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Digital innovation in education in Romania quantitative approach

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Abstract. *Economic growth, productivity and national well-being over time have been promoted through various innovation strategies. Education aims to shape the human personality according to its particularities but also according to the social dynamics, the mobility of teachers through the dynamic integration of man in society. Education differs from one historical stage to another. With the advancement of technology, students have the opportunity to take online courses, regardless of where they are, age, physical limitations or personal schedule. Technology can open up new opportunities for learning and assessment.*
With the help of the regression analysis applied based on the indicators provided by the National Institute of Statistics: the number of students, computers, laboratories and workshops in each county in Romania (2010-2017) tested the influence of technology on the number of students enrolled in schools.
The main conclusion of the study emphasizes that a higher number of children enrolled in school in a county is correlated with the degree of technology. Thus, the number of new devices will increase to ensure the possibility for both teachers and students to evolve. On the other hand, the fact that some areas of the country are less developed and lack funding, is also reflected in the number of children enrolled as well as in the number of computers available.

Keywords: Innovation, technologicalization, education, multiple regression, Natural Breaks.

Introduction

Current Information and Communication Technologies (ICT) have created conditions for the emergence of the knowledge society, based on the generalization of communication. In this context, the role of the educational society, learning and innovation is identified. The knowledge society is possible in the conditions of the existence of the information society, computerized. It can be considered that a society is informational only if the access to IT / digital resources becomes a mass phenomenon. A well-developed information society is the foundation on which the digital society develops, in which citizens become digital citizens, government becomes e-government, services become e-services etc.

The new dimensions and trends that are emerging in contemporary education systems, put the pedagogy of the third millennium in the situation of seeking optimal models for integrating theoretical training for knowledge and practical training for skills (Chiș, 2014). Increasingly, theorists and practitioners in the field of educational sciences are forced to use new communication and information technologies to find the optimal model in solving the problems or requirements of current education systems. The revolution that is taking place in the field of science and technology is constantly provoking the emergence of new concepts, and with them, the emergence of new terms. If a few years ago terms like: e-Learning, New Media, digital education, audio-visual education, nanoscience's, nanotechnologies, etc., were found only in specialized works, today these terms have reached the common language of contemporary society.

Thus, there is a development of MOOC or SPOC online courses (Massive Open Online Course, respectively Small Private Online Course. These courses offer the possibility of unlimited participation using open access via the web, but also involve a proper endowment of learning units), with new technological devices and modern equipment.

This study concept was introduced in 2008 and has developed as a popular way of learning since 2012. Compared to traditional study methods: filmed lectures, readings and problem sets, most MOOCs offer interactive courses with forums for users or discussions on social media platforms to support community interactions between students and teachers. At the same time, immediate feedback on questions or tests can be provided and, last but not least, integrated into all levels of education and training within institutions and companies.

Society is constantly evolving, we live in a time when technology is no longer a luxury, but a necessity and education is a key engine for economic and social development. We cannot talk about a modern learning society without talking about the school as a smart institution, a component of smart cities, in which digital citizens are formed, integrated in the current and future society (Baudier et al., 2020). The smart school is an institution capable of constantly adapting to the contexts of society and providing answers to the problems faced by different areas and social environments. In this type of school, continuous and generative learning is promoted, in favorable learning environments, including virtual learning, in accordance with strategies developed at national or international level, which will make possible the production of learning.

An accessible and valuable education at the same time, requires, in addition to the perfect pedagogical qualities of a teacher, his ability to use modern technologies. All this makes it possible for students to actively participate in courses so that the information they receive allows them to develop appropriate knowledge, skills and attitudes. In line with UNESCO's Sustainable Development Goal 4, teachers' learning of technological skills requires specialized training. To this end, the Commonwealth of Learning (COL) and the University of

Athabasca, Canada have developed a MOOC course on Technology-Enabled Learning (TEL). In addition to the large number of registered participants, which attests to the desire for professional development of teachers (more than 30% of participants), there was also an improvement in the participation rate of students and the funding of courses (Mishra et al., 2020). On the other hand, the use and integration of mobile learning, virtual reality in education, open research and how the notion of blockchain influences education in conjunction with the term digital is reflected in culture and heritage.

It takes time and patience to educate a child and even more so in the situation of distance learning, when using modern teaching methods. An inclusive community approach and strong partnerships are needed for distance learning to be inclusive, as highlighted by government officials, practitioners and experts from over 50 countries at the first UNESCO webinar on 20 March 2020 on the educational response to Covid-19. Catherine Kane, organizer (World Health Organization), believes that "scientific knowledge and global collaboration are evolving faster than ever before." He also stressed that "we cannot stress enough the importance of partnerships, especially between education, work and health, to keep our population healthy, educated and active."

Literature review

In order to stimulate national growth, productivity and national well-being, the innovation strategy has recently been promoted. In terms of innovation, it is seen as an implementation of a new product or a significant improvement of an existing good or service, as a process, a new marketing method or as an organizational method in business, workplace or business practices. external relations (Stéphan, 2019).

Whether we like it or not, according to the activity report of the International Association of Economic and Social Councils and Similar Institutions, the digital revolution is not just a simple concept but is actually a reality that influences our lives (AICESIS, 2019). Things tend to evolve quite fast nowadays. In the use of information and communication technology we must always be willing to make new changes that tend to appear in the structure of social functions, to become aware that we must learn new trades, learn new skills, become better, more conscientious and try everything time to improve our social relationships. The processes underlying the use of information and communication technology continue to develop and diversify exponentially from one year to another, estimating that in the future it will determine new characteristics specific to the environment in which we live (Iancu, 2005). The impact of technology is a positive one, aiming to transform the way we communicate, the way we trade, the way we work, the way we design and manufacture goods and many other things. One of the biggest impacts of technology is the impact on education.

Education has aimed, with the passage of time, the formation of human personality, depending on the particularities of each, but also depending on the social dynamics, the mobility of professions through the dynamic integration of man in society. Plato defined education as "the art of forming good habits or developing the native skills for the virtues of those who have them." Aristotle, in his work "Politics", considered that "education must be an object of public supervision, not private".

Education differs from one historical stage to another depending on the material and spiritual conditions of society. Education is a social phenomenon, specifically human, which appears with society, out of a certain need of its own - that of human development as a human

being, as a workforce and a social being. On it depends our own individual existence, but also our relationship with others, the way in which, as individuals, we will fit into a complex social activity, how we will behave. It must help us to perfect ourselves as individuals, but also to make us useful to the community and, above all, not to conflict with it.

In recent years, technology has led to the creation of significant benefits in terms of education. A person can access online courses, regardless of where they are, age, physical limitations or personal schedule. Educational programs are continuously adapted to the requirements of each individual, so that the information revolution reaches everyone and that no one is located outside the development possibilities (Iancu, 2005).

When it comes to the education system, innovation is essential. Educational institutions must always be able to develop and adapt in order to be able to train students to be part of a world that is constantly changing both technologically and culturally, economically and demographically. As for the European Union, it supports education through several initiatives (Doe, 2019). A first initiative could be a much closer cooperation between universities and businesses. This cooperation would be beneficial in the future as it would primarily encourage the transfer and exchange of knowledge as well as stimulate the entrepreneurial spirit and creativity of each individual. School graduates would thus have a better cooperation between business and academia, as the possibility of young people not finding a job after completing their studies is no longer so high. The European Institute of Innovation and Technology, based in Budapest, aims to promote and integrate higher education, innovation and research to the highest standards, to contribute to sustainable economic growth, to the development of entrepreneurship by increasing the innovation capacity of Member States. of the European Union as well as to address the major social problems facing the Union.

Regarding advanced digitalization in the field of education, it is blocked by four major problems, namely (Nicolae, 2019):

- adequate educational resources regarding the technology-based teaching-learning process;
- training teachers to use technologies in a beneficial way;
- the basic infrastructure needed for technology-based educational processes;
- contents and pedagogical practices appropriate to technology-based education.

The relationship between education and technology has begun to become more dynamic over time. The use of technology in schools is vital and offers students new opportunities for learning and development and gives teachers the opportunity to capture students' attention more easily. With the development of new technologies, traditional learning methods tend to be replaced by interactive resources and new learning strategies. Laptops, phones, tablets, as well as other programs, facilitate learning and make it much more interactive and dynamic. The teacher's guide to using virtual reality in education, developed within the VR @ School project, emphasizes that technology can open new opportunities in terms of learning and assessment but also creates challenges for professional development and teacher training.

2. Methodological framework: models, variables and data

To analyze the impact of digital innovation on education, in this study, we will use multiple regression, and data processing will be done using software: Eviews, GeoDa and Excel. The variables of interest, used in the analysis of data for Romania, are represented by indicators taken from the website of the National Institute of Statistics:

- *number of pupils* - represents the totality of children, pupils and students included in the process of instruction and education in a school year;
- *number of computers* - all computers that have hardware, monitor and keyboard and are in the administration of school / university units;
- *number of school workshops* - which is the room equipped with equipment, tools, machines and equipment for experiences and practical work in a school;
- *number of class laboratories* - which represents the class within an educational unit endowed with installations, apparatus, instruments, substances, teaching materials in which teaching experiences and practical works are carried out.

Data were taken by counties, having as reference years the years 2010-2017.

Regression is a statistical modeling tool that is used to highlight the links between pairs of numerical data and can be used in different analysis cases. The best-known way to apply regression is when we want to determine how the variation of an exogenous variable (X) affects an endogenous variable (Y). Regarding the analysis of the impact of digital innovation on education, in this article, because we have several predictor variables and, implicitly, on a multiple correlation, we will apply multiple regression:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \varepsilon \quad (1)$$

where:
- Y – represents the independent variable;
- β_0 – represents the point of origin of the line / the constant;
- $\beta_1, \beta_2, \dots, \beta_k$ – are the coefficients in terms of predictor variables;
- $X_1, X_2, \dots, X_k$ – represents the values of the predictor variables;
- ε – residual value.

Multiple regression will be performed using the Eviews program. In the case of our analysis, we will consider the dependent variable as the number of students enrolled in schools, and the independent variables will be considered the number of computers, the number of laboratories and the number of workshops. The chosen reference year is 2017.

To test whether the analyzed variables are correlated we will use the Pearson parametric correlation coefficient, and to test the multicollinearity of the variables we will also use the criterion of the influence factor of variation (VIF). As a working method, the exogenous variable will be regressed in the first part in relation to the other explanatory variables, the inflation factor of the dispersion will be calculated: $VIF = \frac{1}{1-R_j^2}$, where R_j^2 represents the coefficient of determination. As an interpretation of the values, we will have:
- $VIF = 1$ – there is no multicollinearity;
- $VIF \in (1,5)$ – multicollinearity is low;
- $VIF \in [5,10)$ – multicollinearity is moderate;
- $VIF \geq 10$ – multicollinearity is severe.

In order to be able to see a correct distribution of the analyzed data regarding Romania, we will make a map of the Natural Breaks type in order to offer a clearer image on the distribution in space. The variable number of computers will be selected as the variable of interest to see which counties have a higher number of computers. As the number of groups, we will choose a number of 5 groups, and the limits of the variation intervals will be

set based on an algorithm so as to maximize the homogeneity within the groups. Regarding the Natural Breaks map, for this there are no longer zero frequency ranges and number differences between counties will be much clearer.

Results and discussions

For a better view regarding the analysis of the selected data, we will make different maps and graphs to illustrate the situation regarding Romania.

Every school in Romania must have high-performance computer laboratories in which students can carry out their activities. For these laboratories to work, they must be equipped with computer equipment, computers or laptops, and give each student the chance to learn to use them. In Romania, there are families who do not have a favorable financial situation and, therefore, cannot afford to purchase such devices. The school must offer children the opportunity to discover a new technology and a new way of learning.

Because we want a more detailed analysis in this regard, we will want to make a map of the type "Natural Breaks" to see which are the counties that have a considerable number of computers in schools, and which counties are less favored. As we can see in Figure no. 1, the counties that have the largest number of computers in schools are Cluj County and Bucharest.

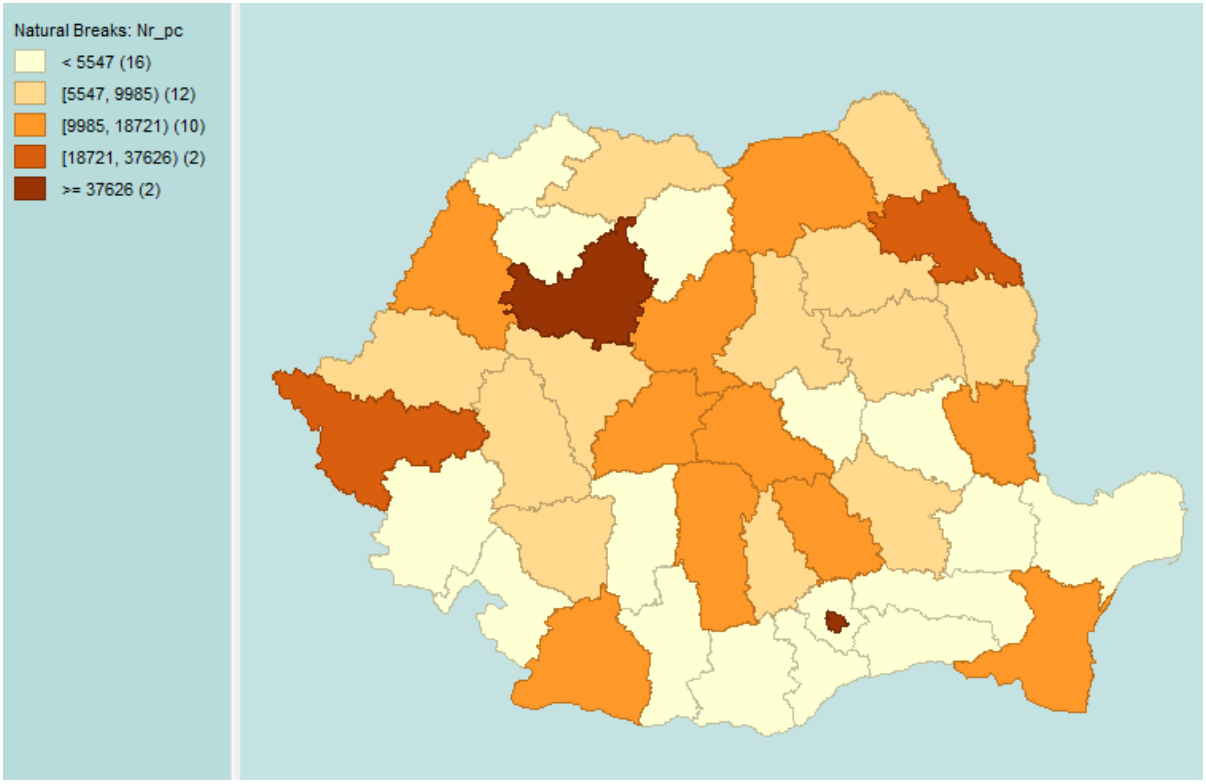


Figure no. 1 – Natural Breaks map for the number of computers in each county
Source: Own realization using the GeoDA program

However, this was to be expected, because in Cluj County and in Bucharest, in 2017, most students were enrolled in schools. We can say that schools also have computers

depending on the number of students enrolled in each school. The counties that had a low number of computers in the educational units were Tulcea, Călăraşi, Olt, Satu-Mare counties.

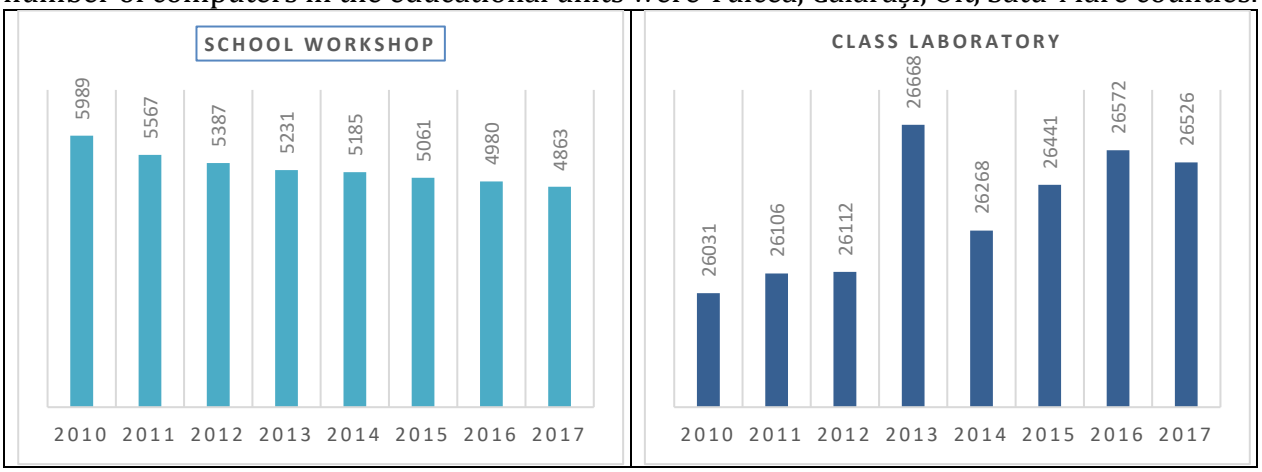


Figure no. 2 – Number of existing school workshops and class laboratories in schools in Romania

Source: Own realization using the Excel program

If we were to make a comparison between the number of laboratories and the number of workshops in educational units in Romania, in the reference years 2010-2017, we can note that in the case of workshops, this number decreased from one year to another, in in the case of laboratories the same does not happen. From 2010 to 2012 the number of laboratories was almost constant, and in 2013 their number will increase considerably.

Specification of the multifactorial econometric model

In the first part of the analysis, we will specify the following model: dependent variable: number_students, independent variables: number_computers, number_workers, number_of workshops.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	20972.02	7448.304	2.815678	0.0077
NUMAR_CALCULATOARE	2.525547	1.530907	1.649707	0.1072
NUMAR_LABORATOARE	78.02181	27.39909	2.847606	0.0071
ATELIERE_IN_SOLI	-72.22746	149.1491	-0.484264	0.6310

R-squared	0.902140	Mean dependent var	85203.83
Adjusted R-squared	0.894414	S.D. dependent var	69473.75
S.E. of regression	22574.78	Akaike info criterion	22.97745
Sum squared resid	1.94E+10	Schwarz criterion	23.14294
Log likelihood	-478.5264	Hannan-Quinn criter.	23.03811
F-statistic	116.7699	Durbin-Watson stat	2.023269
Prob(F-statistic)	0.000000		

Figure no. 3 – Multifactorial regression model

Source: Own realization using the Excel program

Regarding the resulting model we will have:

$$number_students = 20972.02 + 2.5254 \cdot number_computers + \\ +78.0218 \cdot number_laboratories - 72.222 \cdot schoolsworkshops \quad (2)$$

The results of estimating the regression model show that *the number of computers*, *the number of class laboratories* and *the number of school workshops* explain 90.21% of the variation in the number of students enrolled in schools, but still two of the slope parameters are not statistically significant., $prob = 0.1072$ respectively $prob = 0.6310$ being higher than the chosen level of significance, $\alpha = 0.05$.

When testing the validity of the model, we can see that it had $F_{calc} = 116.76$ and $Prob(F_{statistic}) = 0.000000 < 0.05$, which leads us to reject the alternative hypothesis H_0 , which leads us to reject the alternative hypothesis (at least one of the chosen parameters is statistically significant $\beta_j \neq 0$ unde $j = \overline{1,k}$).

If we were to re-specify the model by logarithmizing the variables, we can see that only one parameter is not statistically significant.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.161080	0.510787	8.146408	0.0000
LOG(NUMAR_CALCULATOARE)	0.744095	0.134497	5.532408	0.0000
LOG(NUMAR_LABORATOARE)	0.168629	0.120640	1.397779	0.1703
LOG(ATELIERE_IN_SOLI)	-0.137966	0.062981	-2.190610	0.0347

R-squared	0.940948	Mean dependent var	11.17705
Adjusted R-squared	0.936286	S.D. dependent var	0.545488
S.E. of regression	0.137690	Akaike info criterion	-1.037238
Sum squared resid	0.720420	Schwarz criterion	-0.871745
Log likelihood	25.78199	Hannan-Quinn criter.	-0.976578
F-statistic	201.8349	Durbin-Watson stat	1.814381
Prob(F-statistic)	0.000000		

Figure no. 4 – Multifactorial regression model-model re-specification by logarithm of variables

Source: Own realization using the Eviews program

If we were to interpret the results obtained in the case of the first estimated model, we can see that an increase by one unit in the number of computers, the number of students enrolled in schools would increase by 2.52, given that the other variables analyzed would remain constant.

Next, we want to detect multicollinearity based on the correlation coefficients between the explanatory variables. For this, we will use the first estimated regression model, the one in which the variables are not logarithmic and for the detection of multicollinearity, we will use the Pearson linear correlation coefficient matrix. The result is obtained shows the existence of an almost perfect linear connection between the analyzed variables (Figure no. 5).

	NR__ELEVI	NUMAR_CA...	NUMAR_LA...	ATELIERE_I...
NR__ELEVI	1.000000	0.934594	0.945900	0.901266
NUMAR_CA...	0.934594	1.000000	0.965249	0.929506
NUMAR_LA...	0.945900	0.965249	1.000000	0.958852
ATELIERE_I...	0.901266	0.929506	0.958852	1.000000

Figure no. 5 – Pearson linear correlation coefficient matrix

Source: Own realization using the Eviews program

We want to regress the variable number of computers in relation to the variables the number of laboratories and the number of workshops and for this equation we will calculate VIF ($scalar\ VIFX_2 = 1/(1 - EQ02.@R2)$, where EQ02 represents the regression of the variable X_2 in report to the variable X_1.)

Scalar $VIFX2 = 14.68455 > 10.$ (3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	641.1000	772.2765	0.830143	0.4115
NUMAR_LABORATOARE	12.64698	2.027801	6.236793	0.0000
ATELIERE_IN_SOLI	5.220264	15.57812	0.335102	0.7393

R-squared	0.931901	Mean dependent var	9233.000
Adjusted R-squared	0.928409	S.D. dependent var	8824.967
S.E. of regression	2361.253	Akaike info criterion	18.44052
Sum squared resid	2.17E+08	Schwarz criterion	18.56464
Log likelihood	-384.2509	Hannan-Quinn criter.	18.48602
F-statistic	266.8486	Durbin-Watson stat	1.737147
Prob(F-statistic)	0.000000		

Figure no. 6 – The estimated model regressing the variable number of computers in relation to the other variables

Source: Own realization using the Eviews program

We will further regress the variable number of laboratories in relation to the variable number of computers and workshops in schools.

Scalar $VIFX3 = 24.78027 > 10.$ (4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-136.1206	37.67979	-3.612562	0.0009
NUMAR_CALCULATOARE	0.039483	0.006331	6.236793	0.0000
ATELIERE_IN_SOLI	3.481810	0.670047	5.196371	0.0000

R-squared	0.959645	Mean dependent var	631.5714
Adjusted R-squared	0.957576	S.D. dependent var	640.5434
S.E. of regression	131.9335	Akaike info criterion	12.67122
Sum squared resid	678851.6	Schwarz criterion	12.79534
Log likelihood	-263.0957	Hannan-Quinn criter.	12.71672
F-statistic	463.7153	Durbin-Watson stat	1.642553
Prob(F-statistic)	0.000000		

Figure no. 7 – The estimated model regressing the variable number of laboratories in relation to the other variables

Source: Own realization using the Eviews program

We will further regress the variable workshops in schools in relation to the variables number of computers and number of laboratories.

Scalar $VIFX2 = 12.44215 > 10.$ (5)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	36.49836	5.457856	6.687306	0.0000
NUMAR_CALCULATOARE	0.000550	0.001641	0.335102	0.7393
NUMAR_LABORATOARE	0.117500	0.022612	5.196371	0.0000

R-squared	0.919628	Mean dependent var	115.7857
Adjusted R-squared	0.915506	S.D. dependent var	83.37940
S.E. of regression	24.23654	Akaike info criterion	9.282349
Sum squared resid	22908.99	Schwarz criterion	9.406469
Log likelihood	-191.9293	Hannan-Quinn criter.	9.327844
F-statistic	223.1219	Durbin-Watson stat	1.743062
Prob(F-statistic)	0.000000		

Figure no. 8 – The estimated model regressing the variable number of laboratories in relation to the other variables

Source: Own realization using the Eviews program

As VIF is much higher than the value of 10 in all 3 cases (Equations 3, Equations 4, Equations 5,), we can see that the variable number of computers induces severe multicollinearity. We will also regress the other analog variables as the variable number of computers. As we can see, in these two estimated models, the VIF value is much higher than the value 10, therefore the variables induce severe multicollinearity. In order to be able to remedy multicollinearity, we aim to eliminate from the estimation of the following model the variables the number of laboratories and the number of workshops because these variables are the most strongly correlated with each other. Thus, a model was estimated again that contained the number of students as a dependent variable and the number of computers as an independent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	17272.00	5622.953	3.071695	0.0038
NUMAR_CALCULATOARE	7.357504	0.442774	16.61683	0.0000

R-squared	0.873465	Mean dependent var	85203.83
Adjusted R-squared	0.870302	S.D. dependent var	69473.75
S.E. of regression	25020.00	Akaike info criterion	23.13919
Sum squared resid	2.50E+10	Schwarz criterion	23.22193
Log likelihood	-483.9229	Hannan-Quinn criter.	23.16952
F-statistic	276.1192	Durbin-Watson stat	1.843327
Prob(F-statistic)	0.000000		

Figure no. 9 – Estimation of the regression model by eliminating the variables number of laboratories and number of workshops

Source: Own realization using the Eviews program

Initially, in the first estimated model (Figure no. 3), the parameter corresponding to the variable number of computers was not statistically significant. Following the elimination of variables that induced severe multicollinearity, the number of workshops and the number

of laboratories, we notice that the parameter corresponding to the variable number of computers is statistically significant.

Conclusion

Following the analysis, we can conclude that digital innovation has an important role in the education of young people in Romania. Technology can open up new opportunities for learning and assessment. In order for things to evolve and for young people to be able to develop both professionally and culturally, much more importance should be given to education. Romanian schools should be better equipped with laboratories and workshops for young people to carry out their activities. Schools should also have computers in each school and teach young children to use them for good. As time goes on, everything is digitized. Children must learn from the first years of school to cope with the new era of digitalization. Teachers must always comply with the changes that are taking place in the education system.

Regarding our analysis, a multiple regression was performed as well as a graphical visualization on the situation in terms of the number of computers, laboratories and workshops in schools. In the case of multiple regression, we wanted to see if the number of students enrolled in schools depends on the number of computers, laboratories and workshops in schools. It should be noted that, in the case of laboratories, their number increased considerably in 2013, and the workshops were in a continuous decrease from 2010 to 2017. It is also noted that Cluj County and Bucharest have a large number of computers, while at the opposite pole are the counties: Tulcea, Călăraşi, Olt, Satu-Mare.

The final conclusion I have reached is that the development that is taking place at the level of technology has a pretty big impact on the population, and education systems should take much more advantage of this and train young people who are eager for change, who can highlight the qualities and experience gained in the school years they attended. Digital innovation in education has a significant and positive role in training young people.

Acknowledgments

This work was cofinanced from the European Social Fund through Operational Programme Human Capital 2014-2020, project number POCU/380/6/13/125015 "Development of entrepreneurial skills for doctoral students and postdoctoral researchers in the field of economic sciences".

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