

MATHEMATICAL ALGORITHM ON IMPROVING DISTANCE LEARNING BASED ON DIGITAL TOOLS APPLIED IN THE ROMANIAN PRE-UNIVERSITY EDUCATION SYSTEM

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Abstract: *The crisis of 2020 spring, triggered by the COVID-19 pandemic, has shed a light on the existing and dormant issues of the human society that will contribute to a radical shift of human mentalities. Under the circumstances, a reforming transformation of the education system is on the horizon, a change that will make professionals more aware, get more flexible, and be overall better trained to cope with unexpected situations. This type of transformation should come with a broader commitment of the parents and also community members as active parties and partners with teachers involved in the education process of the young generation. The students themselves should be guided through the process of learning for their progress and ultimately benefit by putting to the best use their intelligence. The aim of this current scientific enterprise lies in collecting information and statistical data on educational issues that occurred or were recorded primarily during the pandemic period, and analyzing the models of good practice provided by various educational actors in terms of unlocking the human potential for reaching the sustainability goals and, based on them, suggest a mathematical algorithm designed to harness and optimize the human potential in a pre-university education institution. The methods employed are induction, deduction, analysis, synthesis, quantitative research, and scientific abstraction. At the same time, quantitative research has been conducted, as previously mentioned, and the questionnaire was the research instrument used in this case. Information from mass media, social media, and websites in Romania, France, the UK, and the Republic of Moldova were analyzed. The current research study could help the political decision-makers and education systems as well as better understand the students' perception of physical isolation and accordingly adopt strategies including online teaching to get optimal results for all interested parties.*

Keywords: *digital instruments, pandemic period, virtual education, learning*

JEL classification: *L20, M51, O30, O31, O32*

Introduction

The analysis of the organization of the distance learning education system and online digital instruments revealed that the traditional education system should be completely reset as it is overall too rigid (for instance, students learn in a forceful way imposed by teachers' authority), mainly focused on the cognitive domain and less on the affective and psychomotor domains [Covey, 2018]. Virtually, the conception of attitudes and values formation is not harnessed, which is at the core of the new educational paradigm promoted across the European space. The personal development of students can be best achieved during the learning process and two features define this. The first one refers to

the responsibility and opportunity of assisting students in the learning process, formally or informally, while the second one approaches the shaping of the self-direction frame, in other words, promoting a responsibility culture for one's own performance and learning [Butnaru et al., 2021].

The main objective of future education includes the elements of customized or personalized learning, organized within education institutions, which should turn into educational centers, and inside families or communities [Suslenko, 2021]. To register an actual increase in the efficiency of personalized learning it is necessary to access all the possibilities of a student, in terms of resources of their living and learning environment, also unlock the possibilities of the community institutions and mass-media means, not to mention the use of distance (online) learning technologies.

In the system of personalized learning, students will no longer focus entirely on content (this part will not have a substantial weight), but rather go with the analysis of strategies and ways of learning, as well as relations established between the participants to the learning process. In this direction, the role and place of the analysis on the learning process will play the most significant part in delivering a quality education system. Most discussions and reflections of the educational actors will revolve around questions of the sort: *What have I learned? Which products have I created? How did we feel? What did go well? What was not clear? How could we overcome certain difficult moments/situations? Which methods have we used in the teaching-learning process? Whom did we better interact with for solving tasks? Which sources have been used? How do you evaluate your own activity? To what extent are we open to helping people with special needs?* The answer to these questions will lead to reaching the objective of the research, collecting information and statistical data on education problems, mainly during the pandemic period, analyzing the models of good practice of various educational actors in terms of unleashing the human potential and thus reach sustainability goals, and further, based on these actions, coming up with a mathematical algorithm to optimize the human potential in a pre-university education institution.

Literature review

The pandemic changed visions, uprooted stereotypes, and contributed to the building of partnerships and collaborations. In this context, students and academia faced major changes which forced them to adapt and thus maintain the quality of the educational process. The pandemic produced uncertainty, fear, stress, vulnerability, and concern about the future, all harming well-being [Paredes et al., 2021] and generating anxiety. One of the main causes of anxiety in young people is related to contagion for them and their loved ones, as shown by Odrizola-González et al. [2020] in a research study conducted on Spanish pre-university and university. An analysis run by Tee et al. [2020] has shown that 16,3% of the respondents perceived the psychological impact of the COVID-19 pandemic on students ranging from moderate to severe [Tee et al., 2020]. The concern for family health and friends is a stress factor for Swiss pre-university and university students [Elmer et al., 2020]. Tanga et al. [2020] explored the prevalence of stress and depression in a group of Chinese students quarantined in 6 universities to identify the mental risk factors. Taylor et al. [2020] analyzed the quarantine stage of a Canadian group and an American one as

well, during the pandemic period, and proved that general stress combined with isolation are the main consequences of the imposed quarantine.

The studies reveal a great degree of uncertainty regarding the near future of the education process [Akati Karata, 2020]. The pandemic had significant effects on the education system [Daniel, 2020]. Accordingly, the institution in this field of activity was forced to adapt. Romania took special measures to control the pandemic, and consequently, classes of schools, high schools, and universities moved into the online environment which required flexible teaching and learning. Digital transformation reshapes the professional world in many ways. For instance, communication and collaboration have become faster, easier, and more accessible worldwide since the expansion of the online environment paved the way to new models of business and professions, physical labor and routine tasks being taken over by robots and automatic machines [Blake, Mouron, 1982]. These changes influence the features of the job market, such as work organizing, employee-employer relationships, and qualification requirements [Crudu, Cara 2016].

ICT (information and communications technology) and digital technologies are part of the everyday life of most students [Bîrzea, 2005]. Romania has made great efforts, with exceptional results, to introduce information and communications technology in the education process. Between 2001 and 2009, in Romania, it was run the SEI program (IT-Based Educational System) that created and endowed IT laboratories, provided software, and offered training for teachers in all schools and high schools across the country. After Romania became part of the UE, access to European funds made possible the financing of many projects which included both technological endowment and appropriate training for teachers to use it in the classroom. All these actions, complemented by other initiatives, created the opportunity for developing a solid "foundation" that cleared the way for the building of the digitalization edifice [Noveanu, Potolea 2008]. The children of the future are quite familiar with digital tools such as PCs, laptops, tablets, and smartphones and have been interacting with virtual games and stories from an early age. However, as they grow up and enroll in the mass education system, they can see there is quite a gap between reality and what they learn in school. Thus, by adopting new technologies, schools can come closer to children, and, here we are speaking of real digital instruments that can provide extraordinary support, complementing the learning process. They already exist and are used in Romanian schools [Angheluță, 2020]. Nevertheless, it is also important that the teacher is properly trained to use digital resources and convinced by the usefulness of interactive lessons.

The theoretical analysis of the literature in the field has shown that analyses on improving the efficiency of distance learning with the assistance of digital instruments, particularly in the case of Romania (a country with certain issues in implementing the digitalization transformation), have proven insufficient. Considering this, we can state that this research endeavor contributes to filling in the blanks in the literature.

Quantitative analysis of the questionnaires

To demonstrate and provide the logical argumentation of this research enterprise, the analysis has focused on the links between the research objectives, highlighted by the questions in the survey form, and the research hypotheses (Table 2). Accordingly, each objective will be investigated with the help of a question included in the questionnaire.

Each objective has a corresponding hypothesis which is either validated or not. Thus, we have performed, at an early stage, quantitative research which helps collect the necessary data for confirming the hypotheses for reaching the goal and objectives of the research. The inquiry is the method of choice, which helps collect and analyze the necessary data for the research undertaken. The application of the method allows on-site data collection under investigation, provides the possibility of ensuring the privacy of subjects' data, offers the possibility of abstractization to analyze the necessary phenomena only, provides the opportunity that the interviewed subjects benefit from explications in case of misunderstandings, namely the possibility of shaping/ reshaping the discussion to get the necessary information, and last but not least, offers the possibility of monitoring the data collection process and measuring the phenomena suggested for research purposes (Doncean și Suslenco 2022).

The questionnaire is a tool used for quantitative analysis that gets precise quantifiable results about the phenomena suggested for research purposes. The results intended for research purposes are largely objective and accurate. During the development of the research, within a survey based on a questionnaire (an instrument used for data collection), run at the headquarters of a pre-university education institution located in Iași city, there were 60 students (of different grades) who took part in this project. Accordingly, the current research project had a batch of 60 subjects aged between 13 and 14 years old. The respondents were predominantly female (60%), and male (40%). They were recruited by email or online messages sent to study groups. The implementation period of the questionnaire extended from April 2022 to June 2022, during which time 60 questionnaire forms were filled in, and 57 of them proved valid in the end. The questionnaire under discussion included 8 questions that were clearly, objectively, and precisely formulated. The research instrument has been designed in ways that provide the possibility of reaching the research scope and objectives, and the validation of the research hypotheses as well. The questionnaire comprises simple and complex questions to detect the research problematic and reach the objectives (Table 1). We complied with the logic behind formulating the questions, the sequence, and the interconnection as well. Each question led to reaching an objective and validating a hypothesis.

Table 1 Questions and answers of the questionnaire

<i>Questions of the questionnaire</i>	<i>Answers of the questionnair</i>
1. Which are the ways preferred by students to perform distance-learning activities with teachers during the period concerned?	Telephone - 49% Skype -20% Online platforms such as Classroom, Zoom – 45% Viber, Messenger – 28% Others – 4%.
2. Which are the types of distance-learning activities where students got involved?	Individual Tasks –76% Tests –70% Online Lessons – 40% Guided Lecture – 24% Educational Projects – 20%
3. How much do students think they understood the tasks for individual homework?	Very much – 22,7% Much – 38,8% Moderate – 27,9% Little – 7.1% In the least – 3,5%

4. How long did it take, during the school day, to do the tasks suggested by teachers?	From one hour – 7% 2 hours – 28% 3 hours – 19% 4 hours – 10% More hours – 7%
5. How was the organization level of the distance-learning process?	Excellent – 7% Very well – 15% Well – 55% Low – 20% Very low – 3%
6. How did parents understand and involved in the distance-learning process?	Excellent – 5% Very well – 10% Well – 45% Average – 33% They did not have a certain opinion – 7%
7. What was the parents' attitude about the organization of distance learning?	30% accept the fact that their children are busy doing something useful. 25% are actively involved and offer their children the necessary support. 20% do homework with their children. 15% do not see the point of learning during school break time, while 10% have even displayed indifference toward the matter.
8. After the first 2 weeks of distance learning, how was the evolution of organizing the educational process?	The number of students involved in online classes grew. More teachers started to use online platforms. The volume of homework was cut down, and in some cases, it was eliminated. Students worked according to a schedule. The work time was reduced, and the creative tasks were highlighted..

Source: data processed by author

The qualitative analysis of the questionnaires helps us identify the issues faced by the educational actors, namely clarification of positive features recorded in the online / distance-learning period of the education system. In the context of the COVID-19 pandemic, the results of the questionnaire, complemented by the virtual discussions held with educators, students, and parents on social media (mainly Facebook Platform) about the effects, benefits, and some disadvantages of the distance-learning system, we have noticed mixed opinions about the issues mentioned above:

Some think that teachers, students, and parents handled quite well the situation, organizing in an efficient way the learning and teaching processes with the help of digital

Others noticed issues they faced on a daily basis (deficit of organization, lack of direct contact with teachers and classmates/ colleagues, poor involvement of parents, lack of advanced technique, etc).

All the interviewed persons stressed the high importance of relationships between humans, communication, and care about close people. All these attitudes and values are, in fact, the very basis of the new paradigm that emerged within the Romanian education system.

Mathematical algorithm

The mathematical algorithm proposed by the author of this paper is basically the mathematical processing of data through MatLAB program (it performs the operational calculus with numerical values). Accordingly, each question matches an objective. The first question matches the O1 objective which includes 5 vectors, specifically telephone (49%), Skype (20%), online platforms (Classroom, Zoom – 45%), Viber, Messenger (28%), and others (4%).

Table 2. Correlation between the research objectives and hypotheses and the questions of the questionnaire

Objectives Y	Hypotheses X	Questions
Y0=FX0= sum FXi, i=1...8		
O0: evaluation of the influx of harnessing the human potential in building sustainable pre-university education institutions. Importance coefficient Ci – sum (cij)=1	H0: harnessing the human potential has a positive influence on reaching a sustainable level of the pre-university education institutions.	Questions 1-8
Y1=FX1		
O1: identifying ways of harnessing the human potential in pre-university education institutions considering the COVID-19 pandemic. <i>Importance coefficient - 0,2</i>	In education institutions, unlocking the human potential registers a positive trend in the context of the pandemic.	Please assess the ways favored by students in terms of performing distance learning activities with teachers during the period concerned.
Y2=FX2		
O2: identifying types of activities within the pre-university institutions considering the COVID-19 pandemic. <i>Importance coefficient - 0,2</i>	The most important way of harnessing the human potential in the education institutions is the teacher-student collaboration in the research-innovation domain.	Please assess the types of distance learning activities where students got involved.
Y3=FX3		
O3: evaluation of the students' involvement in performing the tasks related to reaching sustainability. <i>Importance coefficient - 0,1</i>	Reaching sustainability is a must of competitive pre-university education institutions.	Please assess the extent to which students show interest in the tasks for individual homework.
Y4=FX4		
O4: evaluation of students' involvement in activities related to reaching sustainability. <i>Importance coefficient - 0,1</i>	Students' involvement in reaching the sustainability of education institutions that show progress.	Please assess the time necessary for performing the tasks.
Y5=FX5		

O5: identifying the key factors for implementing a sustainable organization of the pre-university education institutions. <i>Importance coefficient - 0,2</i>	Implementing the organization of the sustainability of the pre-university education institution.	Please assess the organization level of the distance learning process.
Y6=FX6		
O6: identifying the main measures <i>Importance coefficient - 0,1</i>	The main measure is the parents' involvement in distance learning.	How did the parents understand and get involved in the distance learning process?
Y7=FX7		
O7: identifying the main attitudes related to organizing distance learning. <i>Importance coefficient - 0,1</i>	The main measure is the parents' attitude related to the organization of distance learning.	What was the parents' attitude related to the organization of distance learning?
Y8=FX8		
O8: identifying the evolution of the educational process after 2 weeks of online teaching/ learning. <i>Importance coefficient - 0,1</i>	The main measure is organizing the educational process after 2 weeks of online teaching/learning.	What was the evolution of organizing the educational process after 2 weeks of online school?

Source: developed by the author

For each objective of the research O1-O8 which correspond to the 8 questions, it was done similarly, in the sense that data were rendered as importance coefficients and later developed as matrixes. The polynomials for each objective are calculated according to the primary data collected from the respondents of this present study. To perform a mathematical algorithm, a general econometric model has been used as it follows:

Y0=FX0=SUM Fxi, i= 1.....8, figure Y0 (sum of the partial models)

And partial econometric models – on submodels (on each objective)

Yi=FXi, and the importance factors Fij, i=1 8, j=1.....28, figures Yi

Y1=FX1

Y2=FX2

Y3=FX3

Y4=FX4

Y5=FX5

Y6=FX6

Y7=FX7

Y8=FX8

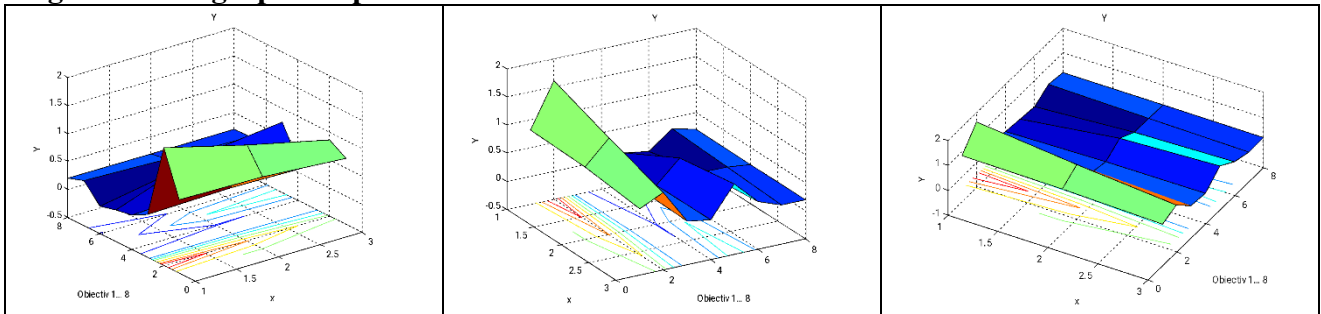
As variable of research, the following variables stands out, namely **Yi independent variable** that expresses the harnessing of the human potential, and **Xi dependent variable** that indicates the sustainability of the pre-university education institutions **i = 18**.

Considering the importance coefficient Ci (shown in Table 2) and the percentage which each of these questions represent from the total criterion of importance for the objectives O1-O8, after the optimization with the assistance of the MatLab program, we get the following solution:

$$Y = \begin{bmatrix} 0.8206 & 0.7937 & 0.6754 \\ 1.6034 & 1.2103 & 0.8686 \end{bmatrix}$$

0.2698	0.3053	0.2704
0.1094	0.1943	0.2106
0.0549	0.5846	0.7571
-0.0097	0.2509	0.3557
0.3000	0.2500	0.2000
0.2000	0.2000	0.2000

Figure 1. The graphic representation of the Y function is as shown below:



Source: developed by the author

The graphical representation of this solution shows us that in the case of $x = 1$, we have a maximum reported to the variable y_1 . Thus, for question no.1 of the questionnaire, there is the optimization possibility in terms of identifying the ways of maximum valorization of the human potential in pre-university education institutions. It is thus confirmed the hypothesis according to which in pre-university education institutions, the valorization of the human potential registers a positive tendency in the context of the COVID-9 pandemic. Further, coming back to the purpose of this research project, namely *the input evaluation of harnessing the human potential to reach the sustainability of pre-university education institutions*, we can state that, based on the research done, we had the possibility of assessing the input of harnessing the human potential on reaching sustainability of the pre-university education institutions.

The general hypothesis of the research „valorization of human potential has a positive influence on reaching the sustainability of pre-university education institutions” – was validated based on the answers given by the respondents of the research.

Conclusions and recommendations

The research conducted here brings a valuable contribution to management science on the sustainability of pre-university education institutions in light of innovational changes. The specific objectives of the research are detailed features of the scientific investigation derived from the general objective, namely harnessing the human potential for developing pre-university education units. Accordingly, based on the research carried out here, we have assessed the input of harnessing human potential on reaching the sustainability of pre-university education institutions. At the same time, following the results obtained, a mathematical algorithm was developed to point out the interconnection between human potential and the sustainability of pre-university education institutions.

The results of this scientific endeavor show that Romanian students trust their own capacity to grow within an online system. The students showed great interest in school success, being open to modernization and improvement of the distance educational process, and also came up with suggestions for the overall reforming of the educational system.

An encouraging fact is that parents got actively involved in expressing their opinions about organizing the distance learning system. Most of them have proven responsible and open to efficient communication, ready to offer support to the students whenever necessary. During the organization period of distance learning, the part played by parents became rather complex. For instance, a key role was providing a well-defined workspace which helped psychologically the students to take the learning activities more seriously and, generally, get more responsible.

In the organizing process of distance learning emerged some difficulties in terms of organization, especially for certain curricular subjects where the organization of lab works and practical activities was not possible. Real interaction with students, as it happened before, was no longer possible. And in the cases where there was not available a PC, laptop, tablet, etc., the relationship with students was kept through telephone calls or chat. The teacher had to identify any way of communication for providing the materials and tasks for homework, sometimes with the help of other students.

This research enterprise complements, to an extent, the literature in the field by providing the perceptions of Romanian students regarding the implementation of online education during the pandemic period. The results represent a starting point for designing a future strategy of education at the national and institutional levels, as a hybrid system could replace the classical education system in the near future, and, coming back to the traditional educational system may never happen again.

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