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Risk Countermeasure Portfolio Management for Remote Learning Based on Lecture Type

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Abstract

The rapid development of ICT has ushered in various new approaches to remote Learning. Measures to improve the quality of higher education have been explored by surveying and analyzing the actual situation in other countries and the implementation methods and systems of advanced initiatives. Due to the rapid spread of the COVID-19 pandemic from 2020, teleworking has been implemented in companies and remote learning in universities and other educational institutions to control the spread of infection. For university classes, sessions that would normally be conducted face-to-face are increasingly being conducted remotely, but there are various risks and challenges inherent in this approach. These risks have caused anxiety and dissatisfaction among both students and faculty, and in some cases have prevented the smooth implementation of classes. This paper proposes and evaluates specific countermeasures by conducting a risk assessment of remote learning for universities. Specifically, we conducted risk assessments for two main types of remote learning: on-demand and live-streaming. Then, on the basis of the results, we developed countermeasures such as the enhancement of environmental facilities (for the on-demand type) and privacy-conscious countermeasures (for the live-streaming type). We also clarified the effectiveness of the proposed measures by comparing the risk values before and after their implementation. Finally, we constructed a portfolio of risk countermeasure proposals from the practical viewpoint of operability and developed guidelines for a phased introduction of the system. Our study will contribute to the safe and secure operation of remote learning in the future.

Keywords: Remote Learning, On-Demand Type, Live-Streaming Type, Risk Breakdown Structure, Risk Matrix, Risk Management Portfolio

1 Introduction

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Since 2020, the spread of COVID-19 has had a major impact on the facilitation of classes at universities and other institutions [1]. Students have often not been allowed to enter the campus and so must take remote classes using computers from home. In some cases, first-year students who entered school in April finished their first semester without ever having set foot on campus. As of 2022, the COVID-19 pandemic shows no sign of abating, and new variants are increasing the number of infected people. As a result, it is essential to offer remote learning in addition to face-to-face university classes. Remote learning has actually been promoted worldwide since before the outbreak of COVID-19 [2] as a way to meet the needs of a variety of course styles, to offer a research environment that is less subject to time and location constraints, and to eliminate travel time between universities by promoting credit transfer. However, remote learning poses a variety of risks and problems that move beyond the traditionally understood cyber risks. For example, faculty members need time to change the curriculum and prepare lessons for remote classes, and students have to deal with issues related to IT literacy and environment construction.

This paper identifies and analyzes the risk factors of remote learning. Specifically, we divided remote classes into on-demand (pre-recorded classes that can be taken at any time) and live-streaming (classes that can be taken in real time) types based on whether or not they are conducted in real-time and then performed a risk analysis. Based on the results of this analysis, we then proposed various countermeasures, such as the enhancement of environmental facilities for the on-demand type and privacy-conscious measures for the live-streaming type, and evaluated their effectiveness. Finally, we constructed a risk countermeasure portfolio with a focus on practical applicability and developed guidelines for the gradual introduction of these countermeasures. This study will contribute to the safe and secure operation of remote Learning in the post-corona era, which is also referred to as the New Normal era.

2 Current Status and Issues of Remote Learning

2.1 Current Status of Remote Learning

On April 16, 2020, a state of emergency was declared nationwide in Japan due to the spread of COVID-19, and people were asked to refrain from leaving their homes in order to reduce transmission of the virus. Universities and other educational institutions began to offer remote learning courses that students could take at home, replacing face-to-face classes with remote sessions using web conferencing systems and the like. In total, more than 90% of national universities introduced remote learning, although some had to close temporarily as preparations could not be made in time [1]. By the second half of 2021, two years after the advent of COVID-19, nearly 100% of Japanese universities were allowing face-to-face teaching, including a hybrid format of face-to-face and remote learning. Among them, 40% of universities were mainly conducting face-to-face classes [3], indicating an overall return to in-person classes.

However, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has stated that it will promote the Digital Transformation (DX) of university education in the post-COVID period by fully utilizing the experience gained in dealing with the pandemic, and that DX will free students from time, place, and cost limitations while enabling them to take advantage of recordings and computer-based teaching and learning (CBT). The report states that by utilizing digital content such as computer-based testing, students can learn anytime, anywhere [4]. In addition, remote learning has been accepted in terms of both teaching methods and content, and about 30% of post-COVID courses can now be taken online [5]. Remote learning, which

spread rapidly during the pandemic, is expected to continue to be promoted in the post-COVID era.

2.2 Issues in Remote Learning

MEXT has clarified what problems and risks exist in the remote learning that has been implemented so far, citing the results of a joint Asahi Shimbun/Kawaijuku survey [1]. More than 90% of respondents answered that "handling experiments, practical training, and practical skills courses" was a major issue or problem. The majority of universities also identified "students' communication environment and ICT skills" and "students' motivation to learn and mental health" as challenges. In addition, in a survey conducted by MEXT for university students asking what they felt was negative about online classes, respondents answered that they "could not take online classes with friends," "had too many assignments such as reports," and "felt physical fatigue," as shown in Table 1 [6].

Although there was no major discrepancy between the issues recognized by the universities and the problems felt by students, the biggest issue overwhelmingly cited by universities was the quality of the classes, especially in terms of experiments, practical training, and practical skills courses, while the biggest issue cited by students was "not being able to take classes with friends," indicating a discrepancy in the main focus on human relationships.

Table 1: Negative points of online classes (taken from [6]).

	What was wrong with the online class?	Response rate(%)
Response	I miss being able to take classes with friends and other students.	53.0
	There were too many reports and other assignments.	49.7
	I felt physically fatigued	44.0
	There were no or few opportunities for mutual communication, such as questions, etc.	43.9
	It was harder to understand than in-person classes	42.7
	There was no sufficient explanation of class format	21.3
	It was an insufficient communication environment	15.5
	Other	6.7

3 Related Work

Various studies have been conducted on issues related to online learning. Specific related works are discussed below.

D. J. Cranfield et al. [7] conducted a survey of students in three countries (South Africa, Wales, and Hungary) to investigate students' perceptions of the challenges associated with online learning, including remote learning. They focused on (1) learning environment at home, (2) participation in learning, (3) desire to participate, and (4) impact on study skills. Although the findings varied depending on each country's response to the pandemic, support for students, and available resources, the study concluded that students' digital requirements and the challenges of the home learning environment are of key importance.

D. J. Lemay et al. [8] surveyed students' perceptions of online learning before and after the transition to online learning. Their results indicated that the barriers to fully online learning were not just technological and educational challenges but also the social and emotional ones inherent in self-isolation and social distancing. They concluded that, in addition to the technical and educational aspects, teachers and educational technologists should pay attention to the social and emotional aspects of online learning in order to successfully support students in online learning environments.

R. B. Salvador et al. [9] investigated the online educational experience of engineering undergraduates during the COVID-19 pandemic and its temporal psychological impact. The responses to a student survey indicated that there were significant differences in students' connections with other students and teachers, learning environment conditions, and boredom levels, depending on the time elapsed over a six-month period. The study also revealed a significant correlation between academic achievement and the learning environment.

Overall, while some studies have identified issues based on survey analyses of pre- and post-transition perceptions and the emotional impact on students who have had to make an abrupt transition to online learning, there has not been enough research on systematic risk assessment. Therefore, in this paper we wish to present a systematic risk assessment for remote learning based on risk management methods. This will contribute to safe and secure remote learning from a comprehensive perspective.

4 Risk Assessment for Remote Learning

We tackled the risk assessment of remote learning in the following order: 1) risk identification, 2) risk analysis, and 3) risk evaluation [10]. Specifically, we identified the risks of remote learning from a comprehensive perspective, analyzed the impact of each risk on remote learning, and investigated the effectiveness of the countermeasures by the degree to which risks were reduced after the countermeasures were implemented.

4.1 Risk Identification of Remote Learning

We utilized the Risk Breakdown Structure (RBS) method [11] from the Mutually Exclusive, Collectively Exhaustive (MECE) perspective to exhaustively and systematically extract risk factors for remote learning. Table 2 shows the results of the risk factor extraction [12].

In the first level, we categorized the risk factors into on-demand and live-streaming types. In the second level, risks were defined as those related to "class preparation," "class implementation," and "class impact," and in the third level, risks were subdivided on the basis of these categories. Note that the results of these extractions were validated through several reviews by the authors. The validity of this review is supported by the multifaceted perspectives of the authors, among whom are university professors, corporate researchers, and students.

As shown in Table 2, the main risk factor in the on-demand model is that it does not have an adequate communication environment (e.g., Wi-Fi and PCs). In the live-streaming type, measures to protect privacy are insufficient, and the volume of homework is much higher than in face-to-face classes.

4.2 Risk Analysis of Remote Learning

4.2.1 Risk matrix analysis

Next, the risk factors identified in 4.1 were analyzed using the risk matrix method. Typical risk analysis methods include the use of decision trees based on quantitative perspectives and qualitative perspective risk matrices [13]–[14]. We opted to use the risk matrix method because it is suitable for desk research.

As shown in Figure 1, the risk matrix method classifies risks into four categories according to their frequency of occurrence and impact: avoidance, mitigation, acceptance, and transference. Table 3 shows the countermeasures we devised on the basis of this method.

Table 2: Risk factor extraction results for remote learning.

No.	Level 1	Level 2	Level 3 (Risk factor)
1	On-demand type	Class Preparation	Lack of sufficient communication environment for on-demand classes
2			Lack of sufficient places to take on-demand classes
3			Lack of equipment for taking on-demand classes
4			Lack of security measures
5			Difficulty in responding to system problems
6			Lack of understanding of how to use the specified software
7			Lack of understanding of how to operate ICT equipment
8		Class implementation	Blurry educational materials (sound and display)
9			Lack of real-time communication with teachers
10			More assignments compared to face-to-face classes
11			Lack of understanding of teaching materials related to practical aspects
12			Lack of realism in the classroom
13		Impact of classes	Lack of communication with friends and seniors
14			Physical and mental fatigue
15			Hard to make friends
16	Live-streaming type	Class Preparation	Lack of sufficient communication environment for live-streamed classes
17			Lack of sufficient places to attend live-streamed classes
18			Lack of live class attendance equipment
19			Lack of security measures
20			Difficulty in responding to system problems
21			Lack of understanding of how to use the specified software
22			Lack of understanding of how to operate ICT equipment
23		Class implementation	Blurry sound and display in live environment
24			Lack of measures to protect privacy
25			More assignments compared to face-to-face classes
26			Lack of understanding of teaching materials related to practical aspects
27			Lack of realism in the classroom
28		Impact of classes	Lack of communication with friends and seniors
29			Physical and mental fatigue
30			Hard to make friends

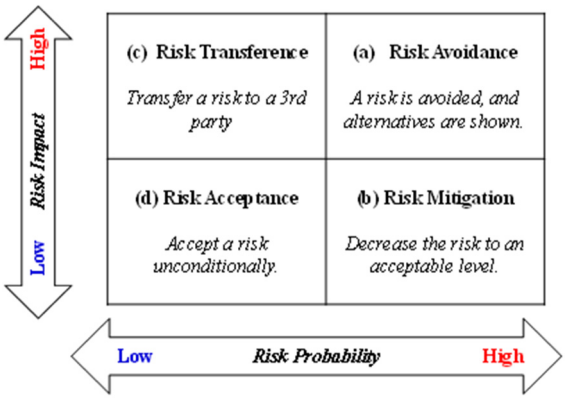

Figure 1: Risk matrix methodology.

4.2.2 Characteristics of risk analysis

Using the results in Table 3, we analyzed the trends for each measure to determine how each risk should be addressed.

Table 3: Proposed measures to address major risk factors in remote learning.

No.	Level 1	Level 2	Level 3 (Risk factor)	Risk Probability	Risk Impact	Risk Analysis	Proposed Countermeasures
1	On-demand type	Class Preparation	Lack of sufficient communication environment for on-demand classes	L	H	Transference	Change to WiFi router or other flat-rate network connection
2			Lack of sufficient places to take on-demand classes	L	L	Acceptance	Use empty classrooms at universities, etc.
3			Lack of equipment for taking on-demand classe	L	H	Transference	Distribute and loan by the university
4			Lack of security measures	L	H	Transference	Install security software
5			Difficulty in responding to system problems	L	H	Transference	Set up a help desk
6			Lack of understanding of how to use the specified software	L	H	Transference	Conduct software-use briefing sessions
7			Lack of understanding of how to operate ICT equipment	L	H	Transference	Setting up a help desk
8		Class implementation	Blurred delivered educational materials (sound and display)	L	L	Acceptance	Loan equipment with good performance
9			Lack of real-time communication with teachers	H	L	Mitigation	Use chat, email, telephone, etc..
10			More assignments compared to face-to-face classes	H	H	Avoidance	Adjust the amount of assignments to correlate with other classes
11			Lack of understanding of teaching materials related to practical aspects	L	H	Transference	Use videos etc. to make it easier to understand
12			Lack of realism in the classroom	L	L	Acceptance	Use video and frequent communication
13		Impact of classes	Lack of communication with friends and seniors	L	L	Acceptance	Use of chat, e-mail, telephone, etc.
14			Physical and mental fatigue	L	H	Transference	Ensure adequate rest and counseling
15			Hard to make friends	H	L	Mitigation	Provide a place to use chat, email, etc.
16	Live-streaming type	Class Preparation	Lack of sufficient communication environment for live-streamed classes	L	H	Transference	Change to WiFi router or other flat-rate network connectio
17			Lack of sufficient places to attend live-streamed classes	L	H	Transference	Use empty classrooms at universities, etc.
18			Lack of live class attendance equipment	L	H	Transference	Distributed and loaned by the University
19			Lack of security measures	L	H	Transference	Installation of security software
20			Difficulty in responding to system problems	L	H	Transference	Setting up a help desk
21			Lack of understanding of how to use the specified software	L	H	Transference	Conducting software use briefing sessions
22			Lack of understanding of how to operate ICT equipment	L	H	Transference	Setting up a help desk
23		Class implementation	Sound and display blurred in live environment	L	L	Acceptance	Loan of equipment with good performance
24			Lack of measures to protect privacy	L	H	Transference	Avoid background images and sound.
25			More assignments compared to face-to-face classes	H	H	Avoidance	Adjusting the amount of assignments in collaboration with other classes
26			Lack of understanding of teaching materials related to practical aspects	L	H	Transference	Use of videos, etc. to make it easier to understand
27			Lack of realism in the classroom	L	L	Acceptance	Use of video and frequent communication
28		Impact of classes	Lack of communication with friends and seniors	L	L	Acceptance	Use of chat, e-mail, telephone, etc.
29			Physical and mental fatigue	L	H	Transference	Adequate rest and counseling
30			Hard to make friends	H	L	Mitigation	Provide a place and use of chat, email, etc

(1) Risk Transference: Eighteen risk response measures were transfers. The results indicated that there are many risk factors that occur infrequently but have a large impact when they do occur. Various resources are needed to deal with each situation—specifically, the university should lend Wi-Fi equipment and PCs etc. to students [15].

(2) Risk Mitigation: There were three risks that were reduced by the countermeasures. The proposed countermeasure requires the use of communication tools to deal with the situation—specifically, the use of video conferencing services and chat rooms. For example, chat rooms can be used to address concerns that arise during class time. This would also enable students to resolve any concerns about course counseling, club activities, personal life, etc. in a timely and

easy manner.
(3) Risk Avoidance: There were two risks that were avoided. The proposed countermeasure is to coordinate with the faculty members by sharing information.
(4) Risk Acceptance: There were seven risks that were retained. Proposed countermeasures include upgrading equipment etc.

4.3 Risk Evaluation of Remote Learning

In this subsection, we clarify the effectiveness of the proposed countermeasures for the main risk factors in remote learning shown in Table 3 by adding quantitative evaluations.

4.3.1 Ordinary risk value equation

In general, risk value can be expressed as follows [16]–[17].

Risk value = value of asset * value of threat * value of vulnerability ... (1)

All elements on the right-hand side of Eq. (1) tend to be very difficult to calculate, so we use the following approximation to simplify them.

4.3.2 Approximate risk value equation

4.3.2.1 Approximation of asset and threats

To simplify the quantification of risk countermeasures, we approximate the asset value and threat in Eq. (1) by the impact and frequency of occurrence in the risk matrix, as shown in Figure 2. We assume that the asset value is the degree of impact and define the risk value as 5 when high and 1 when low, in accordance with the literature [18]. Similarly, threats are assumed to be frequency of occurrence and defined as 3 for high and 1 for low.

4.3.2.2 Approximation of vulnerability

Next, as in 4.3.2.1, the vulnerability was evaluated on a three-level scale of 3 (high), 2 (medium), and 1 (low), based on the literature [18]. Again, based on the evaluation of the risk matrix, we assume that the risk is 3 (high) for Avoidance, 2 (medium) for Transference or Mitigation, and 1 (low) for Acceptance.

4.3.2.3 Approximation of equation

As stated above, Eq. (1) is approximated as Eq. (2). In addition, the approximate value of each parameter of Eq. (2) is shown in Figure 2.

Risk value ≒ value of risk impact * value of risk probability * value of vulnerability ... (2)

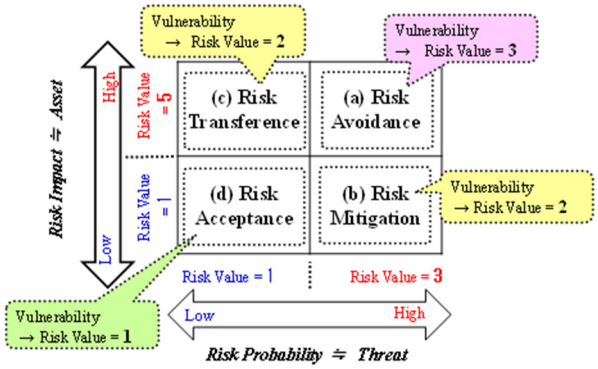

Figure 2: Risk value approximation of risk matrix.

4.3.3 Calculation of risk values

4.3.3.1 Risk values before implementation of proposed risk countermeasures

Using the risk value calculation criteria in Eq. (1) as a basis, we show in Tables 4 and 5 the risk values from Table 2 when the proposed countermeasures in Table 3 have not been implemented.

The total risk value is 141 for the on-demand type and 154 for the live-streaming type, indicating that the live-streaming type has a slightly higher risk value.

4.3.3.2 Risk values after implementation of proposed risk countermeasures

Next, based on the risk value calculation criteria in Eq. (2), Tables 6 and 7 show the risk values that could be reduced by implementing the specific main countermeasure proposals shown in Table 3 (e.g., the appropriate supply of various devices and tools, and the sharing of information among teachers). In this case, the vulnerability is assumed to be 1 (low) by implementing the proposed countermeasures.

The total risk value for each risk factor was calculated for 15 risks each in the on-demand type and the live-streaming type after implementing the proposed risk countermeasures, resulting in a total risk value of 65 for on-demand and 71 for live-streaming.

Table 4: Risk values before implementation of proposed risk countermeasures (on-demand type).

No.	Risk Factor	Threat	Asset	Vulnerability	Value of Risk
1	Lack of sufficient communication environment for on-demand classes	1	5	2	10
2	Lack of sufficient places to take on-demand classes	1	1	1	1
3	Lack of equipment for taking on-demand classe	1	5	2	10
4	Lack of security measures	1	5	2	10
5	Difficulty in responding to system problems	1	5	2	10
6	Lack of understanding of how to use the specified software	1	5	2	10
7	Lack of understanding of how to operate ICT equipment	1	5	2	10
8	Blurred delivered educational materials (sound and display)	1	1	1	1
9	Lack of real-time communication with teachers	3	1	2	6
10	More assignments compared to face-to-face classes	3	5	3	45
11	Lack of understanding of teaching materials related to practical aspects	1	5	2	10
12	Lack of realism in the classroom	1	1	1	1
13	Lack of communication with friends and seniors	1	1	1	1
14	Physical and mental fatigue	1	5	2	10
15	Hard to make friends	3	1	2	6
Total					**141**

Table 5: Risk values before implementation of proposed risk countermeasures (live-streaming type).

No.	Risk Factor	**Threat**	**Asset**	**Vulnerability**	**Value of Risk**
16	Lack of sufficient communication environment for live-streamed classes	1	5	2	10
17	Lack of sufficient places to attend live-streamed classes	1	5	2	10
18	Lack of live class attendance equipment	1	5	2	10
19	Lack of security measures	1	5	2	10
20	Difficulty in responding to system problems	1	5	2	10
21	Lack of understanding of how to use the specified software	1	5	2	10
22	Lack of understanding of how to operate ICT equipment	1	5	2	10
23	Sound and display blurred in live environment	1	1	1	1
24	Lack of measures to protect privacy	1	5	2	10
25	More assignments compared to face-to-face classes	3	5	3	45
26	Lack of understanding of teaching materials related to practical aspects	1	5	2	10
27	Lack of realism in the classroom	1	1	1	1
28	Lack of communication with friends and seniors	1	1	1	1
29	Physical and mental fatigue	1	5	2	10
30	Hard to make friends	3	1	2	6
Total					**154**

Table 6: Risk values after implementation of proposed risk countermeasures (on-demand type).

No.	Risk Factor	Threat	Asset	Vulnerability	Value of Risk
1	Lack of sufficient communication environment for on-demand classes	1	5	1	5
2	Lack of sufficient places to take on-demand classes	1	1	1	1
3	Lack of equipment for taking on-demand classe	1	5	1	5
4	Lack of security measures	1	5	1	5
5	Difficulty in responding to system problems	1	5	1	5
6	Lack of understanding of how to use the specified software	1	5	1	5
7	Lack of understanding of how to operate ICT equipment	1	5	1	5
8	Blurred delivered educational materials (sound and display)	1	1	1	1
9	Lack of real-time communication with teachers	3	1	1	3
10	More assignments compared to face-to-face classes	3	5	1	15
11	Lack of understanding of teaching materials related to practical aspects	1	5	1	5
12	Lack of realism in the classroom	1	1	1	1
13	Lack of communication with friends and seniors	1	1	1	1
14	Physical and mental fatigue	1	5	1	5
15	Hard to make friends	3	1	1	3
Total					**65**

Table 7: Risk values after implementation of proposed risk countermeasures (live-streaming type).

No.	Risk Factor	Threat	Asset	Vulnerability	Value of Risk
16	Lack of sufficient communication environment for live-streamed classes	1	5	1	5
17	Lack of sufficient places to attend live-streamed classes	1	5	1	5
18	Lack of live class attendance equipment	1	5	1	5
19	Lack of security measures	1	5	1	5
20	Difficulty in responding to system problems	1	5	1	5
21	Lack of understanding of how to use the specified software	1	5	1	5
22	Lack of understanding of how to operate ICT equipment	1	5	1	5
23	Sound and display blurred in live environment	1	1	1	1
24	Lack of measures to protect privacy	1	5	1	5
25	More assignments compared to face-to-face classes	3	5	1	15
26	Lack of understanding of teaching materials related to practical aspects	1	5	1	5
27	Lack of realism in the classroom	1	1	1	1
28	Lack of communication with friends and seniors	1	1	1	1
29	Physical and mental fatigue	1	5	1	5
30	Hard to make friends	3	1	1	3
Total					**71**

4.3.4 Evaluation results

Table 8 summarizes the results of Tables 4, 5, 6, and 7. As we can see, the risk reduction rate is approximately 50% for both the on-demand and live-streaming types when the proposed risk countermeasures are applied to class preparation, actual classes, and the impact of classes. Here, as indicated in 4.3.3.2, the vulnerability after the risk countermeasure is assumed to be 1 (low). However, ideally, the vulnerability would essentially be close to 0, so the present evaluation is relatively strict. Table 9 shows the individual effects of the proposed countermeasures on class preparation, class implementation, and class impact.

These findings demonstrate that the introduction of a risk value can clarify the effectiveness of the system better than the previous qualitative evaluation.

Table 8: Risk values before and after risk countermeasures.

Evaluation item	Total Risk Value	
	On-demand type	Live-streaming type
Before risk measures ((1))	141	154
After risk measures ((2))	65	71
Risk reduction rate (((1)-(2)) / (1))	54%	54%

Table 9: Risk value reduction effect by each risk countermeasures.

Risk measure	Reduction Risk	Reduction Risk Rate
Class preparation	65	50%
Class implementation	78	60%
Impact of classes	16	47%
Total	159	54%

4.3.5 Consideration

In the post-COVID era, remote learning is expected to be utilized for four key reasons: (1) to meet the needs of various students with diverse learning styles, (2) for faculty members who need an environment where they can easily balance their main job with their education and research at the university and who need an education and research environment that is less restricted by time and place, (3) to eliminate travel time between universities by promoting credit transfer, and (4) for faculty members who need to use the remote learning system for their own research and education.

According to the evaluation results based on risk values (Table 8), the risk countermeasures for remote Learning presented in this paper can reduce these risks by half for the 30 risk factors associated with remote learning (shown in Table 1). In other words, the proposed countermeasures will help contribute to safe and secure remote learning even in the post-COVID era. Note that the evaluation based on the approximation formula is a desk evaluation, not a concrete implementation evaluation, and it is therefore positioned as a relative evaluation.

4.4 Risk Countermeasure Portfolio for Remote Learning from the Viewpoint of Practical Applicability

We were able to quantitatively clarify the effectiveness of the risk countermeasures based on the results presented in subsection 4.3. In this subsection, we further propose a portfolio of risk countermeasures from the viewpoint of practicality. In general, it is not feasible to introduce all risk countermeasures at once due to the cost. Therefore, we propose implementing a portfolio of the risk countermeasures shown in subsection 4.3 so that they can be gradually introduced. It is generally best to introduce risk countermeasures in stages while taking into account their effectiveness in relation to their cost. Phased introduction can be considered from the perspective of urgency of the risk, priority based on return on investment, or dynamic priority based on the life cycle of the risk countermeasure (risk occurrence, response, and maintenance). For the countermeasures we proposed in 4.3, we assumed in advance that risks may occur in the future. That is, the proposal assumes a life cycle of risk countermeasures. Therefore, we created a portfolio for the life cycle of risk countermeasures.

To this end, we referred to Computer Security Incident Response Team (CSIRT), which is a security response framework. Specifically, we came up with a prioritized portfolio of risk countermeasures based on the CSIRT risk countermeasure classification [19]–[20] by J. Wiik et al. and Y. Kenmoku et al. Risk countermeasures are classified into three categories: Proactive Service, Reactive Service, and Security Quality Control Service. Proactive Service and Security Quality Management Service are classified as proactive countermeasures and have a higher priority in terms of timing than Reactive Service. To create our portfolio, we classified each risk countermeasure proposal into Proactive Service, Security Quality Management Service, or Reactive Service with the idea that they should be implemented step by step from the viewpoint of practicality. The following presents the results of our detailed analysis of the portfolio for each of the four categories of the risk matrix.

4.4.1 Risk Transference

The main countermeasures against risk transference include the provision of various resources (e.g., equipment) to meet each situation and circumstance. The portfolio in the on-demand type of risk transference was classified based on the following perspectives. As shown in Table 10, three of the eight risk factors (No. 1 (Lack of sufficient communication environment for on-demand classes), No. 6 (Lack of understanding of how to use the specified software), and No. 11 (Lack of understanding of teaching materials related to practical aspects)) were classified as Proactive Service, since it is essential to set up and prepare explanations before a class is conducted. Risk factors No. 3 (Lack of equipment for taking on-demand classes), No. 4 (Lack of security measures), No. 5 (Difficulty in responding to system problems), and No. 7 (Lack of understanding of how to operate ICT equipment) were classified as Security Quality Control Service, as they are measures that require continued support even after the class has finished. Finally, No. 14 (Physical and mental fatigue) was classified as Reactive Service because it requires measures that address students' health conditions.

For the ten risk factors for the live-streaming type (Table 11), five of them (No. 16 (Lack of sufficient communication environment for live-streamed classes), No. 17 (Lack of sufficient places to attend live-streamed classes), No. 21 (Lack of understanding of how to use the specified software), No. 24 (Lack of measures to protect privacy), and No. 26 (Lack of understanding of teaching materials related to practical aspects)) were classified as Proactive Service because it is essential to take these measures in advance, e.g., setting up and preparing explanations before the class. Number 18 (Lack of live class attendance equipment), No. 19 (Lack of security measures), No. 20 (Difficulty in responding to system problems), and No. 22 (Lack of understanding of how

to operate ICT equipment) were classified as Security Quality Control Service because they are things that will require ongoing support even after the remote class is in operation. Number 29 (Physical and mental fatigue) was classified as Reactive Service because, as with the on-demand type, it is necessary to respond to students' health conditions.

Table 10: Risk Transference (on-demand type).

No.	Risk factor	Proposed Countermeasures	Pre	Post	Quality
1	Lack of sufficient communication environment for on-demand classes	Change to WiFi router or other flat-rate network connection	○		
3	Lack of equipment for taking on-demand classes	Distribute and loan by the university			○
4	Lack of security measures	Install security software			○
5	Difficulty in responding to system problems	Set up a help desk			○
6	Lack of understanding of how to use the specified software	Conduct software-use briefing sessions	○		
7	Lack of understanding of how to operate ICT equipment	Setting up a help desk			○
11	Lack of understanding of teaching materials related to practical aspects	Use videos etc. to make it easier to understand	○		
14	Physical and mental fatigue	Ensure adequate rest and counseling		○	

Pre: Proactive Service, Post: Reactive Service, Quality: Security Quality Control Service, and same below.

Table 11: Risk Transference (live-streaming type).

No.	Risk factor	Proposed Countermeasures	Pre	Post	Quality
16	Lack of sufficient communication environment for live-streamed classes	Change to WiFi router or other flat-rate network connectio	○		
17	Lack of sufficient places to attend live-streamed classes	Use empty classrooms at universities, etc.	○		
18	Lack of live class attendance equipment	Distributed and loaned by the University			○
19	Lack of security measures	Installation of security software			○
20	Difficulty in responding to system problems	Setting up a help desk			○
21	Lack of understanding of how to use the specified software	Conducting software use briefing sessions	○		
22	Lack of understanding of how to operate ICT equipment	Setting up a help desk			○
24	Lack of measures to protect privacy	Avoid background images and sound.	○		
26	Lack of understanding of teaching materials related to practical aspects	Use of videos, etc. to make it easier to understand	○		
29	Physical and mental fatigue	Adequate rest and counseling		○	

4.4.2 Risk Mitigation

Among the measures for risk reduction, risk countermeasures focusing on communication tools (e.g., telephone and email) are important. In the portfolio for risk mitigation, of the two risk factors in the on-demand type (Table 12), No. 9 (Lack of real-time communication with teachers) was considered Proactive Service, since educational elements such as promotion of tool use is

required in advance. The other risk factor, No. 15 (Hard to make friends), generally depends on the individual qualities of each student, so it is reasonable to make a judgment based on the implementation status (e.g., setting up an environment that facilitates making friends, such as a chat environment or group work setting) as necessary. Therefore, we decided to classify this as Reactive Service, which is an after-the-fact measure.

Similar to the on-demand type, No. 15 (Hard to make friends) for the live-streaming type (Table 13) was also classified as Reactive Service because it needs to be judged after class implementation has begun.

Table 12: Risk Mitigation (on-demand type).

No.	Risk factor	Proposed Countermeasures	Pre	Post	Quality
9	Lack of real-time communication with teachers	Use chat, email, telephone, etc..	○		
15	Hard to make friends	Provide a place to use chat, email, etc.		○	

Table 13: Risk Mitigation (live-streaming type).

No.	Risk factor	Proposed Countermeasures	Pre	Post	Quality
30	Hard to make friends	Provide a place and use of chat, email, etc		○	

4.4.3 Risk Avoidance

The main measure to address risks categorized as risk avoidance is to coordinate information sharing among faculty members. For the on-demand type (Table 14), we classified No. 10 (More assignments compared to face-to-face classes) as Proactive Service because it requires prior coordination of assignments among other courses in advance.

For the live-streaming type (Table 15), we classified No. 25 (More assignments compared to face-to-face classes) as Proactive Service for the same reason as the on-demand type.

Table 14: Risk Avoidance (on-demand type).

No.	Risk factor	Proposed Countermeasures	Pre	Post	Quality
10	More assignments compared to face-to-face classes	Adjust the amount of assignments to correlate with other classes	○		

Table 15: Risk Avoidance (live-streaming type).

No.	Risk factor	Proposed Countermeasures	Pre	Post	Quality
25	More assignments compared to face-to-face classes	Adjusting the amount of assignments in collaboration with other classes	○		

4.4.4 Risk Acceptance

The main countermeasure for risk acceptance is to upgrade communication and other equipment. In the portfolio for risk acceptance, of the four risk factors for the on-demand type (Table 16),

No. 2 (Lack of sufficient places to take on-demand classes) was classified as Proactive Service, because adjustment before class implementation is essential as a countermeasure. Number 8 (Blurred delivered educational materials (sound and display)) and No. 12 (Lack of realism in the classroom) were classified as Security Quality Control Service because they are measures that need to be taken continuously after the remote class is in operation. Number 13 (Lack of communication with friends and seniors) was classified as Reactive Service, which is an after-the-fact measure, because it requires a situation-specific response.

Two of the three risk factors for the live-streaming type (Table 17), No. 23 (Sound and display blurred in live environment) and No. 27 (Lack of realism in the classroom), were classified as Security Quality Control Service because they require continuous investment and consideration of mechanisms, as in the on-demand service. Number 28 (Lack of communication with friends and seniors) was also classified as Reactive Service because, as with the on-demand type, it requires a situation-specific response.

Table 16: Risk Acceptance (on-demand type).

No.	Risk factor	Proposed Countermeasures	Pre	Post	Quality
2	Lack of sufficient places to take on-demand classes	Use empty classrooms at universities, etc.	○		
8	Blurred delivered educational materials (sound and display)	Loan equipment with good performance			○
12	Lack of realism in the classroom	Use video and frequent communication			○
13	Lack of communication with friends and seniors	Use of chat, e-mail, telephone, etc.		○	

Table 17: Risk Acceptance (live-streaming type).

No.	Risk factor	Proposed Countermeasures	Pre	Post	Quality
23	Sound and display blurred in live environment	Loan of equipment with good performance			○
27	Lack of realism in the classroom	Use of video and frequent communication			○
28	Lack of communication with friends and seniors	Use of chat, e-mail, telephone, etc.		○	

4.4.5 Effectiveness of Countermeasure Portfolio

Above, we described our plan for the portfolio for the proposed risk countermeasures from the viewpoint of practical applicability. As mentioned, the previous portfolio was based on methods such as assigning priorities according to risk levels (high, medium, low) to take into account the threat and impact of the risk content [21]. The new portfolio proposed here from 1) (Risk Transference) to 4) (Risk Acceptance) is summarized in Table 18. This portfolio was made from the viewpoint of dynamic classification in CSIRT (before and after risk occurrence) for each risk countermeasure category of risk transference, mitigation, avoidance, and acceptance, and we also provided a more highly operational step-by-step implementation plan.

Our analysis indicates that, when establishing secure remote learning, it is advisable to implement measures based on the following priorities from the viewpoint of practicality:

- pre: investment considerations such as environment, equipment development, and

cost generation, and

- post: measures in response to the results.

This approach seems to be the most rational.

Table 18: Summary of analysis of risk countermeasure portfolio.

	Prior implementation (Proactive Service, Security Quality Control Service.)	Post implementation (Reactive Service)
1)Risk Transference	・ICT equipment setting change ・Usage Explanation ・Video Preparation ・Consideration of whether or not to deploy a new ICT environment	・Health response to implementation status
2)Risk Mitigation	・Promoting the use of communication tools	・Provide mechanisms and venues for interaction through various tools
3)Risk Avoidance	・Adjustment of assignment volume by sharing information on assignment volume by faculty members	-
4)Risk Acceptance	・Coordinate resCoordinate reservations for resources ・Consideration ofConsideration of upgrading ICT equipment ・Consideration of creating atmosphere through videos and communication tools	・Provide mechanisms anProvide mechanisms and venues for interaction through various tools

5 Limitations of Proposed Model

The risk countermeasures derived from the proposed model are qualitative evaluations based on desktop assessments. Practical aspects such as the cost-effectiveness of implementing these risk countermeasures will be discussed in the future.

6 Conclusion and Future Work

We conducted a risk assessment for remote Learning, which has been rapidly expanding since the advent of COVID-19. On the basis of a literature survey and other information on the current situation in remote Learning [22], we comprehensively extracted the risk factors related to two types of remote Learning (on-demand and live-streaming) and identified a total of 30. We then conducted a risk analysis of these factors and proposed countermeasures. The main countermeasures include the use of Wi-Fi and PCs loaned by the university, as well as the use of video conferencing services and chat. We then clarified the effectiveness of these countermeasures by evaluating their risk values. Finally, we presented a portfolio to identify the priorities of the proposed risk countermeasures in terms of practical applicability and then proposed and analyzed the phased introduction of risk countermeasures with reference to the classification of CSIRTs. Our findings demonstrate that the proposed method can contribute to the safe and secure operation of

remote learning from the viewpoint of practical applicability.

Future work will examine the costs of providing an adequate supply of various equipment and tools, along with methods for reducing these costs.

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