	0.2	2.9	0.2	0.0	
		Average	1.5	0.3	2.4	0.3	8.9	***

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

Average pre- and post-course evaluation values for all 35 categories were 4.2 and 5.1 respectively. Results of paired t-tests for pre- and post-evaluation values are shown at the bottom of TABLE III. Significant differences in pre- and post-course values were observed in all 35 categories. It was discovered that awareness related to ability had improved as a whole after the course.

The results of t-tests for pre- and post-evaluation values for each category of awareness related to ability are shown in TABLE III. The 20 categories of (2), (6), (7), (14)-(17), (20), (22)-(28) and (31)-(35) were observed to have significant differences. There were no significant difference trends for the 4 categories of (4), (8), (21) and (29). Therefore, it was discovered that awareness evaluation values were improved for these.

One of the goals of the lectures was to cultivate the ability to think and to solve problems through various activities. It can be said that evaluation values for evaluation categories (26) Ability to solve problems and (28) Ability to think which are related to this were improved.

It was discovered that all evaluation values for categories (31) to (35) related to knowledge of Operations Research improved. It is thought that by solving 3 problems in each chapter: example, practice and challenge, knowledge about OR and decision-making methods, expressing social phenomena in mathematical models, knowledge about algorithms to solve the mathematical models, and volition to solve social phenomena are increased.

IV. CONCLUSION

After a detailed explanation of the example solution, practice problem sheets with a framework for filling in the blanks with numerical values and results are distributed and practice is conducted. Challenges are conducted after explanation of the solution the following week. The effects of the class method focusing on practice were reported. The most frequent activities that helped with development were: listening to the lecture and the explanation of answers, preparation for and revision of lessons, and asking questions, etc. The following was discovered through an analysis of educational information that was gained from this class.

(1) Term recognition improved overall after the course. All 29 terms, not including the check terms, had improved after the course.

(2) Awareness related to ability improved overall after the course. The 20 awareness categories out of the total 35 categories improved after the course. In particular, the 5 categories for awareness related to OR class contents all improved.

Students submitted practice problem and challenge problem sheets several times until they got the answers right. We would like to study the effects of this in the future. In addition, we would like to be more inventive with the practice methods and research the role of media in further improving effects.

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TABLE III. SIGNIFICANCE TEST OF AEARENESS RELATED TO ABILITY.

Awareness related to Ability	Before		After		Significance Test	
	m	SD	m	SD	t-value	p
(1) Interest in and curiosity about computers	6.7	1.5	6.9	1.4	0.7	
(2) Understanding of computers	4.7	1.6	5.5	1.3	2.7	*
(3) Computer operation skills	4.7	1.5	5.2	1.3	1.4	
(4) Computer usage methods and broadening of situations	4.7	1.6	5.5	1.6	2.1	+
(5) Ability to set challenges, ability to discover problems	4.3	1.7	4.6	1.4	1.1	
(6) Ability to plan, to do things in a planned manner	4.1	1.5	4.8	1.1	2.8	*
(7) Cultivation of understanding of knowledge learned	4.5	1.0	5.2	1.1	2.9	**
(8) Ability to study by oneself, ability to learn	4.3	1.2	5.0	1.4	2.0	+
(9) Ability to gather information, ability to conduct research	4.9	1.4	5.5	1.8	1.2	
(10) Ability to sort through related information or data	4.4	1.7	4.9	1.4	1.2	
(11) Ability to analyse information	4.5	1.3	5.1	1.8	1.3	
(12) Ability to express thoughts in writing	3.9	1.7	4.4	1.8	1.7	
(13) Ability to express thoughts through media other than writing	3.9	1.9	4.1	1.6	0.5	
(14) Ability to speak and explain things to others in an easy-to-understand manner	3.7	1.9	4.7	1.9	4.1	***
(15) Ability to make presentations	3.9	2.0	4.6	2.0	2.6	*
(16) Ability to listen to what people are saying and ability to ask people questions	4.7	2.1	5.4	1.8	2.3	*
(17) Communication ability	4.5	2.3	5.5	2.1	2.7	*
(18) Ability to appropriately self-evaluate one's thoughts	4.3	1.6	4.7	1.6	2.0	+
(19) Ability to appropriately evaluate other people's thoughts	4.8	1.8	5.3	1.5	1.9	+
(20) Ability to correct and improve on one's own thoughts	4.5	1.6	5.1	1.3	2.6	*
(21) Ability to pursue matters deeply, ability to explore matters	4.3	1.7	4.9	1.3	2.1	+
(22) Ability to execute, ability to practice, ability to put into action	4.1	1.4	5.1	1.6	3.3	**
(23) Ability to cooperate with others, ability to study in cooperation with others	4.5	1.7	5.6	1.9	3.1	**
(24) Sense of accomplishment, sense of satisfaction	4.6	1.7	5.6	2.1	2.5	*
(25) Sense of fulfilment, sense of achievement	4.8	1.7	5.6	2.1	2.3	*
(26) Ability to solve problems	4.4	1.5	5.1	1.4	2.2	*
(27) Ability to construct and create knowledge	4.0	1.7	4.9	1.4	3.1	**
(28) Ability to think, consider and come up with ideas by oneself	4.2	1.5	5.2	1.8	2.4	*
(29) Creativity/ability to create	4.3	1.6	4.9	1.7	1.8	+
(30) Interest in and curiosity about this field	4.8	1.8	5.2	1.6	1.0	
(31) Knowledge about Operations Research	2.1	1.6	5.1	1.4	6.1	***
(32) Knowledge about decision-making methods	2.5	1.6	4.7	1.4	5.1	***
(33) Knowledge about expressing current societal problems in mathematical models	2.2	1.4	4.4	1.2	6.5	***
(34) Knowledge about algorithms that solve mathematical models	2.4	1.6	4.6	1.3	6.2	***
(35) Volition to solve current societal problems	3.4	1.5	4.8	1.5	3.8	**
Average	4.2	1.2	5.1	1.2	4.8	***

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

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