Analysis of Learning Effect through Voice Signal Analysis in Online Education Environment

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Abstract

The new coronavirus infection (COVID-19) that appeared suddenly has permeated our daily lives and changed our way of life. In the field of education, education is being conducted in a non-face-to-face teaching method to prevent the spread of coronavirus. In the end, e-Learning, a new educational and training system that can provide a lifelong education environment in the 21st century information society, is increasing in use in the field of education. The biggest advantage of the online education system is that it provides an environment in which you can learn the necessary contents anytime, anywhere. However, there are cases in which the learning effect is reduced because various learning support is not available in the online space due to the sudden change of the educational environment due to the covid-19. Therefore, in this thesis, a study was conducted to analyze the learning effect of online education with voice signals for college students who are receiving education through an online education environment. To this end, the learning effect was classified into a group saying that the learning effect increased and a group that decreased due to online education, and the voices of the subjects in each group were collected. As a result of the experiment, the results of the vocal cord vibration (Pitch), Degree of voice breaks, Jitter and Shimmer were consistent among the elements of voice signal analysis between two groups.

Keywords: online education, learning effect, pitch, degree of voice breaks, jitter, Shimmer

1. Introduction

The novel coronavirus infection (COVID-19) is spreading all over the world, becoming a pandemic and disrupting humanity. This phenomenon is causing confusion in all areas of society, and is a situation that has a fatal and uncomfortable effect on the daily life of mankind. Of course, in the field of education, we are also conducting non-face-to-face lectures under the influence of COVID-19 (Santanu, 2020; Erhan, 2020).

In Korea, before March 2020, the government prepared educational countermeasures to prevent and prevent the spread of the novel coronavirus infectious disease crisis management situation depending on the severity of the crisis. Most universities across the country postponed the opening of classes, and while looking at the situation of infectious diseases, the schedule of in-person classes was changed from time to time to be notified and delayed and withdrawn (Lee, 2020; David, 2020). However, in the end, after going through several reversals, face-to-face classes were conducted only in some courses where practical, experimental, and practical skills were needed, and one semester class at most universities nationwide was conducted in a non-face-to-face distance online learning method (Lee, 2020).

As the unprecedented online distance learning was introduced to almost all college classes, many problems arose in terms of class preparation and design, technical preparation and class operation, and education quality and learning effects for distance learning. Both teachers and learners who are familiar with the existing face-to-face classes are bound to experience confusion and conflict. The major problems that emerged from the sudden online education environment were pointed out as poor lecture quality, poor distance learning technology system, lack of teaching-learning tools, and reduced educational effect due to the absence of communication and interaction activities (Allen, 2016).

As the method of acquiring new knowledge and learning has changed due to the development of ICT technology,

rapid changes have also occurred in university education. In particular, developing the ability to solve problems and generate creative ideas through interactive activities to share knowledge and exchange opinions with others through online learning spaces has become an important part of university education (Colpaert, 2006; Donovan, 2019). The online learning environment has formed a new educational paradigm through the use of social network services (SNS) based on digital technology, artificial intelligence (AI) and big data technology, and learning management system (LMS). In particular, in university education, learner-centered project-based learning and problem-solving-based learning are being accepted and actively implemented as educational methods to strengthen the competency of future talents, which are made more dynamic and effective with the support of information and communication technology (Alhabeeb, 2017; Mapuva, 2009).

Despite this change in educational paradigm, online-based distance classes at four-year universities in Korea in 2019 were found to be very poor compared to face-to-face classes. In an unprepared situation, teachers, learners, education-related people, as well as parents, were all confused about the sudden distance education at university due to the sudden outbreak of coronavirus infectious disease in 2020 (Lam, 2020). The center of confusion appears to be in terms of teaching-learning plans and design for distance online learning, establishment and operation of an online learning technology support system, operation of online classes, and pursuit of learning effects (Aroyo, 2004; Stanchevici, 2019). The situation is unfolding in which the demands are continuing.

In the situation where policies such as improvement and support for online education environment are developed and applied, it is necessary to analyze and reflect the degree of learning effect and satisfaction that students accept due to current online education. Therefore, in this thesis, a study was conducted to analyze the learning effect of online education with voice signals for college students who are receiving education through an online education environment. To this end, the learning effect was classified into a group saying that the learning effect increased and a group that decreased due to online education, and the voices of the subjects in each group were collected.

2. Method

The development of computer and internet technology not only brought about many changes in our lives, but also foreshadows a great change throughout society. On-line education, which is commonly used as a concept in contrast to off-line education, refers to the Internet, Intranet, and Extra-net. E-learning is education using educational CD-ROM or software and includes computer-based education, web-based education, virtual classroom education and digital collaboration that emphasizes collaboration. E-learning is a higher concept than online education, and distance learning is classified as the broadest concept (Hsieh, 2008; Seaman, 2018). In fact, e-learning, cyber education, and online education are not largely divided and are used in almost the same meaning.

The advantage of online education is that first, when offline classes based on face-to-face classes are not possible, non-face-to-face classes are possible using online infrastructure. The traditional offline teaching method is a method in which teachers and students conduct classes face-to-face, but online classes can eliminate educational gaps when face-to-face classes are not possible. Second, it can improve students' self-directed learning ability. When face-to-face education is limited, as it is now, it helps to develop the ability to learn alone. In addition, the fact that students can study at the place and time they want to class helps improve students' self-directed learning ability. Third, students can learn flexibly according to their own interests and interests. Schools teach according to a set curriculum. Students are educated and evaluated in every subject, whether they want it or not. The advantage of online classes is that not only the content of the curriculum but also students can do additional learning according to their interests. You can also browse videos on YouTube about things you've been interested in while taking classes. You can engage in learning with a flexible mindset through instant internet search and watching related videos (Karkar-Esperat, 2018).

Online education incurs a large initial cost for equipment purchase and system installation. Due to the online school opening within a short period of time, many teachers have prepared online classes and initiated a non-face-to-face class ordinance using interactive platforms with students. Each school supplies personal PCs to teachers, but the cost to prepare a video camera and microphone for interactive communication increases. Due to the nature of online classes, there are technical restrictions on the use of equipment because computers or video equipment are used as a medium. There are many difficulties in developing content and using equipment due to the first online school opening for all teachers. Physical restrictions for education, such as the absence of informational devices in devices, can lead to inequality in education for students. Another problem with online classes is that although more than 20 years have passed since Korea introduced online education services, there are technical limitations, and many students and parents do not know how to use online remote classes. I think there are a lot of problems because the

online school starts with insufficient information. Instructor cannot identify students. In the existing classroom classes, two-way communication is possible, and during the lecture, the instructor can see the responses of students and adjust the speed, and instant communication is possible. However, in online classes, it is difficult for instructors to accurately identify students (Shebansky, 2018). Figure 1 shows the advantages and disadvantages of online education.
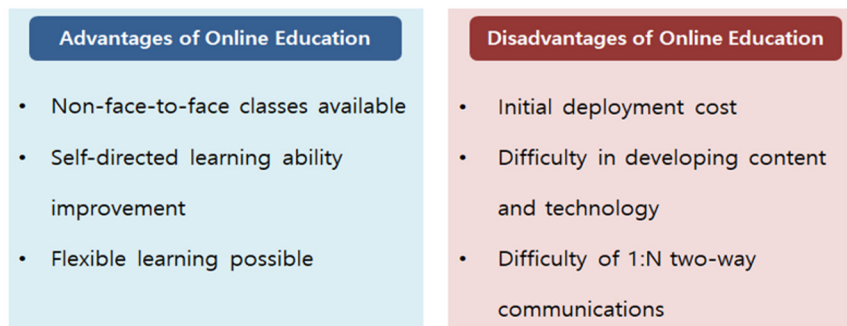

Figure 1. Advantages and Disadvantages of Online Education

Online education is based on online-based learning, and refers to a form of learning that takes place anywhere and anytime by using digital tools such as web, mobile or smartphone. Online-based learning differs in concepts and definitions little by little, but most of them consist of various types, such as Web-based learning, e-learning, cyber learning, distance learning, and mobile learning. In the early stages of the introduction of online-based learning, instructors played a role of delivering planned learning content using designated information and communication media, and learners played a passive role in passively viewing and accepting the provided learning content. The role of the information and communication system as a medium was to check the delivery of learning content, check the achievement level of knowledge as a learning effect, and identify the strengths and weaknesses in the technical part (Statisitcs, 2018). However, as the paradigm of online-based learning changed from the instructor to the learner-centered according to the educational demand according to the development of information and communication technology and the constructivist perspective, the learner took the initiative in selecting the learning content. Through this process, the development of learning competencies for problem solving and creation of creative ideas became the key, and the learning system was transformed into a situation that plays a role in helping this.

Nevertheless, it is said that, excluding cyber colleges and broadcasting and communication colleges, the proportion of online classes in domestic universities is only about 1% of all college classes. This shows that even under normal circumstances before the novel coronavirus outbreak, online learning at universities has failed to meet the trends of the educational paradigm and the needs of learners. In addition, online remote classes at universities in 2020, which took place suddenly in the event of an abnormal coronavirus infectious disease, are insufficiently prepared, and various problems are exposed in implementation. It is difficult to be sure that the situation of infectious diseases will improve in the future, and similar situations can always unfold (Kerry, 2018; Rajive, 2018). Therefore, it is urgent to prepare for the future by grasping the actual condition of remote classes and exploring ways to improve them.

As demand for online learning increases and research on the effects of online learning is actively conducted, interest in the advantages and challenges of online distance learning is increasing compared to the traditional face-to-face learning method. In college education, online learning provides flexible teaching methods and academic schedules, and also brings cost savings in terms of the management of the university and the financial aspects of students' college life. In addition, in terms of learning experience, online learning allows students to freely choose and control in the use of learning time and space, use of textbooks, and assignments. In particular, in terms of language education, it provides abundant communication opportunities, and has the effect of improving problem-solving skills and reflective and critical thinking skills through social knowledge building and collaboration (Nikulova, 2016). In addition, international students living in their home countries and taking online classes have the advantage of being able to conveniently access and use authentic learning materials and materials as well as the academic culture and atmosphere of the university they are taking (Martyshenko, 2013).

On the other hand, there are also challenges and problems that hinder smooth online classes. First, the operating entity is slow to accept the online education system due to insufficient administrative, educational, and technical support. In addition, compared to blended or face-to-face courses, the percentage of dropouts in online courses is

higher. Particularly noteworthy is that students' motivation to learn is lowered due to delayed feedback and poor quality compared to face-to-face classes or lack of clear explanations and discussions (Lee, 2012; Nikulova, 2014). In addition, they become aware that they are isolated from fellow students and instructors, which leads to cultural disparity and makes them feel like strangers in class.

Based on the case of converting face-to-face classes to online classes as described above, studies to explore the effects, advantages, issues and solutions of distance online learning have been conducted in various aspects abroad. But, studies that reflect the educational environment of Korean universities are rare. However, in accordance with the change of society in the era of the 4th industrial revolution and the demands of a new educational paradigm, the necessity of remote online learning in the university education field is clear and will continue to spread in the future.

3. Voice Analysis Parameter

In this paper, in order to analyze the effect of online education on learners' learning effects, the group of subjects was classified according to the increase and decrease in learning effect. In addition, in order to conduct an experiment to study the change of voice signal according to the learning effect, voice analysis element technology related to vocal cord vibration was applied to the experiment. To this end, a pitch analysis factor related to the rate of change and regularity of the vocal cord vibration was applied to the test voice, and an experiment was performed using jitter and shimmer, which are detailed analysis techniques of the pitch analysis factor. In the human voice, tremor, stress, etc. of the voice may change due to changes in mood or emotion. Therefore, an increase or decrease in the learning effect due to online education may be associated with changes in mood, emotion, and the like. In the end, this study was conducted based on the hypothesis that as the interest and fun of online education increase, the pattern of speech will also change constantly. In order to carry out the research in this paper, the association between speech and patterns was analyzed as a basic study. For this purpose, the change of voice pattern according to food intake was performed as a basic study. In other words, prior studies were conducted to compare and analyze changes in mood and emotions caused by food intake (Kim, 2012).

First, pitch is an analysis element that means the trembling of the vocal cords, and the height of the voice is acoustically expressed as an f0 value. Usually, the pitch is expressed as high or low with the height of the sound felt audibly in mind. f0 is also referred to as the fundamental frequency, which depends on the person's emotions and emotions. The pitch value indicates how many times there is a vibration of the vocal cords per second and is affected by the size, length, and mass of the vocal cords. The larger the vocal cords are, the slower they vibrate, so the pitch value of men with relatively larger vocal cords than women is about 120Hz, women vibrate at an average of about 230Hz, and young children are very high around 300Hz (Cariani, 1996; Fred, 2005).

The information of the voice waveform takes a form in which similar shapes are continuously repeated in a certain section. This repetition period provides the most important information to characterize the voice waveform, and this repetition period is called the pitch. Pitch is the lowest frequency with periodicity excluding DC components, and refers to the periodicity of the lowest frequency in the voice signal in which many frequencies are overlapped, that is, peak values with the widest time interval in the time domain. In the case of a voice signal, a certain period is repeatedly maintained. When the autocorrelation coefficient is obtained, it takes a periodic form with a value very similar to its own value again after a certain repetition period. At this time, if the repeated period is obtained, the pitch result value based on the statistical characteristics is extracted. However, it is only ideal to make the speech analysis section infinitely, and in reality, the result should be obtained within a finite range. Therefore, in order to evaluate all voice signals in the same way, the autocorrelation coefficient is normalized to extract the pitch result value required for analysis (Xingwei, 2019). Therefore, due to accurate acquisition of the pitch period, useful information can be extracted from the voice signal regardless of the speaker's state, and this pitch period plays a decisive role in sound quality. The Pitch detection method applied in this paper is the autocorrelation method in the Praat analysis program. This uses the feature that pitches are well represented in the autocorrelation function.

Second, jitter indicates how much change in pitch, which is the vibration of the vocal cords, in pronunciation within a unit time. It is the ratio of the length of the three vibrations of the voice waveform to the one vibration of the voice waveform (Ichiyama, 2008). The vibration time within the fundamental frequency is expressed as a percentage. In normal voice, the rate of change is not high, but if there are nodules in the vocal cords or cancerous tissues, there are many changes. It is commonly used to judge whether or not the vocal cords are diseased or if the jitter is more than 1.0% as a pathological voice. Studies that show that jitter is correlated with an increase in age and studies that do not correlate with an increase in age coexist. In addition, jitter tells how fluctuating a period of the vibration frequency is, and is audibly related to hoarseness and harsh sounds (Walker, 1999).

The figure below Figure 2 is a screen where the pitch and jitter analysis results are measured by extracting the voice report after selecting the pulses from the experimental data. For pitch and jitter analysis, a section in which a pulse wave was generated was selected from all voices used in the experiment, and the average pitch and jitter values of the section were measured.
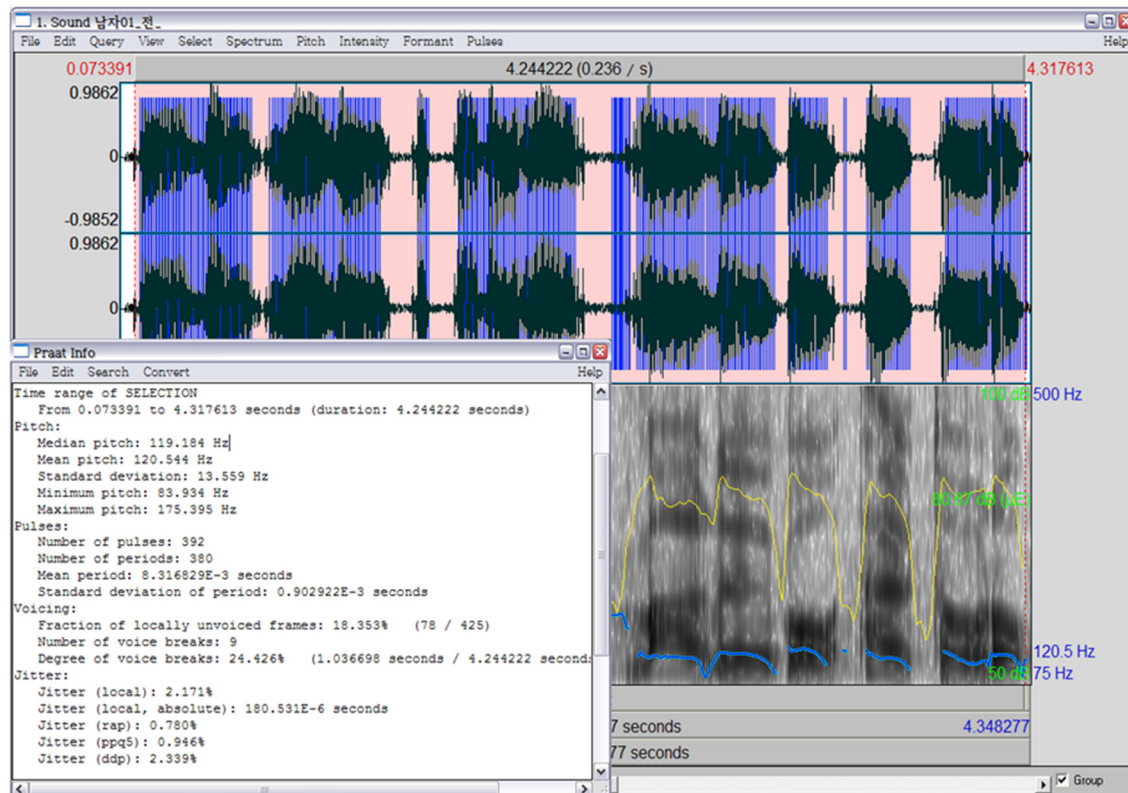

Figure 2. Pitch and Jitter Analysis Result Measurement Screen

Third, shimmer shows how regular the change in amplitude value at each point in the voice waveform. It shows the variation of the vocal cord amplitude and tells the accuracy of the amplitude. The change in amplitude per vibration period is evaluated in dB, and the irregular change in pitch during continuous vowels is expressed as a percentage. Also, vocalists can adjust the loudness to gradually increase or decrease by training. Usually, in patients with laryngeal cancer, if the vibration of the vocal cords is irregular, the amplitude value at each time point is also not constant (David, 1984; Kim, 2011).

Finally, degree of voice breaks is total duration of the breaks between the voiced parts of the signal, divided by the total duration of the analysed part of the signal (MDVP calls it DVB). Since silences at the beginning and the end of the signal are not considered breaks, you will probably not want to select these silences when measuring this parameter (Hunter, 2016).

4. Research Method and Result Discussion

In this paper, to analyze the effect of online education, which is the core of the non-face-to-face education field due to the spread of COVID-19, on the learning effect of learners, an experiment applied with voice signal analysis was performed. To this end, the results were derived by configuring subjects, establishing an experimental environment, collecting and analyzing voices, and analyzing the significance of the results.

First, an experimental group was composed of subjects who clearly felt the increase or decrease in learning effect due to online education. The experimental group was classified into a group with increased learning effect and a group with decreased learning effect. Second, the subjects' voices were collected through the same environment and equipment. The voices used in the experiment were collected before and after online education. That is, the voices of the test subjects before and after online education were collected. The collected voices were collected by having

them read the sentence "I have interest and fun in online education" in the same way.

Third, the collected voice was converted into a pulse signal for the same section using the Praat program, and the pitch, jitter, shimmer, and break were analyzed respectively. Finally, the significance analysis for each group according to the increase or decrease in learning effect was performed through the analyzed voice signal results. Figure 3 shows the analysis of the voice signal in the Praat program used in the experiment.

In the paper, the test subject group consisted of 30 female college students. Among them, it was classified into a group of 15 people who assessed that the learning effect increased by online education and 15 people who assessed that the learning effect decreased by online education.
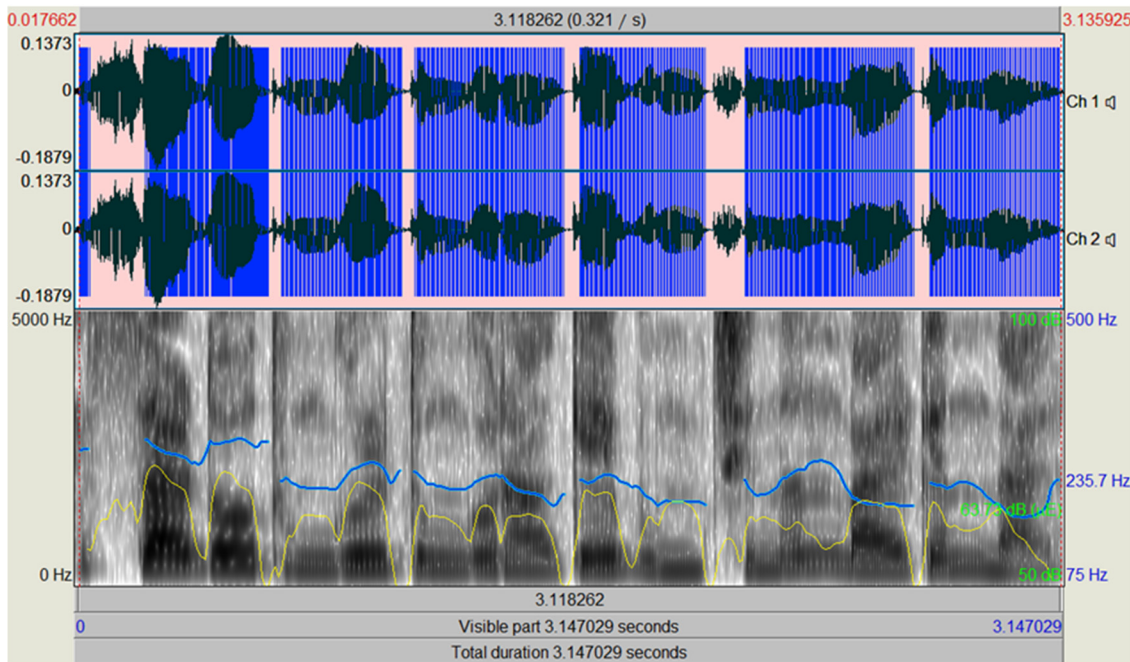

Figure 3. Voice Signal Waveform and Analysis

Table 1. Voice Signal Analysis Result of Group with Increased Learning Effect

Subject	Pitch(Hz)		Jitter(%)		Shimmer(dB)		Degree of voice breaks(%)	
	Before	After	Before	After	Before	After	Before	After
In01	200.851	208.468	2.198	2.334	0.973	0.924	18.531	20.185
In02	231.918	229.486	1.478	1.625	0.869	0.805	15.985	16.842
In03	208.540	218.452	1.786	1.649	0.777	0.925	14.948	16.058
In04	207.382	214.105	1.685	1.825	0.825	0.801	15.583	18.482
In05	218.576	220.642	2.048	2.147	0.800	0.768	13.857	14.652
In06	225.492	223.251	1.446	1.685	0.935	0.928	14.131	13.852
In07	234.953	238.450	1.650	1.924	0.924	0.938	13.965	17.405
In08	221.845	232.547	2.138	2.058	0.936	0.904	15.825	16.843
In09	209.684	214.695	2.094	2.114	0.702	0.701	14.051	17.852
In10	215.647	227.324	1.853	1.930	1.069	0.994	14.582	13.496
In11	204.006	204.568	1.687	1.947	1.128	0.983	16.010	20.644
In12	239.451	231.562	1.490	1.645	0.948	1.028	17.864	18.942
In13	238.411	244.156	2.234	2.263	0.939	0.903	13.524	14.805
In14	226.510	230.685	1.681	1.782	0.748	0.741	18.642	20.177
In15	218.634	224.693	1.746	1.994	0.857	0.769	16.598	17.952

Table 1 shows the results of analyzing the negative signal of the group of subjects who evaluated that the learning effect was increased. The voice signal analysis elements applied to the study are pitch, jitter, shimmer and degree of voice breaks, and are the result of voice signal analysis before and after online education. Conversely, Table 2 shows the results of analyzing the negative signal of the group of subjects who evaluated that the learning effect was reduced. In the same way as in the group that the learning effect was increased, voice signal analysis corresponding to pitch, jitter, shimmer, and degree of voice breaks was performed, and this is the result of analysis of voice signals before and after online education.

Table 2. Voice Signal Analysis Result of Group with Decreased Learning Effect

Subject	Pitch(Hz)		Jitter(%)		Shimmer(dB)		Degree of voice breaks(%)	
	Before	After	Before	After	Before	After	Before	After
De01	216.659	204.740	1.640	1.299	0.800	0.685	13.447	14.044
De02	239.186	232.485	1.622	1.578	0.946	0.933	15.585	16.327
De03	227.223	225.832	2.231	2.187	0.949	0.936	13.216	17.181
De04	209.625	212.568	1.286	1.204	0.984	0.925	16.011	16.825
De05	236.412	229.582	1.664	1.523	0.996	0.882	14.182	15.942
De06	214.523	210.557	1.395	1.307	1.108	1.084	14.924	16.208
De07	218.230	214.751	0.998	1.152	0.924	0.712	15.648	17.480
De08	226.372	221.540	1.842	1.421	0.934	0.997	13.857	15.481
De09	209.645	204.931	2.010	1.853	0.971	0.768	16.101	16.725
De10	218.285	214.052	1.842	1.442	0.898	0.709	14.925	16.085
De11	222.135	218.647	1.624	1.227	0.847	0.685	15.528	17.493
De12	207.592	205.699	2.137	1.825	0.928	0.728	16.824	18.481
De13	238.509	231.487	1.227	1.106	0.768	0.705	15.928	16.398
De14	224.886	228.641	1.542	1.589	0.830	0.692	18.647	17.855
De15	216.743	211.038	1.674	1.169	0.928	0.994	16.394	16.994

As a result of the analysis, in the group with increasing learning effect, the result was that the subject pitch value increased by 80.0% after online education. In addition, after online training, a result of an increase in the subject jitter value of 86.7% was derived. On the contrary, in the group whose learning effect was decreasing, the result was that the subject pitch value decreased by 93.3% after online education. After online training, the result was derived that the jitter value of the subject decreased by 86.7%. However, in the shimmer analysis and the degree of voice breaks analysis, both groups produced the same results. In shimmer analysis, both groups resulted in a decrease in shimmer values in subjects of 80% or more. In addition, the degree of voice breaks analysis also resulted in increasing results in more than 80% of the subjects.

Finally, in order to test the results of the study, 5 female college students were selected, compared and analyzed separately from the experimental group. The test group performed the same research environment and procedure as the experimental group. In addition, voices before and after online education were collected and interest in online education was investigated. As a result of the test experiment, 4 out of 5 people derived the same voice change pattern as the study result and the association of interest in online education. Table 3 shows the experimental results for 5 test groups. As can be seen from the experimental results, the experimenters T01, T02, T04, and T05 were drawn in the same pattern as the study results. However, the T03 experimenter showed a decrease in the learning effect of online education, but an increase in the voice analysis pattern.

Through this, it can be seen that similar changes occur in the pitch and jitter analysis in the voice signal after online training. Based on the research results in this paper, it is possible to measure the learning effect through the analysis of voice signals before and after online education. In other words, it can be analyzed that the learning effect through online education increases as the vocal cord vibration increases and the rate of change of the vocal fold vibration increases in the voice after receiving online education. On the contrary, if the vocal cord vibration decreases in the voice after receiving online education and the rate of change of the vocal cord vibration decreases, it can be analyzed that the learning effect through online education decreases.

Table 3. Experimental Results for 5 Test Group

Subject	Pitch(Hz)		Jitter(%)		Shimmer(dB)		Degree of voice breaks(%)		Learning effect
	Before	After	Before	After	Before	After	Before	After	
T01	198.580	204.852	1.982	2.128	0.892	0.902	17.526	19.250	Increase
T02	211.485	223.502	1.520	1.702	0.952	0.911	19.285	19.854	Increase
T03	209.045	216.547	1.825	1.853	0.825	0.803	15.648	16.524	decrease
T04	214.285	207.863	1.892	1.604	0.910	0.902	16.855	17.632	decrease
T05	221.546	228.527	1.992	2.185	0.792	0.775	14.956	16.482	Increase

5. Conclusion

The e-learning market, which was represented by Internet lectures before COVID-19, is undergoing a trend change to the education industry in which education and ICT technologies are grafted due to the online opening due to COVID-19 and interest in the Untact industry. In the early 2000s,'e-learning', represented by Internet lectures, appeared, but the development of the edutech industry using VR and AI is slow. However, with the recent opening of online public education for the first time in history due to COVID-19, social consensus about the need to revitalize the edutech industry is forming. In order to solve the problems of existing one-way online education, it is evolving into real-time interactive classes that allow remote discussions and writing learning reports while watching content. However, various forms of online education such as development of contents and provision of an interactive education environment are applied, but the educational effect of learners is unknown.

Recently, due to COVID-19, the non-face-to-face lecture situation has been performed by most educational institutions, and in the process, how students are learning online video in the function of the existing Learning Management System (LMS). As these learning processes change, research to understand how appropriate formative evaluation is performed and the degree of learning has improved is becoming more important. Online education increasingly emphasizes the importance of student diagnosis and formative assessment. And, in relation to formative evaluation, there is a growing need to analyze and build the ability to evaluate in a learning management system (LMS), as instructors usually observe and evaluate in face-to-face classes. After all, the reliability of measuring learners' learning effect is the most important situation.

Therefore, in this thesis, a study was conducted to analyze the learning effect of online education with voice signals for college students who are receiving education through an online education environment. To this end, the learning effect was classified into a group saying that the learning effect increased and a group that decreased due to online education, and the voices of the subjects in each group were collected. As a result of the experiment, the results of the pitch, degree of voice breaks, jitter and shimmer were consistent among the elements of voice signal analysis between two groups.

As a result of the experiment, it can be analyzed that the learning effect through online education increases when the vocal cord vibration increases and the rate of change of the vocal fold vibration increases in the voice after receiving online education. In addition, it can be analyzed that the learning effect through online education decreases when the vocal cord vibration decreases and the rate of change of the vocal fold vibration decreases in the voice after online education.

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