

Article

System-Cluster Technology of e-Learning Improvement under the Conditions of COVID-19

Tsvetana Stoyanova ¹, Philip Stoyanov ¹, Anzhelika Remnova ², Svitlana Kushniruk ², Lyudmyla Rakityanska ³ and Svetlana Drobyazko ^{4,*} 

¹ Department of Management, University of National and World Economy, 1700 Sofia, Bulgaria; tsvets7@yahoo.com (T.S.); phstoy@yahoo.com (P.S.)

² Department of Pedagogy, Dragomanov National Pedagogical University, 01601 Kyiv, Ukraine; anremn@ukr.net (A.R.); sv_kushniruk@ukr.net (S.K.)

³ Department of Pedagogy, Kryvyi Rih State Pedagogical University, 50000 Kryvyi Rih, Ukraine; L_rakityanska@ukr.net

⁴ The European Academy of Sciences Ltd., London WC2H 9JQ, UK

* Correspondence: drobyazko.s.i@gmail.com

Abstract: The paper defines the scientific provisions on the feasibility and effectiveness of using e-learning under conditions of quarantine restrictions related to the COVID-19 pandemic. It was proved that within the use of e-learning there has been a convergence between the scientific and methodological bases and the learning process itself, and new approaches to the general didactic and information content of e-learning courses within the education process have been formed. Modern platforms of e-learning are examined and a scheme involving the synchronous technology of e-learning was formed. Within the framework of the suggested learning platform, effective learning tools under conditions of quarantine restrictions were identified, the use of which allows the most successful solution of didactic tasks facing e-learning to be ensured on the basis of the everyday use of digital media and electronic devices for learning purposes. The fractal-cluster technology of an e-learning organization was suggested for an introduction. The functional dependencies on the forms and technologies of the educational process for the efficiency of higher education were obtained. The expediency of introducing fractal-cluster structures into the organizational component of the educational process was determined. Based on the tools of the fractal-cluster approach, a model of organization of the educational process in the information-entropy format was formulated.

Keywords: COVID-19; didactics; e-learning; e-learning technologies; fractal-cluster structure of learning; principles of learning; process of learning; search teaching methods



Citation: Stoyanova, T.; Stoyanov, P.; Remnova, A.; Kushniruk, S.; Rakityanska, L.; Drobyazko, S. System-Cluster Technology of e-Learning Improvement under the Conditions of COVID-19. *Sustainability* **2021**, *13*, 14024. <https://doi.org/10.3390/su132414024>

Academic Editors: Neil Gordon and Han Reichgelt

Received: 26 November 2021

Accepted: 16 December 2021

Published: 19 December 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The beginning of the XXI century was characterized by the understanding of large segments of world society that intellectual potential is a determining constructive factor in the development of civilization. Science and education are now understood as the main factors of intellectual growth. In the XVII century, Francis Bacon said “Knowledge is power.” Moreover, today this wisdom has taken material shape on the scale of the whole of civilization. The unprecedented rise in the student population worldwide is a reflection of this phenomenon. The evolution of information-communication technologies, the informatization of society, and changing methods of distribution and in the use of information have significantly affected the learning process. E-learning is one of the modern means of implementing the learning process based on information-communication technologies. The forms and methods of e-learning contribute to the individualization of the process of the professional training of future specialists, increase the amount of independent work, help in the formation of an information culture, and encourage the use of innovative means of finding and using information.

According to the data from UNESCO, professional success is impossible without education in the XXI century (UNESCO 2020). Furthermore, a person must replenish his/her professional knowledge throughout life. For a serious professional advancement of a specialist, he or she will obviously need to obtain several higher education qualifications. Nonetheless, not to mention the current economic situation worldwide, which has significantly worsened during the COVID-19 pandemic, even the most developed countries are unable to solve the problem of increasing the population with a higher education by increasing special purpose funding for crisis programs in the field of education. On the whole, there are two main ways of solving this problem: (1) increase the number of education establishments (extensive way); or (2) develop innovative educational technologies that allow an increase in both the number of educational institutions of a new type (virtual institutions, Internet universities) and the contingent of students for individual programs. Extensive growth is economically less attractive than intensive growth, and, therefore, distance learning emerges as the most promising technology among the whole range of innovative technologies in terms of the fastest solution for the global problem of improving the educational level of the population under conditions of the growing COVID-19 pandemic.

It is known that education has three main tasks: (1) the transfer of the cultural code to the next generation; (2) the transfer of professional standards; (3) the education of the elite that will manage the development of society in the next period. It should be noted that distance learning, first of all, solves the second task, i.e., the transfer of professional standards to the new generation and the retraining of specialists, and provides an opportunity to obtain a second higher education and a special education in any place worldwide within a short time at affordable prices without the breach of the quarantine restrictions of a specific country.

The concepts of adaptive learning, personalization of learning, and an individual trajectory of learning have recently been widely discussed in the fields of distance, mixed, and electronic learning. These concepts are not new, but in traditional formal learning they are quite difficult to implement. At the same time, distance learning can make both the content itself and the course structure and learning trajectory dynamic. The dynamism of content at the micro level can be expressed in the dynamics of the course element fractals that can be used. This may be of interest in terms of the communicative interaction of participants in the learning process, but not in terms of personalization. It seems that the dynamics of the content at the macro level are much more useful, i.e., the individualization of the structure of the course, the adaptability of its structural elements, and the dynamic formation of an individual learning trajectory from individual elements of the course. To do this, the course requires “normalization”, i.e., decomposition into individual micro elements (fractals and clusters) combined into a single network structure, which is the basis of learning. At the same time, some elements of the course are static, but each end user receives an individual course that is dynamically built just for him.

2. Literature Review

In the scientific works of a number of authors [1,2] it has been pointed out that distance education is an effective educational system in the field of pedagogical innovation. Based on this, the issue of the didactic principles of the organization of the educational process within distance education has been formed [3]. Furthermore, the experimental studies presented in the works of the authors of [4–6], which are conducted in the field of distance learning, have shown that designed distance learning has to implement both the respective principles of didactics and its own specific principles to the fullest extent. According to Moore and Kearsley [7] and Owens et al. [8], distance learning is a synthetic, integrated, and humanitarian form of learning based on the application of a wide range of traditional and new information technologies and their technical tools, which are used for the delivery of educational material, its independent study, and the organization of a dialogue between a teacher and his students when the process of education is noncritical to their location

in time and space as well as to a specific educational institution. Distance education should be based on a system didactic design [9,10]. The system didactic design covers the entire structure of the learning process, including such aspects as: (a) an analysis of the educational material, what is being taught/learned; (b) a definition of the teaching/learning structure; (c) the testing and reviewing of the designed learning methods; (d) an evaluation of the results—whether the planned learning has actually taken place.

First of all, it should be noted that distance learning is an innovative learning technology. This is critically mentioned in the works of the authors of [11–13]. Furthermore, it is also noted that “innovative learning” is a process and result of such learning and educational activity, which encourages innovative changes in the existing culture and social environment.’ Apart from the support of already existing traditions, this type of learning process stimulates an active response to emerging problem situations, which occur with both individuals and the entire society as well. Thus, distance learning is of high importance for modern society and the development of education. According to the authors of [14,15], any innovative form of learning, including distance learning, requires the use of progressive education models. Currently, these are primarily search models. In the field of education, it is a certain uncertainty or a difficult situation in which a person finds himself which is overcome through thinking. The main and only task of thinking is to transform an uncertain (“problematic”) situation into a certain one using the most useful “tools” in this specific situation: concepts, ideas, and theories. The partial principles of distance learning are revealed in the works of the authors [16–19]. They include the principles of interactivity, reflection, non-linearity of information structures and processes, the combined use of different learning forms, and the complex use of multimedia tools. When choosing a certain type of learning technology, one faces the problem of improving the efficiency of the processes of education and the assessment of the student knowledge level [20,21]. As a rule, one uses two ways of assessing the student knowledge level—direct (objective) and indirect (subjective).

3. Methodology

The leading provisions of the education philosophy and organizational and methodological principles of the educational process arrangement will be defined through the use of the methodological construct of the study. Currently, a global process of convergence of all significant institutions of humanity is being observed, which, first of all, is related to the intellectual potential of civilization—science and education [22,23]. Thus, one can form the following principles of the modern education paradigm:

1. Convergence and symbiosis of the segments and sectors of full-time and distance education;
2. Convergence and symbiosis of the fundamental science and education. Science and education constitute the main components of human progress potential. That is why the two mentioned principles are inextricably interwoven and complement each other. In this context, a unifying formulation of the two principles of education is identified [24];
3. Global convergence of the topological education structures and basic science. The formed principles of global convergence and the decentralization of the education system reflect the corresponding philosophical categories of convergence and divergence. Nevertheless, the paired laws of philosophy—convergence and divergence for the education system as a self-organized system—are a consequence of a more general principle, the metaprinciple of sustainability (survival) of the self-organized system—the education system [25,26].

The methodology of distance education is formed as a communication between teacher and student and it is possible to identify the following characteristics: (a) self-education as a basis for distance learning, which involves the motivation of students for their own learning, as well as a certain level of self-organization of an individual; (b) communication between teacher and student on the principle of “one to one”, which corresponds to the form and

content of individual consultation; (c) communication and “one to one” interaction does not preclude “one to many” interactions because a teacher, according to a pre-arranged schedule, works with many students at once; (d) “many to many” interaction means that it is possible to simultaneously communicate with many students who share experiences and impressions; (e) increasing the possibilities of traditional learning; (f) allowing an increase in the efficiency of the independent work of students and the level of motivation to study to stimulate the development of their intellectual potential [27].

The introduction of distance learning technologies in the educational process is aimed at a deeper understanding of the educational material and the formation of such competencies as communicative (direct communication through the network), informational (search for information in various sources and the possibility of its critical understanding), and self-education (skill to learn independently). As practice shows, if a student does not learn to make decisions independently or determine the content of his/her educational activities and find ways to implement it, he/she will not be able to master one or another subject. In addition, distance learning has an educational function—it contributes to the formation of main personality traits: activity, independence, self-improvement, and creativity.

The methodology of distance education is based on process informatization and the latest information-communication technologies (ICT). In the process of distance learning, distance courses are used—information products that are sufficient for learning in certain subjects. This involves creating and supporting the “life” of a common educational space that could reach the maximum number of people wishing to receive education and unite not only students and teachers from different countries stimulating a useful process of sharing experiences and promotes the circulation of knowledge [28]. Instrumental and methodological advantages related to the informatization of distance education include (1) the use of the most modern means to obtain information, including ICT and Internet capabilities; (2) larger volumes of information that can be obtained under conditions of distance learning in a shorter time; (3) convenience, allowing each student to have the opportunity to choose their own rhythm and mode of obtaining knowledge in an environment comfortable for him/her, which will positively affect the learning process; (4) individualization allowing each student to adapt their learning to their needs; (5) accessibility, which saves time and money through the use of educational facilities and the provision of free access to educational materials; and (6) flexibility allowing the material to be taught according to the level of preparation and the basic knowledge of students, creating additional sites with the necessary information and sites where students can share information, answer each other’s questions, and learn by teaching others.

4. Results

4.1. Modern Distance Learning Platform

Distance learning is the most efficient education system in the field of economic innovations. In this context, the development and further study of the most optimal and universal methods required for the functioning of this system seem to be quite relevant. The establishment of distance learning and its further development took place and still takes place based on the above-mentioned scheme, and, consequently, the mentioned principles.

Distance education is a new type of learning that has emerged due to the demands of modern society and due to the development of new computer technologies. Actually, it is a complex range of educational activities for a wide range of students organized using specialized computer and educational technologies. The demand for the widespread introduction and development of distance education is explained by the fact that traditional forms of education cannot fully cope with rapid information development and the growing social need for modern educational technologies. The introduction of distance education systems based on computer, video, multimedia, and communication technologies has allowed this problem to be solved more effectively [29,30].

Currently, thanks to the use of digital communication technologies, the majority of professionals consider the distance learning system as the most reliable platform, which

guarantees the stability and universality of received knowledge while preserving and developing the individual cognitive activity of a student. The diagrams of the traditional problem-search education method and the virtual-training education method are given in Figures 1 and 2.

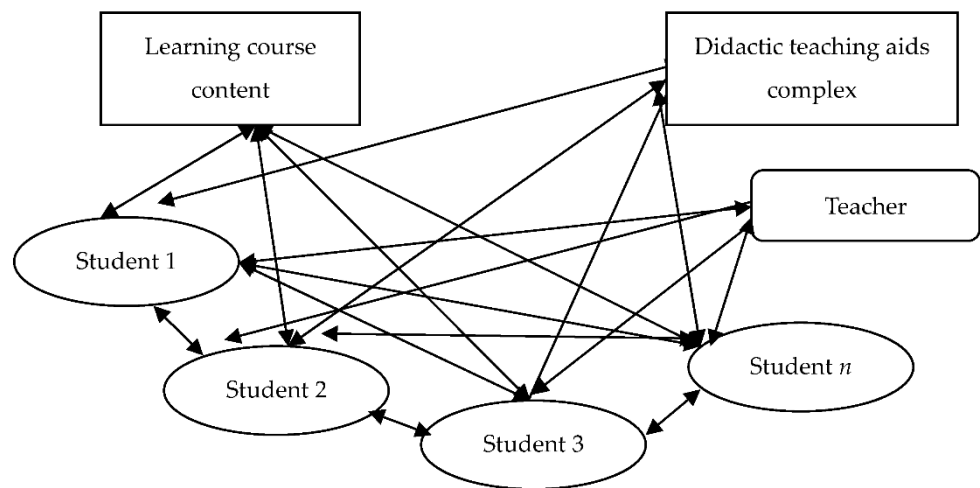


Figure 1. Diagram of the problem-search method of learning including the use of digital technologies.

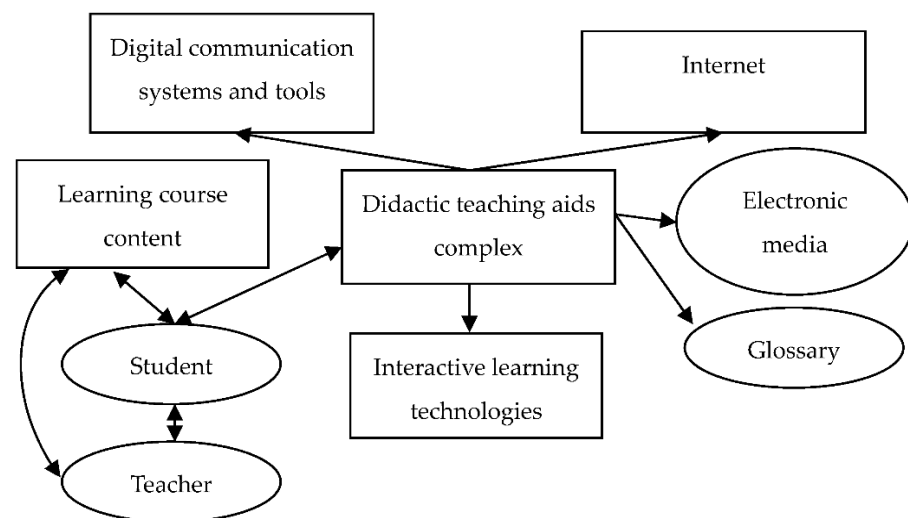


Figure 2. Diagram of the synchronic distance learning technology.

According to the above diagrams (Figures 1 and 2), there is a change in the teacher–student relationship in the innovative education technologies, compared to the traditional learning scheme. In the innovative technologies presented in Figures 2 and 3, a teacher is a colleague of a student in the distance learning process, in contrast to the classical scheme, where a teacher rules over the student.

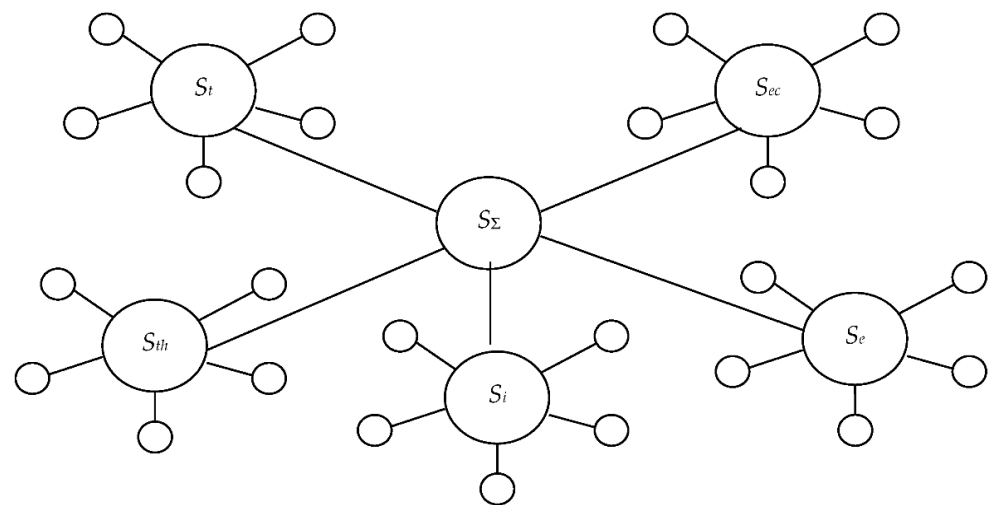


Figure 3. Diagram of two-level fractal-cluster structure of distance learning process.

Distance learning technologies consist of pedagogical and information technologies. The characteristic features of distance learning are discussed in Table 1.

Table 1. Characteristic features of distance learning.

Attribute	Content
Flexibility	pupils, students, attendees receiving distance education mostly do not attend regular classes but study at a convenient time and place
Modularity	a distance learning program is based on the modular principle; each individual course creates a holistic view of a particular subject area, which allows the formation of a learning program that meets individual or group needs from a set of independent modular courses
Parallelism	learning is carried out simultaneously with professional activities (or learning in other areas), i.e., without discontinuing work or other activities
Large audience	simultaneous access to many sources of educational information of a large number of pupils, students and attendees, and communication through telecommunication of students among themselves and with teachers
Economy	efficient use of learning areas and technical means, the concentrated and unified presentation of information, and the use and development of computer modeling should lead to lower costs for training of specialists
Technological effectiveness	use of new achievements of information technologies in the educational process, which contribute to the introduction of a person into the global information space
Social equality	equal educational opportunities regardless of place of residence, state of health and social status
Internationality	opportunity to receive education in educational institutions of foreign countries without leaving one's own country and the provision of educational services to foreign citizens and compatriots living abroad
New teacher role	distance education expands and renews the role of a teacher, makes him/her a mentor-consultant who should coordinate the cognitive process, constantly improves the courses he teaches, and increases creative activity and skills in accordance with changes and innovations
Positive student impact	increasing the creative and intellectual potential of a person receiving distance education through self-organization, the desire for knowledge, the use of modern information and telecommunications technologies, and the ability to make responsible decisions
Quality	quality of distance education is not inferior to the quality of full-time education, as the best teaching staff are involved in the preparation of teaching aids and the most modern teaching materials are used the introduction of specialized quality control of distance education for its compliance with educational standards is envisaged

Distance learning provides higher education students with access to non-traditional sources of information, increases the efficiency of independent work, provides completely new opportunities for creative self-expression, and finds and consolidates various professional skills. Teachers, in turn, are allowed to implement completely new forms and methods of learning using conceptual and mathematical modeling of phenomena and processes [31].

Within the given topic, researchers have identified two variants where the presented “problem-search” approach is implemented [32]: (1) the search approach of practical, cognitive-applied orientation within which the learning process is built as a search for new practical information; and (2) the search approach of theoretical and cognitive orientation, within which the learning process is built as a search for new theoretical knowledge and new cognitive points of reference. This structure of learning is based on the independent development of theoretical ideas of attendees about objects and phenomena of the world and the modeling of scientific research. The research approach provides the entire distance learning system with a research orientation. This means a change in the position of an attendee in the learning process. The latter is given more initiative and a more subjective nature compared to traditional learning process. When speaking about distance learning, it is appropriate to refer to a person receiving knowledge just as an “attendee.” To be successful in distance education, he or she is required to be extremely motivated, self-organized, hard-working, and have a certain starting level of education [33].

As a means of activating the cognitive activity of students in distance education, it makes sense to consider the studies of the leading didacticians related to their ideas about three levels of research learning. These ideas relate to the following: at the first level, a teacher sets a problem and outlines a method for its solution; at the second level, a teacher only sets a problem and students look for a method for solving it by themselves; at the highest, the third level, students set the problem as well as look for the method and solution by themselves.

The main advantages of distance learning are extraterritoriality, synchronous and asynchronous modes of interaction between the participants in the educational process: teacher–student, student–student, student–study group; the possibility of involving specialists from certain fields in learning; the simultaneous study of ICT tools with the study of other subjects, as well as the assurance accessibility and lifelong learning. The main tools of communication in distance learning are [9]: (1) e-mail, forum, chat, video conferencing, blog, Wi-Fi technology, etc, (2) distance learning as a basis for continuing education is aimed at mastering the skills of independent educational work and the formation of key competencies by adults.

The stages of formation of information competence of students at the profession-oriented level can be represented as follows:

Stage 1. Search for sources of information in accordance with the set educational tasks.

Stage 2. Extraction and primary processing of information (a student extracts information on a given topic from one or more sources and systematizes it within a certain structure).

Stage 3. Information processing and decision making based on it.

Stage 4. Presentation of information (a student prepares a comment accompanying the presentation, creative work).

The specifics of distance learning based on telecommunications technologies and Internet resources affect the methods of selection and the structuring of content, and the methods of implementing of certain methods and organizational forms of learning, which affect the functioning of the entire system. An adult learner selects and processes information, makes hypotheses, and makes decisions based on his/her own thoughts and their own vision of the problem. The cognitive, mental activity of an individual allows him/her to go beyond the received information to build new knowledge. The role of a network teacher is to help students and encourage them to develop independent thinking and new views on the phenomenon or subject under study. At the same time, the teacher

and the student remain participants in such a process in active dialogue. Thus, within the framework of distance education it is possible to create an educational environment in which a student feels more comfortable becoming an active participant in the educational process when the habits of self-study, self-planning, learning, and processing large amounts of information using modern technologies of lifelong learning are encouraged. These goals of distance learning can be achieved through the use of fractal-cluster technology.

4.2. Fractal-Cluster Technologies of Distance Learning Organization

The distance learning process can be conventionally divided into two parts by topological features, which can be conventionally identified as “learning” and “provision.” The topological structure of the educational process of “learning” is the personality of a teacher who represents the root of all didactic provisions [34]. It should be mentioned that these two topological structures are attributes of the learning process. As is known, the substance of dialectics is the division of the whole into opposites and an understanding of the substance of these opposites. The authors suggest the fractal-cluster method of relationship as the basis for the method of organization and efficiency assessment of the process of distance learning. The fractal-cluster relationship will make it possible to carry out an efficiency assessment of any system by five clusters: (1) energetic (S_e), (2) transport (S_t), (3) ecologic (S_{ec}), (4) technological (S_{th}); (5) informational (S_i). A fundamental result of the fractal-cluster relationship is the fact that, unlike the classical econometric model where intensive parameters are used, one can use extensive parameters, such as monetary value, time, and a number of processes [35]. In this context, Figure 3 shows the schematic structure of the conventional division of the learning process into components (upon the principle of two-level fractal-cluster structure).

Each of the above clusters S has its ideal value expressed in one of the extensive parameters in relation to the entire econometric system, i.e., the sum of all five clusters:

$$S_{\Sigma} = S_e + S_t + S_{ec} + S_{th} + S_i = \sum_{i=1}^5 S_i = S_{\Sigma}(t) \quad (1)$$

where $i = 1, 2, 3, 4, 5$ corresponds to energetic, transport, ecologic, technological, and informational clusters.

The main task that arises in the process of clustering is the informal substantiation of the breakdown of the sum of certain arrays into classes. Different methodological approaches to learning represented by a set of five clusters can be considered as objects. A priori values on the distribution of the general population are not required for the application of a fractal-cluster analysis. Each method of distance education is a sum of observed parameters that can be interpreted as a task within the educational program for training of specialists.

The total value of clusters $S_{\Sigma}(t)$ changes over time. The period of evolution of the system is significantly longer than the period of rebuilding of the system clusters $\{S_i\}$ in the ideal state $\{S_i^{ideal}\}$ in each moment of time. One first carries out a fractal-cluster analysis and a classification of the “provision” of the learning process, i.e., the classification of the infrastructure of an educational institution that provides the learning process. According to the idea of the fractal-cluster representation of the system, an extensive parameter for quantitative analysis could be, for example, time or money spent on the different components of the learning process [36]. Therefore, it will be appropriate to use either time or money spent on various forms of the learning process.

- I. Energetic cluster—“provision” of the learning process: time spent by teachers and staff on subsistence (salaries); time spent on communication with university/faculty management; time spent on educational tests and checks; expenses on accounting, making various reports by teachers; time spent on receiving education workloads by a teacher, skill enhancement of teachers.

- II. Transport cluster—“provision” of the learning process: time spent on the movement of operators; change time used by teachers and assistants for a break; time spent by teachers obtaining the weekly schedule and for daily clarification of the schedule; time spent by teachers on communication with assistants; life support in transport (safety techniques, instruction time); external circumstances that facilitate the movement of information, education materials, and students (room repairs, movement along a corridor); time spent on work of operators regarding schedule making, classroom assignment.
- III. Technological cluster—“provision” of the learning process: expenditure of teacher energy for giving classes (the function of the number of students, psychological climate, the average intellectual potential of the group, ergonomics); expenditure of time on the transfer of teachers; expenditure of time on relations of teachers and students with the dean’s office introduction of distance education systems based on computer, video, multimedia, and; expenditure of time on preparation for classes, professional development courses, i.e., everything that concerns the improvement of the learning process, time spent on learning new material [37].
- IV. Informational cluster—“provision” of the learning process: trips of teachers related to obtaining new information, information via telecommunications, telephone; expenses for relations of teaching staff, the staff of other universities, other organizations where information is obtained for further development of the teaching process, for development of scientific publications; time spent on search for information about new information and finding new knowledge; time spent on the expansion of the database, search for information.
- V. Ecologic cluster—“provision” of the learning process: rent payments, utility bills; maintenance of the university vehicles; weatherization of walls, fire safety; time spent on improvement of the psychological climate, physical health, ecology of mind, culture of assistant-teacher relationships.

Figure 4 shows the evolutionary line of the system (continuous line), which is formed from a set of straight-line sections, which model the quasi-statistical value of the total value of the clusters S_{Σ} at each fraction of time Δt_j , the absolute value of the summarized cluster S_{Σ} remains constant.

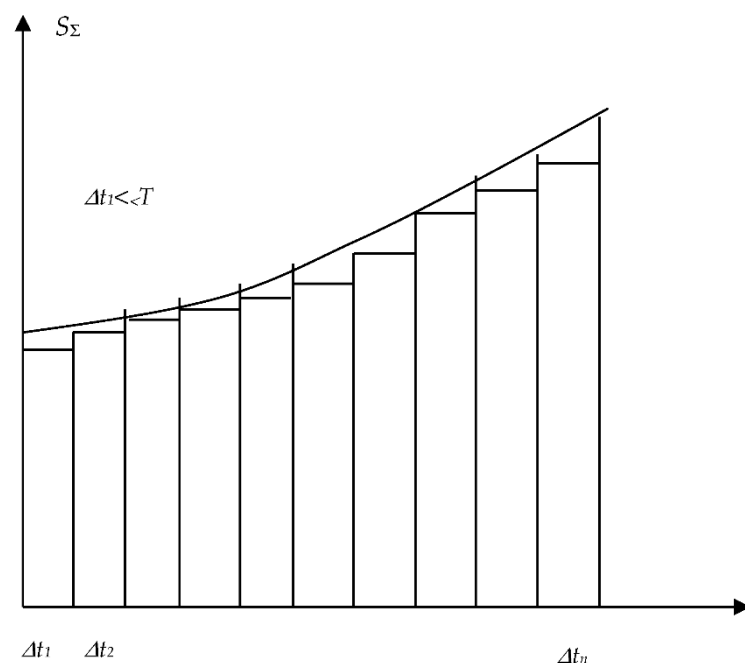


Figure 4. Evolutionary curve of distance learning within a fractal-cluster structure.

Each of the above clusters K_j has a range of sub-clusters, and each of the sub-clusters consists of five sub-clusters of the higher level. The ideal sub-cluster ratios in a cluster would be the same as for the main clusters. Naturally, it is much more difficult to restructure the learning process—“learning” by clusters, as not all can be measured in money in the learning process, and, sometimes, the psychological climate of the institution, students themselves and teachers play the key role in this process.

The correlations of the above clusters with the components of the pedagogical principles (sub-principles) are presented in Appendix A (Tables A1–A6). Thus, for example, the correlation between the sub-cluster of the transport cluster and the sub-principles of the principle of individualization of the pedagogical process is presented in Table A1. The sub-principle of the passion of the educational environment was introduced for the correlation of the energetic sub-cluster of the transport cluster. The passion of the educational environment is a dominant characteristic related to the irresistible desire of the entire team of the educational institution and the students to solve the set scientific and creative tasks. The creation of the passionate environment depends, primarily, on the creative and energetic potential of the institution management staff, the scientists who are currently working in it, and those outstanding scientists who have contributed to the creation of the university traditions during the previous periods [38].

The clusters of the learning process (“learning”) and their correspondence to the pedagogical criteria and effectiveness conditions are also presented in Appendix A. Thus, for example, the energy cluster corresponds to the criterion of the pedagogical process—the pace of learning and the principle of dynamism. The transport cluster corresponds to the criterion of the person-centered learning and the principle of individualization. The ecological cluster corresponds to the criterion of learning and the ecological–valedological principle (or the principle of periodic mobilization and relaxation). The technological cluster corresponds to the criterion of system-targeted differentiation of learning and the principles of optimization and ergonomics of the learning process [39,40]. The informational cluster correlates with the criteria of computerization, student awareness of digital technologies and the principle of informativeness. The correlation between the fractal-cluster structures of the learning complexes and their didactic characteristics is presented in Table 2.

Table 2. Correlation between the fractal-cluster structures of the learning complexes and their didactic characteristics.

Clusters	Didactic Characteristics of Learning Complexes
1. Energetic cluster	The rate of the learning information provision
2. Transport cluster	The level of increase in indicator of education quality improvement
3. Ecologic cluster	The level of fatigue during learning
4. Technological cluster	The level of practical skills obtained
5. Informational cluster	The level of learning complexes being provided with bibliographic information

Given the potential capabilities of these tools, a teacher working in the distance education system should consider the principle of the integrated use of digital learning tools. This principle requires, based on the nature of the learning task, a balanced use of verbal, visual, and practical methods at each class. It is obvious that the modern didactic model of distance learning provides for maximum efficiency of the use of learning time [41]. Therefore, in this case, it is necessary to mention another facet of modern didactics—the technologization and digitalization of the learning process. It is known that the development of digital technologies and the maximum use of learning opportunities has contributed to the ability to reach large audiences of students, an increase in the information capacities and bandwidth of the technical means, and an individualization of channels for delivery of learning information. This can be achieved through the use of an interactive learning system, a series of computer-assisted classes, and video lectures in each subject course. Thus, distance learning is closely related to the use of automated learning tools. Computer-assisted classes can be used both for subject learning and skills

training [42]. Herewith, they can be conducted both according to a learning schedule and on an individual basis.

Distance learning becomes such an educational system, which is able, on the one hand, to adapt flexibly and dynamically to socio-economic changes in society, and, on the other hand, to be stable in its psychological and pedagogical basis and meet the requirements of the remote and extremely isolated audience under the condition of the COVID-19 pandemic. Thus, a methodological and practical understanding of the practice of distance learning shows that it is necessary to identify five general didactic teaching methods: (1) information-receptive, (2) reproductive, (3) problem-based, (4) heuristic, (5) exploratory—which cover the totality of pedagogical acts of interaction between teachers and students both during face-to-face contact and interactive interaction via the means of the information technologies [43].

The process of the creation and production of teaching aids for distance education can be implemented as follows: direct development by a university, an order for their production by specialized organizations, purchase of ready-made aids with or without their subsequent adaptation. At present, in distance education, traditional regulated forms of education are widely used, such as lectures, seminars, consultations, examinations, and independent work. The specificity of the use of these forms in distance education is reflected in the frequency of their use in the learning process and the predominant use of new information technologies. The system of individual educational planning provides for the development of normal, accelerated or delayed versions of an individual learning plan for each teacher, which is different both in its content and the pace of learning. The decision about maximizing or minimizing of the learning process and the intensity of learning is made by students themselves. There are two types of systems for student assessment—ongoing and final assessments [44]. A student is admitted to the ongoing assessment in an academic subject after he or she passes all the stages of learning, included in the normative set: homework, module tests, coursework, etc. A student is admitted to the final assessment after he or she passes ongoing assessments in all subjects of the curriculum and practical works. The academic mobility of students is implemented through various links with educational unions, associations, and agreements with foreign universities and educational centers. At the same time, students may be offered the opportunity to participate in a variety of additional training programs. The virtual-training system comes down to the student individual choice of a virtual mode of work with the training product, its learning and consolidation in individual and group training forms.

5. Discussion

Over the last decade, a significant number of studies have been conducted to analyze the effectiveness of distance education (comparative analysis) and the impact of various technological tools, educational design, content development, pedagogical issues, and individual characteristics of students.

Mankind has entered a new stage of its development when information processes have become one of the most important components of human life, so at the stage of education development, finding new forms of organization of the educational process has become introduction of distance education systems based on computer, video, multimedia, and become an urgent problem. The modern system of higher education is undergoing major changes that have led to the improvement and the emergence of new educational technologies. Today higher education institutions must actively position their contribution to the innovation process introduction of distance education systems based on computer, video, multimedia, and social development and develop innovative technologies that will ensure the formation of professional skills of students. Currently, the amount of information that is so necessary to obtain, understand and master the levels of education is growing. This has led to the introduction of information technologies in education and the formation of a separate type of learning—e-learning. E-learning is a fundamentally new, high-tech approach to the process of knowledge transfer. E-learning provides an opportunity to

create systems of mass lifelong learning and general exchange of information. It is this system that can most adequately and flexibly respond to the needs of society for the training of highly professional professionals. It can be stated that e-learning has entered the 21st century as the most effective system of training and continuous support for high qualification level of specialists in various fields and industries.

Among the important disadvantages of e-learning that can be studied and neutralized in further scientific studies one should note the lack of direct contact between the personal teacher (tutor) and the remote student due to the extreme professional workload of national teachers. Students of foreign distance courses can receive answers to their letters in a few hours, because there are many more teachers than students in countries with significant experience in implementing distance learning. Unfortunately, the opposite situation has developed in this country—there are a lot of people wishing to receive distance education, and there are few experienced teachers who are familiar with the latest technologies of distance communication.

In general, distance education meets the requirements for the information society and ensures the full entry of the country into the international educational space. For the distance learning system to occupy a worthy place in the national education system, it is necessary, first of all, to create a global computer network of education and science, because it is a computer that allows learning materials to be obtained, being both a library, a center of reference information and a communication center, which makes it one of the participants in the implementation of the program of continuing education. The need to shape the person of the next millennium is a serious challenge to the global education system. As clearly and adequately as one can identify and implement new learning technology and its distance forms that improve the quality and increase the mass nature of education, so productively the national system of education will fulfill this historic order to create a new civil society in the country.

Thus, one can conclude that the introduction of distance learning technologies in education will contribute to the attainment of a qualitatively new educational product. A significant expansion of the information educational environment, increasing opportunities for communication between students and teachers, and access to global information resources—all of these contribute to increasing student motivation to learn, strengthen their creative self-realization, master skills in telecommunications, as necessary living conditions in the information society, and overcoming the impossibility of full-time education due to the COVID-19 pandemic.

6. Conclusions

The study showed that distance education is a promising direction for the development of the modern education system, which can solve a number of urgent problems, especially under the conditions of forced isolation. Thus, distance education does not negate existing educational trends, technologies, and forms of learning; it is rather integrated into traditional and familiar systems, complementing and developing them, especially in the direction of the use of digital communication channels and digital devices for information storage and display. The study also showed that there is no single format for the launch of distance learning technologies. Among the main characteristics of distance learning, it is useful to highlight the following ones: the existence of a teacher and a student and, as a minimum, the existence of an agreement between them; spatial separation of a teacher and a student; spatial separation of a student and an institution; continuous learning of a student; interaction between a student and a teacher; specially selected learning materials.

The authors have substantiated a theoretical and methodological approach according to which distance education based on the latest information-computing and telecommunication technologies is the most appropriate for teaching humanitarian and socio-economic subjects, and, consequently, for the provision of educational services in these subjects. Based on the theses of the fractal-cluster theory, the authors have developed the model of organization of learning process as an information-entropic system. They structured the

learning process according to scheme “provision”–“learning.” They also developed and implemented the system-cluster approach for the diagnosis, design, and forecasting of the process of improvement of the quality of distance education. The structuring and comparative classification of classical and innovative learning technologies were carried out. The analysis has shown that distance learning technologies are most appropriate to the strategic objectives of modern society in the area of education development: significant increase in the number of people with higher education and, at the same time, improvement of the quality of education itself. The authors proved the efficiency of distance learning under conditions of epidemiologic isolation. They also substantiated the didactic conditions of distance learning technology and the specificity of its virtual training form.

Author Contributions: Conceptualization, S.D. and T.S.; methodology, S.D.; software, P.S.; validation, A.R.; formal analysis, S.K.; investigation, L.R.; resources, S.D.; data curation, T.S.; writing—original draft preparation, P.S.; writing—review and editing, A.R.; visualization, S.K.; supervision, L.R.; project administration, P.S.; funding acquisition, A.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. The learning process (a compulsory aspect of education).

Clusters	Criteria and Conditions of Efficiency	Principles
1. Energetic	Pace of learning	Outreach Dynamicity
2. Transport	Personality-centered education	Individualization Ecologization
3. Ecologic	Education is an integrated ability of students to a learning activity (ability to analyze, compare, generalize, the flexibility of thinking, ability to identify essential things).	Valeologization (introduction of pedagogy of health preservation in the educational process) [45]
4. Technological	System-targeted differentiation of learning	Optimization Ergonomics
5. Informational	Computerization level Student awareness level, a ratio of computer-assisted and online classes to a total number of classes.	Informativeness

Table A2. Energetic cluster—the principle of dynamicity.

Sub-Clusters of the Energetic Cluster	The Principles of Dynamicity of the Pedagogical Process
1 Energetic	The principle of periodic mobilization and relaxation of a student
2. Transport	The principle of transition from education to self-education, from learning to self-learning, from development to self-development; transition of pedagogical management to self-management of the student and the team
5. Informational	The principle of heredity, prospects, and problematity
3. Ecologic	The principle of periodic mobilization and relaxation of an individual
4. Technological	The principle of novelty and a sufficient variety of activities organized for pedagogical purposes

Table A3. The principle of individualization of the pedagogical process–transport cluster.

Sub-Clusters of the Transport Cluster	The Principle of Individualization of the Pedagogical Process
Informational	The principle of the individual significance of the learning-creative activity
Technological	The principle of considering personal qualities, creative skills
Transport	The principle of individualization of the style of learning-creative activity
Ecologic	The principle of optimization
Energetic	The principle of the passionarity of the learning environment

Table A4. The principle of informativeness–the informational cluster of the learning process.

Sub-Clusters of the Informational Cluster	Sub-Principles of the Informational Principle
Energetic	The principle of the social and personal significance of information
Transport	The principle of the information generalization
Ecologic	The principle of reliability, credibility of information
Technological	The principle of information measure (dosing, excess, and discreteness)
Informational	The principle of required and sufficient variety of tools, methods

Table A5. The technological cluster of the learning process–the principle of optimization of the learning-creative activity.

Sub-Clusters of the Technological Cluster	The Principles and Rules of Optimality
Energetic	Combination of the emotional and rational elements
Transport	Combination of the personal (individual) and collective elements
Ecologic	Optimization of conditions (hygienic, psychological, aesthetic) of the learning-creative activity
Technological	Combination of theory and practice, of the specific and abstract elements
Informational	Combination of the logical and heuristic elements

Table A6. The ecologic cluster of the learning process–eco-logotype–valeological principle (principle of periodic mobilization and relaxation).

Sub-Clusters of the Ecologic Cluster	Principles, Criteria, and Rules of Ecological Compatibility of the Pedagogical Process
Energetic	Student assessment of the importance of the principle of periodic mobilization and relaxation during the learning process
Transport	Assessment of student need for acquiring the information on the eco-logotype–valeological rules of the learning process, the need for integration of the new learning technologies, periodic mobilization and relaxation
Ecologic	Criteria of ecological and valeological compatibility
Technological	Criteria for assessment of student knowledge and skills in periodic mobilization, relaxation during the learning process
Informational	Student awareness about educational and scientific literature (traditional and digital data media)

References

1. Sun, A.; Chen, X. Online education and its effective practice: A research review. *JITE Res.* **2016**, *15*, 157–190. [[CrossRef](#)]
2. Ubon, A.; Kimble, C. Knowledge management in online distance education. In *Proceedings of the 3rd International Conference Networked Learning*, 1st ed.; University of Sheffield: Sheffield, UK, 2002; pp. 465–473. ISBN 978-090-283-141-4.
3. Boettcher, J.V.; Conrad, R.M. *The Online Teaching Survival Guide: Simple and Practical Pedagogical Tips*, 1st ed.; John Wiley & Sons: Hoboken, NJ, USA, 2010; ISBN 978-047-042-353-0.
4. Bryant, J.; Bates, A.J. Creating a constructivist online instructional environment. *TechTrends* **2015**, *59*, 17–22. [[CrossRef](#)]
5. Crawford-Ferre, H.; Heather, G.; Wiest, L.R. Effective online instruction in higher education. *Q. Rev. Distance Educ.* **2012**, *13*, 11–14.
6. Kapp, K.M. *The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education*; John Wiley & Sons: Hoboken, NJ, USA, 2012; ISBN 978-111-809-634-5.
7. Moore, M.; Kearsley, G. *Distance Education: A Systems View of Online Learning*, 3rd ed.; Cengage Learning: Boston, MA, USA, 2011; ISBN 978-111-152-099-1.

8. Owens, J.; Hardcastle, L.; Richardson, B. Learning From a Distance: The Experience of Remote Students. *J. Distance Educ.* **2009**, *23*, 53–74.
9. Marty, O. Monetizing French Distance Education: A Field Enquiry on Higher Education Value(s). *Int. Rev. Res. Open Distance Learn.* **2014**, *15*, 111–131. [[CrossRef](#)]
10. Navarro, P.; Shoemaker, J. Performance and perceptions of distance learners in cyberspace. *Am. J. Distance Educ.* **2000**, *14*, 15–35. [[CrossRef](#)]
11. Drobyazko, S.; Okulich-Kazarin, V.; Rogovyi, A.; Goltvenko, O.; Marova, S. Factors of Influence on the Sustainable Development in the Strategy Management of Corporations. *Acad. Strateg. Manag. J.* **2019**, *18*, 1–5.
12. Keengwe, J.; Kidd, T.T. Towards best practices in online learning and teaching in higher education. *JOLT* **2010**, *6*, 533–541.
13. Parker, K.; Lenhart, A.; Moore, K. The Digital Revolution and Higher Education: College Presidents, Public Differ on Value of Online Learning. Available online: <https://files.eric.ed.gov/fulltext/ED524306.pdf> (accessed on 29 September 2021).
14. Martensa, R.; Bastiaens, T.; Kirschner, P.A. New learning design in distance education: The impact on student perception and motivation. *Distance Educ.* **2007**, *28*, 81–93. [[CrossRef](#)]
15. Assari, S. Diminished Economic Return of Socioeconomic Status for Black Families. *Soc. Sci.* **2018**, *7*, 74. [[CrossRef](#)]
16. Drobyazko, S.; Barwinska-Malajowicz, A.; Slusarczyk, B.; Chubukova, O.; Bielialov, T. Risk Management in the System of Financial Stability of the Service Enterprise. *J. Risk Financ. Manag.* **2020**, *13*, 300. [[CrossRef](#)]
17. Finch, D.; Jacobs, K. Online education: Best practices to promote learning. *Proc. Hum. Factors Ergon. Soc. Annu. Meet.* **2012**, *56*, 546–550. [[CrossRef](#)]
18. Zuazu, I. Graduates' Opium? Cultural Values, Religiosity and Gender Segregation by Field of Study. *Soc. Sci.* **2020**, *9*, 135. [[CrossRef](#)]
19. Means, B.; Toyama, Y.; Murphy, R.; Bakia, M.; Jones, K. Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies. Available online: <https://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf> (accessed on 12 September 2021).
20. Thomas, M. *Digital Education: Opportunities for Social Collaboration*, 1st ed.; Palgrave Macmillan: London, UK, 2011; ISBN 978-134-929-382-7.
21. Wang, Y.D. Building student trust in online learning environment. *Distance Educ.* **2014**, *35*, 345–359. [[CrossRef](#)]
22. Pape, L. Blended Teaching & Learning. *Sch. Adm.* **2010**, *67*, 16–21.
23. Isopahkala-Bouret, U. Troublesome Access: Non-Admission Experiences in the Competitive Finnish Higher Education. *Soc. Sci.* **2019**, *8*, 302. [[CrossRef](#)]
24. Andersson, T.; Schwaag-Serger, S.; Sörvik, J.; Wise, E. *The Cluster Policies Whitebook*; IKED: Malmö, Sweden, 2004; ISBN 978-918-528-103-9.
25. CIM (Inter-American Commission of Women). *COVID-19 in Women's Lives: Reasons to Recognize the Differential Impacts*; OAS: Washington, DC, USA, 2020; ISBN 978-0-8270-7047-9.
26. Nuevas Publicaciones Cubanas Para Enfrentar Efectos de la COVID-19 Sobre la Educación. Available online: <https://es.unesco.org/news/nuevas-publicaciones-cubanas-enfrentar-efectos-covid-19-educacion> (accessed on 26 November 2021).
27. Rieble-Aubourg, S.; Viteri, A. COVID-19: Are We Prepared for Online Learning? Available online: <https://publications.iadb.org/publications/english/document/CIMA-Brief-20-COVID-19-Are-We-Prepared-for-Online-Learning> (accessed on 10 October 2021).
28. Rooij, S.; Zirkle, K. Balancing pedagogy, student readiness and accessibility: A case study in collaborative online course development. *Internet High. Educ.* **2016**, *28*, 1–7. [[CrossRef](#)]
29. Simonson, M.; Smaldino, S.; Zvacek, S. *Teaching and Learning at a Distance Foundations of Distance Education*, 6th ed.; Information Age Publishing: Charlotte, NC, USA, 2015; ISBN 978-162-396-798-7.
30. Mata-López, W.A.; Tobón, S. Analysis of Factors Associated to the Enrollment and Demand of Computing-Related Careers. *Soc. Sci.* **2019**, *8*, 1. [[CrossRef](#)]
31. Yates, A.; Brindley-Richards, W.; Thistoll, T. Student engagement in distance-based vocational education. *J. Open Flex. Distance Learn.* **2014**, *18*, 29–44.
32. Natriello, G. Modest changes, revolutionary possibilities: Distance learning and the future of education. *Teach. Coll. Rec.* **2005**, *107*, 1885–1904. [[CrossRef](#)]
33. Nguyen, T. Beyond No Significant Difference and Future Horizons. *J. Online Learn. Teach.* **2015**, *11*, 309–319.
34. Abdin, M.J.; Rahman, M.M. Cluster Development Models: Challenges and Opportunities. *IJEFM* **2015**, *3*, 358–366. [[CrossRef](#)]
35. Solvell, O.; Lindqvist, G.; Ketels, C. *The Cluster Initiative Green Book*, 1st ed.; Ivory Tower: Stockholm, Sweden, 2003; ISBN 978-919-747-831-1.
36. Boja, C. Clusters Models, Factors and Characteristics. *Int. J. Econom. Pract. Theor.* **2011**, *1*, 34–43.
37. Muirhead, B. Enhancing social interaction in computer-mediated distance education. *Educ. Technol. Soc.* **2000**, *3*, 1–11.
38. Bowen, W.G. *Higher Education in the Digital Age*; Princeton University Press: Princeton, NJ, USA, 2011; ISBN 978-069-115-930-0.
39. Denny, P. The Effect of Virtual Achievements on Student Engagement. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*; ACM: New York, NY, USA, 2013; ISBN 978-145-031-899-0.
40. Ffowcs-Williams, I. Cluster Development: The How, Five Phases. In *Proceedings of the TCI Annual Conference*, Hong Kong, China, 2005; Available online: https://www.researchgate.net/figure/Five-Phases-Twelve-Steps-Source-I-Ffowcs-Williams-Cluster-Development-The-How-Five_fig1_312981199 (accessed on 6 November 2021).

41. Saykılı, A. Distance Education: Definitions, Generations and Key Concepts and Future Directions. *Int. J. Contemp. Educ. Res.* **2018**, *5*, 2–17.
42. Allen, I.E.; Seaman, J. Changing Course: Ten Years of Tracing Online Education in the United States. Available online: <https://files.eric.ed.gov/fulltext/ED541571.pdf> (accessed on 6 November 2021).
43. OECD (Organization for Economic Cooperation and Development). *Teachers and School Leaders as Lifelong Learners. TALIS 2018 Results*; OECD Publishing: Paris, France, 2019; Volume 1.
44. Callaway, S.K. Implications of online learning: Measuring student satisfaction and learning for online and traditional students. *Insights A Chang. World J.* **2012**, *35*, 245–359.
45. Mueva, A. Development of Students' Valeological Culture. In Proceedings of the SCTCMG 2019 International Scientific Conference Social and Cultural Transformations in the Context of Modern Globalism, Cyprus, 2019; Available online: https://www.europeanproceedings.com/files/data/article/110/7326/article_110_7326_pdf_100.pdf (accessed on 6 November 2021).