



EVALUATION OF THE SIGNIFICANCE GRADES OF THE PROBLEMS EXPERIENCED BY MATHEMATICS TEACHERS IN DISTANCE EDUCATION IN THE COVID-19 PANDEMIC BY THE ENTROPY METHOD

Oğuzhan Bahadır¹, Hande Türkmençalıkoğlu², Ebenezer Bonyah^{3*}

^{1,2}Department of Mathematics, Faculty of Science and Letters, Kahramanmaraş Sütçü İmam University, Turkey

³Department of Mathematics Education, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, University in Kumasi, Ghana

*Corresponding author: ebbonya@gmail.com

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ABSTRACT

The entropy formula, created by Claude E. Shannon using probability calculations, is an essential and objective measurement method used in multi-criteria decision-making. The purpose this study was to evaluate the problems experienced by mathematics teachers during the Covid-19 and the degree of importance of these problems were determined. Expert opinions were used to identify the problems. In the study, the 'Entropy' method was used to determine the degree of importance of the problems. After determining the problems, a questionnaire was applied to 22 teachers working in different geographical regions of Turkey and with different service lengths. According to the entropy results, it has been determined that the most critical problem faced by mathematics teachers in the distance education process is the 'communication problem' between students and teachers. In conclusion, mathematics teachers must find the right learning method to overcome communication problems so that in the future, distance learning will not experience obstacles.

EVALUASI TINGKAT SIGNIFIKANSI MASALAH YANG DIALAMI GURU MATEMATIKA PADA PENDIDIKAN JARAK JAUH DI MASA PANDEMI COVID-19 DENGAN METODE ENTROPY

Kata Kunci:

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ABSTRAK

Rumus entropi, yang dibuat oleh Claude E. Shannon menggunakan perhitungan probabilitas, adalah metode pengukuran penting dan objektif yang digunakan dalam pengambilan keputusan multi-kriteria. Tujuan penelitian ini adalah untuk mengevaluasi permasalahan yang dialami oleh guru matematika selama masa Covid-19 dan tingkat kepentingan permasalahan tersebut. Pendapat ahli digunakan untuk mengidentifikasi masalah. Dalam penelitian ini, metode 'Entropy' digunakan untuk menentukan tingkat kepentingan masalah. Setelah menentukan masalah, kuesioner diterapkan pada 22 guru yang bekerja di wilayah geografis yang berbeda di Turki dan memiliki masa kerja yang berbeda. Berdasarkan hasil entropi, telah ditentukan bahwa masalah terpenting yang dihadapi oleh guru matematika dalam proses pendidikan jarak jauh adalah 'masalah komunikasi' antara siswa

dan guru. Kesimpulannya, guru matematika harus bisa menemukan metode pembelajaran yang tepat untuk mengatasi permasalahan komunikasi ini agar kedepannya pembelajaran jarak jauh tidak mengalami kendala.

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1. INTRODUCTION

The Covid-19 pandemic, which we have been fighting for more than two years, has had and continues to have profound effects on health, economic, psychological, social life and education. All education systems around the world have been affected by the pandemic, and schools and universities have had to take a break from face-to-face education. Exams to be held have been postponed or had to be cancelled. The United Nations Educational, Scientific and Cultural Organization (UNESCO) has announced that it will support countries to ensure the continuity of education for all through distance education in order to minimize the negative effects of school closures. For this purpose, various measures have been taken to prevent the interruption of education in all countries of the world. In the event that formal education cannot be provided due to the global pandemic, distance and open education applications have come to the fore as an alternative source of learning. The Covid-19 pandemic has made online learning a rapidly evolving and much-needed form of teaching so that it can be a part of education [1]. Many countries, especially China, USA, Italy, Spain, France, Turkey and Germany, have suspended face-to-face education and accelerated distance education studies. As a result of these studies, millions of students around the world have started to receive education with distance education applications [2]. As of March 16, 2020, schools in all education levels in Turkey have been suspended for a week, and then as of March 23, 2020, students have started to receive education from the internet and television channels by distance education method. In this context, three new TV channels were established by the Ministry of National Education, and then education was continued with the live class application over the Education Information Network (EBA).

When the historical process of distance education is examined, it is seen that it dates back to the 1700s. It is thought that the first distance education application was made through letters. In the Boston Newspaper published in the USA on March 20, 1928, it was stated that 'Shortcut Lessons' would be given and it was announced that these courses would be carried out through distance education. At the end of the 1800s, distance education institutions started to be established in countries such as Germany and France and significant investments were made. In the 1900s, educational radio broadcasts began to be made in the USA, and towards the end of the 1900s, distance education developed more and started to be popular with students [3].

The first studies on distance education in Turkey date back to 1927. The physical inadequacies of educational institutions brought the question of "Can distance education be done?" and in 1927, the Minister of National Education, Undersecretary, Members of National Education and Discipline, 11 Education Trustees and General Managers held a meeting and discussed the basic problems of education. At the end of the meeting, it was agreed that the method of teaching by letter could bring a solution to the education problem [4]. Since the adoption of the Latin alphabet in 1928, the main aim in education has been to increase the literacy rate and various studies have been carried out in this field. In the 1950s, distance education programs were started at the Banking and Commercial Law Research Institute of Ankara University Faculty of Law. Establishment of Eskisehir Anadolu University Open Education Faculty in 1982-1983 greatly accelerated the development of distance education in Turkey [5]. Developing technologies, improvement

of communication infrastructure and the development of the internet have made distance education widespread. Through the Internet, students had easier access to printed resources, written and visual content. Distance education has become a part of our education system thanks to the faster developing information and communication technologies since the beginning of the 2000s. Today, millions of students actively use distance education [6].

Distance learning or online learning is a form of learning and teaching those teachers and student who are not physically in the same environment and/or time use various online teaching materials. It can be examined in two types, synchronous and asynchronous [7]. In asynchronous online learning, e-mail, specific Learning Management Systems (EBA, LMS, etc.) of various countries, and various online discussion forums are generally used. In synchronous online learning, one of the types of online learning, teachers and students interact online at the same time, even if they are not in the same place [8]. Synchronous online learning usually uses various online learning platforms such as webinars, group chats, video conferencing, and telephones [9]. According to the study conducted in Indonesia [10], the inequality of knowledge among mathematics teachers and the ability of mathematics teachers to use learning platforms can cause educational inequality and trigger the digital divide. When teachers participate in education only with asynchronous learning, this may cause students to feel isolated [9]. For this reason, teachers should combine the benefits of both online learning styles, increase their knowledge and skills on this subject, and work on improving themselves [11].

Online learning is considered as integrated learning activities that take place directly or indirectly through online communication using various internet-connected devices such as smartphones or laptops [12]. Distance education, which we use more actively in the education process with the Covid-19 pandemic, has been a useful tool in transferring the benefits of the technology age we live in to the education process. Although the pandemic period caused many negativities, when evaluated in terms of education, it can be considered as an opportunity to improve educational practices and strategies, and to re-evaluate methods that have moved away from their basic philosophy and are no longer valid [13]. Despite all these developments, the fact that distance education takes the place of direct face-to-face education without being an addition to face-to-face education has brought many problems, especially adaptation, not only in our country but also in all countries of the world. It has been determined that the difficulties experienced during the online learning application are caused by various factors such as teachers, students, parents, school management, school curriculum [14]. It has been observed that the adaptation problem of students to the distance education process is more common, especially in underdeveloped countries where traditional education models are predominantly used. Inequality of opportunity in education, causing technology addiction, eye health problems in students as a result of students staying in front of the computer screen during class hours, etc. situations are the main problems that distance education can cause [15].

Distance education may have advantages and disadvantages as well as its effects may vary according to different branches as has been revealed by various studies [14], [16], [17]. Visualization and the use of technology have become a necessity in mathematics education in today's conditions. More or less mathematical thinking skills are required in every occupational group. For this reason, mathematics lessons should be given to students starting from primary school, avoiding a rote and imposing understanding, and integrating them with daily life. It has been observed that the distance education process affects mathematics teaching both positively and negatively. The main positive contributions are;

the student's not being disconnected from the learning process, the excess of subject repetitions, the excess of activity and example sharing. Not being able to get feedback from students, not being able to reach every student and not being able to use materials in mathematics teaching can be listed as negative effects [16]. In online learning, some course topics in the mathematics curriculum have also caused mathematics teachers to have difficulties. According to the results obtained from the researches, 70% of the mathematics teachers emphasized that the subject of geometry is the most difficult subject taught to students through online learning. The reasons for this situation can be listed as: requiring higher visualization than other subjects, needing to give more examples, and taking more time to create a geometry learning environment [14]. While online learning is an alternative to education and a solution to school closures, it is unlikely to replace face-to-face education between students and teachers [17]. However, previous studies have not revealed much about the degree of distance learning problems from the teacher's perspective.

The purpose of this study is to the problems experienced in mathematics teaching during the distance education process during the Covid-19 process were identified and evaluated from the perspective of the teacher. This study offers novelty in the form of information related to the degree of importance of the problems experienced which are determined by the Entropy method, a multi-criteria decision-making method, and the results are evaluated. In the following sections of the study, an explanation of the 'Entropy' method, which is a research method, is made and the degree of importance of the problems experienced in mathematics education.

2. METHOD

Multi-criteria decision making (MCDM) refers to the ability to make a preference decision (for example, evaluation, prioritization or selection) over available alternatives, which are characterized by multiple and often divergent qualities. The structure of the alternative performance matrix x_{ij} denotes the rank of alternative i according to criterion j , and w_j denotes the weight of criterion j . Since each criterion has a different meaning, it cannot be said that all criteria are of equal weight. Finding a suitable weight for each criterion is one of the main goals of MCDM [18].

There are various methods for weighting criteria in the literature. These fall into two different groups: subjective weights and objective weights. Subjective weights are determined only by the comments of the decision makers. AHP method [19], least squares method [20] and Delphi method [21] belong to this category. Objective methods, on the other hand, are methods that determine weights by using only mathematical models, regardless of the preferences of the decision makers. Entropy method and multi-objective programming methods can be given as examples [18]. The Shannon entropy method is an objective weighting measure proposed by researchers [22].

2.1 Shannon Entropy Method

As a concept taken from thermodynamics, entropy represents the energy of a system in physics, which cannot be converted into mechanical work and is distributed to the universe. With the use of the concept of entropy in Information Theory by Shannon in 1948, the problems and aspects of information and communication were explained with the help of probability calculations. Entropy is a statistical parameter that measures how much information is produced on average in a system, information gain and information loss in the system [23]. It is seen as a measure of uncertainty in the system [24]. Entropy is a convenient method used for weighting criteria in multi-criteria decision making methods. The importance degrees of the criteria are calculated using Shannon's

probability-based entropy formula. While calculating the weights related to the criteria in the decision problem in the entropy method, the fact that there is no need for another subjective evaluation other than the data in the decision matrix shows the objectivity of the method and provides a more scientific evaluation of the data. The use of entropy weighting method in multi-criteria decision-making processes can minimize the impact of the human factor on the evaluation findings. Thus, it can be ensured that the research conducted is more scientific and the results of the research can be evaluated in a more reasonable way [25].

The steps of the method are summarized below [26]:

Step 1: Creating the Initial Decision Matrix

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}_{m \times n} \tag{1}$$

Here x_{ij} is the success (performance) value of the i th alternative according to the j th criterion. $i = 1, 2, \dots, m$ and $j = 1, 2, \dots, n$.

Step 2: Generating the Normalized Decision Matrix

Using the following formula

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}} \quad i = 1, 2, \dots, m \quad j = 1, 2, \dots, n \tag{2}$$

we obtain the normalized decision matrix $R = (r_{ij})_{m \times n}$. Thus outliers in different measurement units are eliminated.

Step 3: Calculating Entropy Values for Criteria

The entropy value of each criterion is calculated with the following formula.

$$e_{ij} = -\frac{1}{\ln m} \sum_{i=1}^m r_{ij} \ln r_{ij} \quad j = 1, 2, \dots, n \tag{3}$$

Step 4: Calculating Degree of Differentiation

The d_j uncertainty is calculated as the degree of diversity with the equation $d_j = 1 - e_j$.

Using this, weight of criteria is given by

$$w_j = \frac{d_j}{\sum_{j=1}^n d_j} \quad \text{where } \sum_{j=1}^n w_j = 1 \tag{4}$$

In the study, a multi-criteria decision model was created to determine the most important problem faced by mathematics teachers in distance education. The steps of the entropy evaluation process are given in Figure 1.

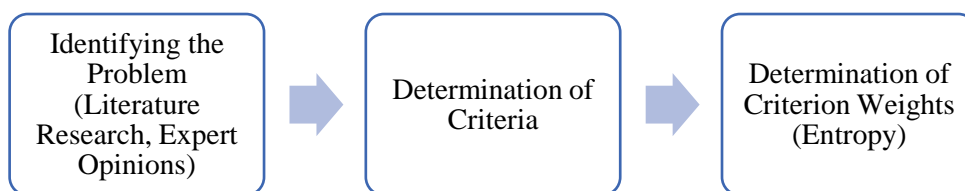


Figure 1. Entropy Application Stages

2.2 Analysis

The analysis of the criteria obtained as a result of the interviews was made with the entropy method. The research framework is depicted in Figure 2.

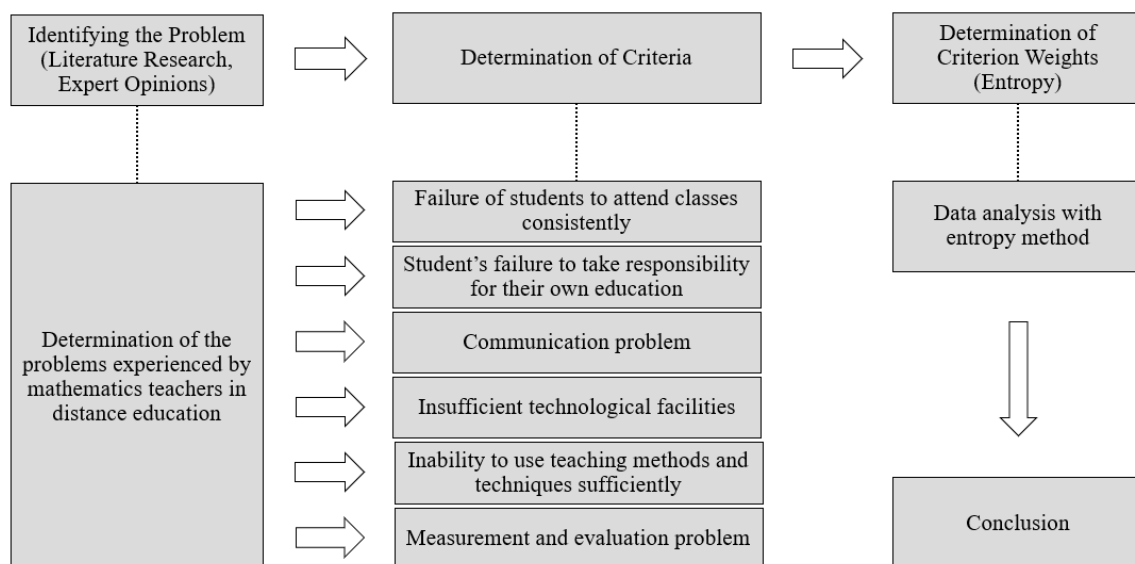


Figure 2. Research Framework

The study has been done in detail in the literature on education from above. Kavuk and Demirtaş [27], during the Covid-19 process, there have been problems with the internet for distance learning and the ability to develop at a level that can be largely sufficient in education. As a result of their analysis, Avcı and Akdeniz [28], on the other hand, determined that teachers had problems with technological infrastructure and internet in the distance education process, inequality of opportunity in education emerged, and the end of adaptation was experienced during the transition to distance education. Expert opinions were taken to determine the problems experienced in mathematics teaching in the distance education process and criteria were created as a result of the interviews. As a result of the opinions received from mathematics teachers working in different geographical regions of Turkey, a total of 7 criteria regarding mathematics teaching in distance education were determined. Information on these criteria is presented below:

- 1) *Failure of students to attend classes consistently*: Students do not attend classes regularly and do not stay in class during the whole class hour.
- 2) *Failure of students to take responsibility for their own education*: They are learning problems caused by students' lack of self-control, study discipline and taking responsibility.
- 3) *Communication problem*: These are the problems caused by the lack of technological tools such as microphones, headphones and cameras, or the inability of some students to express themselves in the online classroom environment. Student-teacher communication is one-sided, not mutual. The teacher cannot get enough feedback from the student.
- 4) *Insufficient technological possibilities*: Lack of internet infrastructure and connection required for distance education or tablet, computer etc. to participate in distance education. The lack of distance education tools.
- 5) *Inability to use technology adequately*: It is the inability of students or teachers to use technology adequately and efficiently.
- 6) *Inability to use teaching methods and techniques adequately*: It includes the inability to use various teaching methods and techniques required by constructivist education, the lack of learning by doing, the lack of peer learning, the lack of in-class games and activities.

7) *Measurement and evaluation problem:* The problem experienced by the teachers is not getting feedback from the students during the lesson and not being able to control the assigned homework in a healthy way.

3. RESULTS AND DISCUSSION

According to the Figure 1, the problems experienced by mathematics teachers in distance education were determined by making use of literature review and expert opinions. Since the determined criteria are not of equal importance, it was necessary to weight the criteria. In this context, the criteria are weighted with the Entropy method. The criteria created by taking expert opinions are shown in Table 1.

Table 1. Main Criteria

Criteria	Code
Failure of Students to Attend Classes Consistently	C1
Students' Failure to Take Responsibility for Their Own Education	C2
Communication Problem	C3
Insufficient Technological Facilities	C4
Inability to Use Technology Sufficiently	C5
Inability to Use Teaching Methods and Techniques Sufficiently	C6
Measurement and Evaluation Problem	C7

The first step of the entropy method was created for weighting the criteria. While creating the decision matrix, the criteria were compared according to the importance scale created by Saaty and the average of the scores given by the experts to the criteria was taken. A questionnaire was presented to 22 mathematics teachers, having actively taught in distance education during the pandemic, work in different geographical regions of Turkey, and have different lengths of service. The decision matrix created regarding the opinions is shown in Table 2.

Table 2. Decision Matrix

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇
C ₁	1,000	2,422	4,564	1,693	4,009	4,451	3,956
C ₂	2,915	1,000	4,972	2,820	4,043	4,330	3,327
C ₃	1,823	1,630	1,000	2,092	3,126	3,028	2,290
C ₄	3,181	3,599	3,774	1,000	4,565	4,171	4,148
C ₅	1,332	1,240	1,810	0,948	1,000	2,767	2,993
C ₆	1,680	1,751	1,995	2,142	2,601	1,000	2,324
C ₇	2,096	2,103	3,135	2,690	3,017	3,105	1,000

In the second step, the normalization process was performed by dividing each element in the matrix by the corresponding column sum. The normalized decision matrix is shown in Table 3.

Table 3. Normalized Decision Matrix

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇
C ₁	0,071	0,176	0,214	0,126	0,179	0,194	0,197
C ₂	0,297	0,072	0,233	0,210	0,180	0,189	0,166
C ₃	0,129	0,118	0,047	0,156	0,139	0,132	0,114
C ₄	0,226	0,261	0,177	0,074	0,204	0,182	0,207
C ₅	0,094	0,090	0,085	0,070	0,044	0,121	0,149
C ₆	0,119	0,127	0,093	0,160	0,116	0,043	0,115
C ₇	0,149	0,153	0,147	0,200	0,134	0,135	0,049

Then, the entropy values of the criteria were calculated and these values were shown in Table 4.

Table 4. Entropy Values for Criteria

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇
C ₁	-0,188	-0,305	-0,330	-0,261	-0,308	-0,318	-0,320
C ₂	-0,326	-0,190	-0,339	-0,328	-0,309	-0,315	-0,298
C ₃	-0,265	-0,252	-0,143	-0,290	-0,275	-0,267	-0,247
C ₄	-0,336	-0,350	-0,306	-0,193	-0,324	-0,310	-0,326
C ₅	-0,223	-0,217	-0,209	-0,187	-0,138	-0,255	-0,283
C ₆	-0,254	-0,262	-0,222	-0,293	-0,250	-0,136	-0,249
C ₇	-0,284	-0,287	-0,282	-0,322	-0,270	-0,271	-0,149

The criteria weights (w_j) were determined by calculating the degrees of differentiation. The degree of differentiation and the importance weights of the criteria are shown in Table 5.

Table 5. Entropy (e_j), Differentiation Degrees (d_j) and Significance Weights (w_j)

e_j	0,9652	0,9594	0,9431	0,9644	0,9642	0,9640	0,9639
d_j	0,0347	0,0405	0,0568	0,0355	0,0357	0,0359	0,0360
w_j	0,1261	0,1471	0,2064	0,1289	0,1298	0,1306	0,1307

According to the values in Table 5, the most important problem faced by mathematics teachers in distance education was determined as ‘Communication Problem’. In order of importance, other problems are listed as ‘Students’ failure to take responsibility for their own education’, ‘Assessment and Evaluation’, ‘Inadequate Use of Teaching Methods and Techniques’, ‘Inability to Use Technology Sufficiently’, ‘Insufficient Technological Opportunity’ and ‘Students Not Continuing to Lessons Stably’.

Online learning or distance education is a fast and efficient form of material dissemination using information technologies and the internet [29]. Its features such as the ability to access information without limitations of space and time and the potential to provide learning flexibility to the student have made online learning popular [30]. At the same time, it contributed to the development of students’ independent learning skills [31].

Many institutions in many countries had plans to make greater use of technology in education and training. The sudden outbreak of Covid-19 has meant that innovations and changes that organizations plan to make in months or years must be planned in a matter of days [32]. The lack of time for the transition from face-to-face education to online learning has affected the education sector, especially teachers [31].

The problems experienced by teachers in teaching mathematics lessons were determined and those problems were titled as 7 main criteria. A survey was conducted with 22 teachers working in distance education and mathematics education, and the data were evaluated with the entropy criterion weighting method. Compared with various criterion weighting methods, the biggest advantage of the entropy method is that it does not allow human factors to interfere with the research indicators and thus can obtain more comprehensive evaluation results [33].

According to the results obtained from the questionnaires, it was concluded that the most important problem faced by mathematics teachers in distance education is ‘Communication Problem’. The main reasons for the communication problem are the lack of microphone, camera, headset technical material experienced by the teacher and the student, the difficulties in communicating due to the lack of cameras in the lessons, and the difficulties of the students in expressing themselves in the virtual classroom environment.

The second important problem has been identified as ‘Students Failure to Take Responsibility for Their Own Education’. This result shows that students do not try to complete the missing learning in distance education or the studies supporting distance education with their own efforts and efforts. According to the results of this study, it can be said that the individual learning effort of the students, which is one of the most important elements required for student-centered education, which is the basis of constructivist education, has not reached a sufficient level. The use of various teaching methods and techniques have an important place in mathematics education. In order to build-up the interest of the students in the lesson and to ensure that the teaching is more permanent, various teaching methods and techniques are used according to the gains that should be given in the lessons. In distance education, it can be concluded that the teachers used the visuals and videos related to the subject efficiently, but they could not use the methods that require face-to-face education such as demonstration, in-class activities and drama. Although there are important problems in distance education in ‘Not Using Technology At A Sufficient Level’, ‘Insufficient Technological Opportunity’ and ‘Not Continuing Classes Consistently’, values close to each other have been found.

In this study, the problems experienced in mathematics education were determined and the importance of these problems were listed. For a better quality and efficient distance education process, these problems should be taken into account and solution alternatives should be developed by the authorities. All kinds of infrastructure services should be provided to students, educational tools and equipment with all kinds of technological equipment should be provided so that all students can benefit from distance education equally, and education and awareness-raising activities should be carried out to make distance education.

4. CONCLUSION

In this study, the problems experienced in mathematics education were determined and the importance of these problems was listed. For a better quality and efficient distance education process, these problems should be taken into account and solution alternatives should be developed by the authorities. All kinds of infrastructure services should be provided to students, educational tools and equipment with all kinds of technological equipment should be provided so that all students can benefit from distance education equally, and education and awareness-raising activities should be carried out to make distance education.

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