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Tele-Education under the COVID-19 Crisis: Asymmetries in Romanian Education

Cristina Nicolau [1], Ramona Henter [2,*], Nadinne Roman [3], Andrea Neculau [3] and Roxana Miclaus [3]

1 Faculty of Economic Sciences and Business Administration, Transilvania University of Brașov, 500368 Brasov, Romania; cristina.nicolau@unitbv.ro
2 Faculty of Psychology and Education Sciences, Transilvania University of Brașov, Str. N. Bălcescu 56, 500368 Brașov, Romania
3 Faculty of Medicine, Transilvania University of Brașov, 500368 Brasov, Romania; nadinneroman@unitbv.ro (N.R.); andrea.neculau@unitbv.ro (A.N.); roxicum@unitbv.ro (R.M.)
* Correspondence: ramona.henter@unitbv.ro

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Abstract: The COVID-19 pandemic has deepened social and educational asymmetries in some developing countries, such as Romania. Tele-education failed to replace face-to-face education due to the lack of symmetrical policy, connectivity, infrastructure, digitalized educational materials and digital competences. Was this issue predictable and, hence, the stakeholders' mission failed? Our qualitative research aims at analyzing, in depth, these digitalization asymmetries, with a sample formed of Information and Communication Technology (ICT) specialists working for/with Romanian 1–4 International Standard Classification of Education (ISCED) schools. The collected primary data were processed with Atlas.ti 8. The results emphasize major key areas to be addressed with future public symmetrical policy and change management strategies: equal access to infrastructure, as well as development of compulsory and complementary digital skills (for teachers and students). The necessity to support school management in accessing funding is also required to enhance digitalization.

Keywords: asymmetry; tele-education; digitalization; ICT infrastructure; digital teacher training; replace face-to-face education

1. Introduction

The current coronavirus pandemic, generated by the outbreak of the novel virus SARS-CoV2 [1,2], determined at a global level certain social, economic, medical and educational issues, forcing professionals in all fields to adapt their activities to the new governmental measures and health policies. A lack of symmetry in education, together with the increase in unemployment [3] and inflation rates, generate an educational crisis with outcomes that cannot be neglected as education is the driver of any economic system in terms of knowledge transfer and competence development, including the digital teaching competences [4].

Digital technologies have been introduced in educational institutions, where they are considered to have had a positive impact [5]; but, in a developing country like Romania, this process was a slow one (digitalization was not perceived as a need to be rapidly addressed). Face-to-face education seemed to be comfortable (not requiring changes) and successful (meeting settled standards and indicators) whereas the pedagogical methods and techniques seemed to be sufficient and efficient, at least from the management's perspective, although less creative and lacking attractiveness in today's students' eyes. In time, incorporating multimedia was not enough for teaching and training.

Computer-aided instruction and intelligent tutoring systems were developed as interactive learning environments [6], which with the support of the growth of the World Wide Web and of the extension of Internet connections, gave birth to online learning. The main consequence was a re-shaping of the educational profession, influencing both teachers and trainers, including the most resisting ones, and included networks, television and computers into the educational process, as they enabled long-distance communication and use of multimedia [7].

Under the circumstances generated by the COVID-19 crisis, the main aim of this paper was to determine, in a developing country like Romania, the capacity of its educational system to replace face-to-face education with any form of tele-education because of the lockdown caused by this pandemic. Its general objective (GO) was identifying the level of digitalization that supports Romanian tele-education under the COVID-19 crisis whereas the specific objectives (SO) were as follows:

SO1—Evaluating the asymmetries of Romanian education.
SO2—Examining the resources used for supporting tele-education.
SO3—Identifying key-areas for future development of tele-education in Romania.

2. Literature Review

2.1. The Importance of Tele-Education in Developing Countries during the COVID-19 Crisis

Research shows that children have an important role as transmitters of COVID-19 [8–10]. Under such circumstances, one of the most important measures of public health was to interrupt face-to-face education activities placed in public and private educational organizations and to ban the organization of any event which would gather a large number of people, education-oriented events included.

Before the first months of 2020 when the COVID-19 pandemic started spreading worldwide, digitalization of education in a developing country like Romania seemed to be a regular, smooth process (ICT was introduced when needed). Hence, it has rapidly started to show its lack of symmetry when government policies started banning participation of face-to-face education. Students in all the levels of education, whether public or private, irrespective of their ages (children or adults) or generations, needed to adapt to tele-education as quickly as possible, regardless of whether they had Internet connectivity and/or electric power (Challenge 1), proper ICT infrastructure at home (Challenge 2), or possessed digital competences or had an available adult to provide ICT support (Challenge 3). Teaching and training staff (Challenge 4) faced legal issues and a lack of public policy regarding remote and online job tasks (Challenge 5). In the developing countries where low funding has been used for training public teaching staff [11] and digitalization in general, schools may not have implemented a secure and telecommunication-based educational environment, exposing students (mostly children) to cyber risks (Challenge 6). Hence, the major challenge of tele-education during the COVID-19 pandemic was to properly and timely respond to these challenges in terms of public policy, funding, infrastructure and digital competence training.

2.2. The Symmetry with the Old and New Tele-Education

Tele-education is the teaching–learning process that uses any device merging with telecommunications and computer science for education-purposes. Tele-education does not refer only to a geographical distance between students and teachers as opposed to face-to-face education, but also to the distance between these two actors of education and the resources used for educational purposes, which may be virtual and computer-assisted, or physical like books, textbooks, copybooks and handouts, but used in the absence of an in-person teacher.

The electronic tutor was firstly envisioned by Arthur Clarke in the 1970s [12]. Two-decade experiments showed the efficiency of both wide- and narrow-band techniques used in responding to global education's needs in developed and developing countries [13]. This brought interactivity in the classrooms as well as other opportunities of distant learning (which at first mainly consisted of pen-and-paper-based tasks exchanged by post-mail). Distance education, which exploits ICT, provides

the right means of communication needed so as to avoid any physical contact between students/trainees and teachers/trainers.

The flipped learning pedagogical approach transfers the direct instruction from the group to the individual, offering an active and cooperating learning space, with the educator as facilitator guiding students to apply concepts in a creative manner [14]. On the other hand, tele-education is presumably named by the European Commission (EC) as digital and online learning (DOL), a concept consisting of two main constitutive parts [15]: digital learning (ICT-supported teaching and learning) and online learning (desktop, mobile devices, Internet and web services support learning from a distance and creating a personalized learning experience, reducing time and place as educational constraints).

Tele-education brought about the need for a new didactics, and hence e-Didactics [16] emerged and marked a change of focus from simply teaching to learning engineering, promoting blended and online education; moreover, the classroom is moved into virtual environments, including social networks, using various learning systems and benefitting from unlimited ICT resources whereas teachers' role changed from delivering information to engineering the learning of their students who have thus become actively involved learners [16]. In Romania, teachers make use of ICT and multimedia to enhance learning, but this piece of research shall analyze the level of their use of MOOC platforms and directories such as Moodle, Open edX, Canvas, NovoEd, Udemy, Miriada Coursera, etc., within the processes of e-learning and e-teaching. Still, the real challenge in any type of network-based education is to use the most appropriate pedagogical models that support the teaching–studying–learning process [17].

We investigated the development of this concept as a whole (not including the development of its constitutive parts namely tele-teaching and tele-learning) and we identified that, except from medicine where it received a lot of attention and the concept of tele-medicine is largely used, previous research may be divided according to the two major fields this concept has received special attention from: computer science and engineering, and social sciences and language acquisition. Hence, there are two forms of tele-education [18]: (1) asynchronized—the Internet is used to publish hyperlinked multimedia content whereas offering the opportunity of reaching a large audience with digitalized material (self-learning is highly encouraged as assessment may be delivered as well, not needing the assistance of a professor); and (2) synchronized—the major form being real-time interactive virtual classrooms supported by a multitude of applications developed to meet all students' needs.

The results of tele-education are also influenced by various factors, which reveal a lack of symmetries, starting with demographic ones (unequal educational levels, education isolation, information isolation, regional disparity, rural versus urban gaps and gender issues, with females registering a more serious lack of education [19]). There are also disadvantages in this type of learning: students' low motivation for learning, social isolation, technical incompatibilities among the learning systems available, technology dependency and higher costs for the institutions [20].

2.3. Digital Intelligence of Schools, Classrooms and Students

Intelligent schools refer to the use of computers, multimedia and teacher droids/roboprofessors for educational purposes. In the 1990s, the Program on Educational Building of the Organization for Economic Cooperation and Development (OECD) aimed at encouraging the design of school architecture and environments that serve and foster learning [21]. It also advanced some important ideas to be implemented in all the schools, irrespective of whether the school is located in an OECD country or not: (1) locating ICT resources throughout the school (not in dedicated computer rooms); and (2) reducing the gap between privileged and disadvantaged schools with regard to ICT resources (bringing the educational process outside the school providing more availability to learning).

Additionally, the micro-unit within intelligent schools is the intelligent classroom, a platform or application providing teaching and training staff with written and oral services like digital handwriting, speech and gestures delivery, making annotations on courseware, pointing to objects displayed on media boards and saying predefined commands [21]. Hi-tech component technologies used in the mid-2000s

were interactive interfaces, which could be run with virtual assistants able to speak, digital pens and laser points (hardware) as well as structure providing similarly structured modules or the possibility to create and integrate new ones: architecture and runtime structure, inter-agent communication, runtime environment management and debugging support as well as agent development interface (software) [18]. Irrespective of how much technology is developed, intelligence did not refer to the classroom, but to instructor's ability to intelligently use the room by concentrating on the lecture and not on the technology [22]. Under such circumstances, we highlight that education success depends on the teachers' intermediate to advanced levels of digital competences.

To conclude, tele-education can be performed via various media [23]:

- audio (transmission of the spoken word between learners and instructors, either synchronously, e.g., videoconferencing and short-wave audio, or asynchronously, e.g., audiotape or audiocassette);
- video (either synchronously, e.g., videoconferencing and interactive television, or asynchronously, e.g., slow-scan video, interactive videodiscs and videotapes);
- computer-assisted (Internet, www, email, applications and multimedia applications—interactive or on CD-ROM.

More and more technologies, functionalities and educational benefits of the virtual reality approach [24] have been added. Nevertheless, the technology itself is not enough. The human resource must be able to use it properly, to have the necessary digital competencies. The European Centre for the Development of Vocational Training (Cedefop) [25] considers that a competence is the capacity of using knowledge, skills and abilities from the personal, social and activity fields in various situations. Therefore, the digital competence (or digital literacy), a key competence for lifelong learning in the European Union (EU), covers ICT knowledge and the ability to use this knowledge for problem-solving in any domain.

In this view, this paper explores the asymmetries of Romanian education with regard to digitalization as a response to the COVID-19 crisis; this challenges education in terms of learning acquisition and educational needs, teachers' digital competences, the ICT infrastructure available and cybersecurity.

3. Materials and Methods

3.1. Research Localization

Our study will provide Romania as an example of a developing country. Romania is a member of the European Union (EU). In order to understand the context of using tele-education during the COVID-19 pandemic, we analyzed three types of descriptive data: about the COVID-19 pandemic, about expenditure in education and about national digital performance.

At present (22 August 2020), in Romania, 76,355 cases of COVID-19-infested persons were reported, with 3196 (4.18%) deaths and 34,523 (45.21%) recovered patients. The first case of COVID-19 was reported on 26 February 2020. Since then, Romania has passed through two periods: a state of emergency from 16 March to 15 May 2020, (lockdown for all the residents [26–29]) and a state of alert from 16 May 2020, and still continuing (measures of economic and social relaxation were progressively installed [27,30,31]; but, a second wave of COVID-19 infections set in with a peak of infections on 13 August 2020, with 1454 new cases [26], as presented in Figure 1.

Starting from 11 March 2020, face-to-face learning was banned in schools and on 15 June 2020, the summer vacation started (the new school year is forecast to start on 14 September 2020). However, it is not officially announced how to conduct courses; there are three possibilities, depending on the evolution of the number of cases of COVID-19 on the territory of Romania. There are three scenarios in which the school will normally start: in case the number of infections decreases, the variant in which the pupils and students will be divided in half and to alternate the physical courses with the online ones and the variant in which all the education will take place online, if there is an increased epidemiological risk [32].

Under such circumstances, expenditure on education became a very important indicator, at the government and family level, too. In 2018, Romania spent on education 3.2% of its gross domestic product (GDP); it totaled LEI 30,100 million [33] (approximately Euro 6468 million given the annual average exchange rate of Lei 4.6535 for 1 Euro [34]). This expenditure (see Figure 2) ranked Romania the last within the EU in 2018 [33].

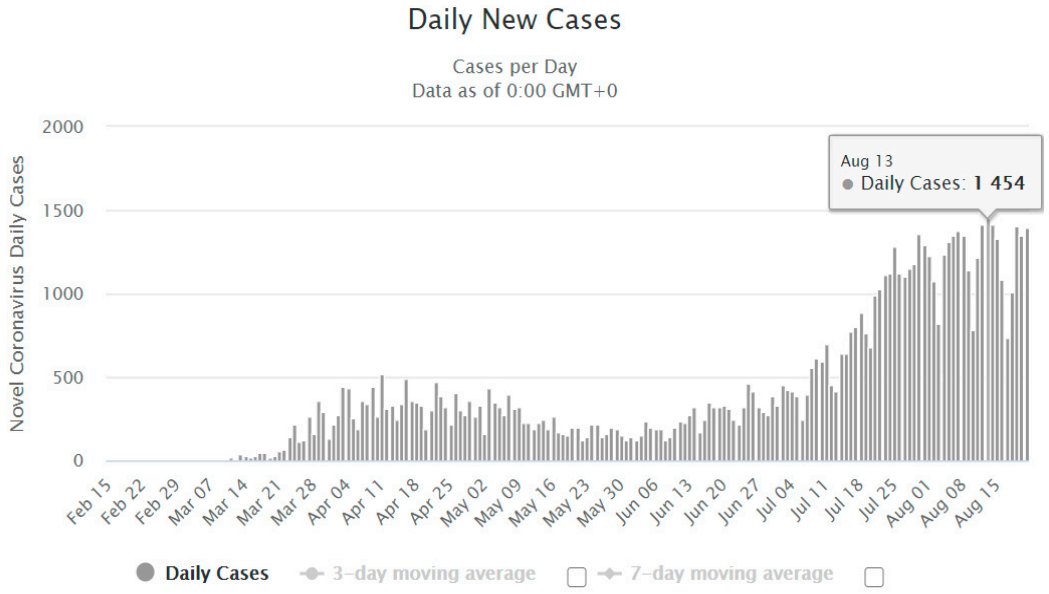

Figure 1. Daily new cases of novel coronavirus infections [26].

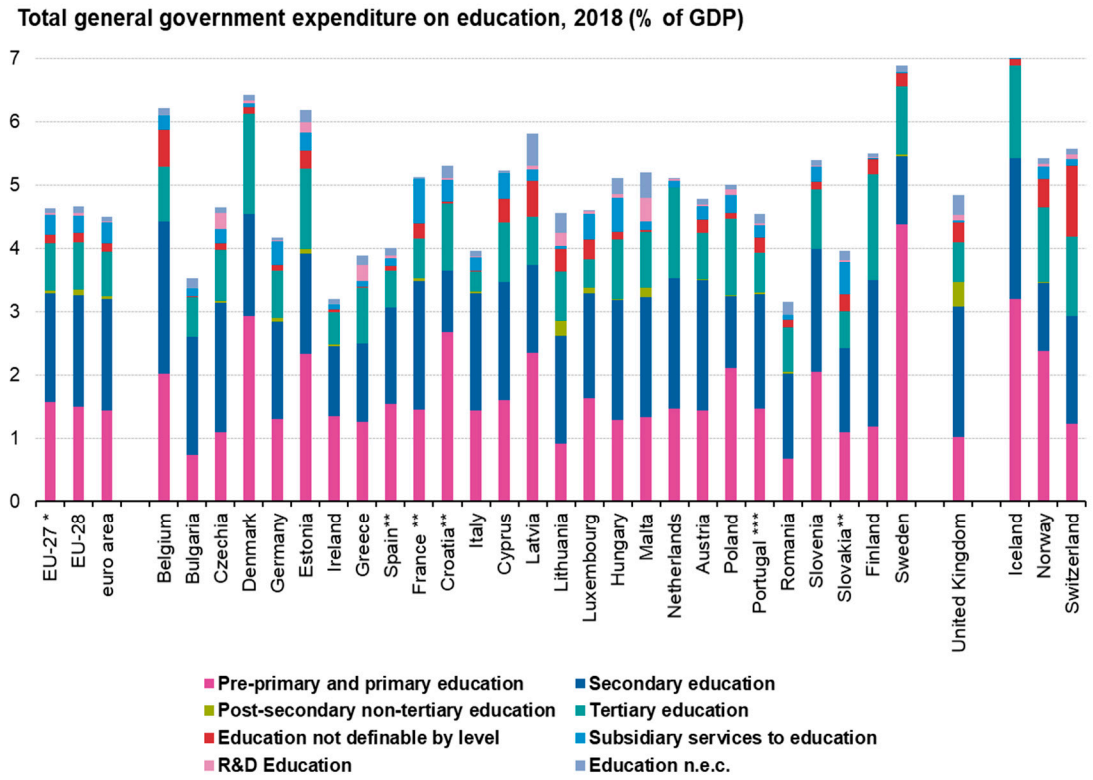

Figure 2. Romania's expenditure on education in 2018 [33].

Other national indicators showing Romania's asymmetries with impact on digitalization are presented in Table 1. Descriptive data show that, in 2018, a household's average revenue was approximately Euro 340 (approximately Euro 260 in rural areas) and spent only 0.32% on education

(0.16% in rural areas), whereas at the national level, approximately Euro 3.04 were spent on phoning, audio, video, photo, information processing equipment and its accessories and Euro 0.40 on information processing equipment and accessories. These data clearly show that the individual investment in ICT is very low and there is a critical need for funding in digitalization in general.

Table 1. Romania's asymmetries with effects on education [35].

Indicator	2017 *	2018 **	Observation
Total monthly income per household.	LEI 1290.9 = Euro 283 per person (LEI 1005 = Euro 220 in rural areas)	LEI 1613 = Euro 346 per person (LEI 1226.84 = Euro 264 in rural areas)	+Euro 63 per person (+Euro 44 in rural areas)
Total monthly expenditure on education per household.	LEI 3.72 = Euro 0.81 (LEI 2.04 = Euro 0.45 in rural areas)	LEI 5.15 = Euro 1.11 (LEI 2.01 = Euro 0.43 in rural areas)	+Euro 0.3 (-Euro 0.02 in rural areas)
Monthly average expenditure on phoning, audio, video, photo, information processing equipment and its accessories.	LEI 12.08 = Euro 2.65	LEI 14.13 = Euro 3.04	+Euro 0.39
Monthly average expenditure on information processing equipment and accessories.	LEI 2.3 = Euro 0.50	LEI 1.87 = Euro 0.40	-Euro 0.10
Share of households having access to computer at home.	65.60% (51.9% in rural areas)	n/a	-/-
Share of households having access to Internet at home.	68.60% (56.9% in rural areas)	72.40% (61.5% in rural areas)	+3.8% (+4.6% in rural areas)
Total number of the population aged 0–17.	3,704,601 persons (1,857,626 in rural areas)	3,680,850 persons (1,825,322 in rural areas)	−23,751 persons (−32,304 persons)
At-risk-of-poverty or social exclusion rate in the population aged 0–17 years.	41.70%	38.10%	-3.60%
Total number of matriculated students.	3,578,561 persons (1,022,507 persons in rural units, of which 77.84% in ISCED 1–3 units)	3,547,301 persons (994,183 persons in rural units, of which 77.50% in ISCED 1–3 units)	−31,260 persons (−28,324 persons in rural units, of which −0.34% in ISCED 1–3 units)
Total number of PC's managed by schools.	387,786 pieces (99,750 pieces in rural areas, of which 93.25% in ISCED 1–3 units)	396,614 pieces (99,275 in rural areas, of which 92.91% in ISCED 1–3 units)	+8828 pieces (−475 pieces in rural areas, of which −0.34% in ISCED 1–3 units)

* Annual average exchange rate was Lei 4.5681 for 1 Euro (source: www.bnr.ro) [34]; ** Annual average exchange rate was Lei 4.6535 for 1 Euro (source: www.bncr.ro) [34].

Moreover, there are still households that do not have a computer or an Internet connection at home (in 2017, more than 30% for the whole country and more than 40% in rural areas for both indicators); so, children belonging to these households have no opportunity for online education if public funding is not used to help them. The number of children with a high poverty or social exclusion risk was still high in 2018 at the national level, being about 1,402,404 children aged 0–17 years. However, we identified severe infrastructure deprivation in Romanian schools, not only in households. In 2018, there were 8.94 students that matriculated with ISCED 1–3 using one personal computer (PC), whereas in rural areas, this number reached 24.40, slightly decreasing from 2017 by 0.17% [35].

In 2019, Romania's index of Digital Economy and Society (DESI), measuring digital performance [36], positioned Romania as 27th within the 28 member states (see Table 2), with a score of 36.5 (increasing by approximately 14% since 2017), whereas the EU average was 52.5 in 2019. It is obvious that the lack of symmetry identified show an urgent need for investment in digitalization of all the Romanian public services, including education.

Table 2. The Digital Economy and Society Index (DESI), 2019 [36].

Index	DESI 2019	Connectivity	Human Capital	Use of Internet	Integration of Digital Technology	Digital Public Service
The EU's score	52.5	53.5	48.0	53.4	41.1	62.9
Romania's score	36.5	59.3	31.1	31.9	20.5	43.2
Romania's rank in the UE	27th	22nd	27th	28th	27th	28th

3.2. Outcome Measures

We designed a semi-structured in-depth research instrument presented in Table 3 consisting of a list of topics and sub-topics to discuss with participants. To reduce fatigue and generate ideas, Sub-topic 2.3. was designed as an "energizer", stimulating the respondents' creativity to think and present examples of any digital item, instrument, device, tool, application, solution or platform used as learning aid in Romanian school that was impressive/surprising enough to say "Wow!".

Table 3. The qualitative research instrument.

Analysis of Digitalization Supporting Romanian Tele-Education Under the COVID-19 Crisis	
Topic	**Sub-Topic**
1. The asymmetries within Romanian education in terms of digitalization.	1.1. The present asymmetries of the Romanian education system. 1.2. Main educational activities using ICT.
2. Digital resources needed for tele-education.	2.1. Existing infrastructure and teaching staff's hardware and software competences. 2.2. IT support for students and teachers. 2.3. Digital "Wow" in education.
3. Future digitalization of schools.	3.1. Fully digital schools and online teachers. 3.2. Costs needed to digitalize a school.

Because of the isolation imposed by the COVID-19 pandemic, interviews were carried out over the phone or by using online applications and every interview lasted about 60 min, out of which 10 min were given in the end to add the participants' personal insights and concerns about the topics discussed.

3.3. Participants

The research design aimed at collecting primary data about the ISCED 1–4 levels of Romanian education (primary, secondary and high school levels) from subjects who may provide the necessary data from within the Romanian public schools. The ICT specialists' opinions brought more objective and accurate data as they are not biased by the desire to distort the truth. The ideal participant has worked with/for public Romanian schools in the ICT field for more than 3 years. We used the snowball sampling method as it is convenient when accessing subjects without target characteristics [37] and we formed a representative non-probabilistic sample with social significance (no statistical logic is needed in qualitative research), which reproduces all the characteristics of the researched population.

This study was conducted at mid-March–April 2020 at the very beginning of the COVID-19 pandemic in Romania and fourteen respondents positively answered our invitation to participate in the study. The research methodology stipulated, according to research ethics, was to obtain informed consent from every participant. The interviews first collected information on the sample characteristics: 100% were male, with an average age of 44.5 years; average IT experience was 18 years, of which 12.5 years in the Romanian public education; and 85.71% holds a bachelor's degree.

3.4. Procedures and Data Analysis

The primary data collected was processed with Atlas.ti 8. We imported the interview notes into this qualitative software and the data analysis consisted of two processes: one inductive, which meant describing seven themes and organizing the participants' words and sentences according to these themes, and one iterative, in which we assigned a label or code to the meanings. Coding of the qualitative data is made on every objective. For the first objective, we grouped the respondents' answers on two paradigms: (1) the perception of *management's and teaching staff's intentions, planning and implementation of digitalization* in education received the following codes, (+/− management support) and (+/− teacher digitalization), used for the following pieces of information: knowledge, skills, intentions, motivations, competitions and funding; and (2) *infrastructure* received the following codes, (+/− infrastructure), used to mark the existence, use or lack of Internet, PC's, phones, labs, YouTube, smart phones, digital textbooks. Moreover, our respondents underlined the need to observe similarities and differences between urban and rural educational environments, which received the following codes (+ urban digital development) and (+ rural digital environment), referring to urban digitalization, rural digitalization, funding and mayor houses' support.

In order to highlight the present condition of the digitalization of the Romanian education, we identified in the subjects' response data three major paradigms, presenting the resources existing in terms of hardware and software, which were divided into the following:

1. *Logistics*: (+ old hardware infrastructure, + new hardware infrastructure), where "old" means both "used" and "old-generation technology" and "new" means both "newly acquired" and "the latest technology"; (+ old software infrastructure, + new software infrastructure), where "old" refers to "outdated" and "new" refers to "the latest generation" and a focus is put on expired and needed licenses coded with (+/− software license); (− enough infrastructure) presents opinions regarding the need of investment in infrastructure, an idea also suggested by (+ teacher's own infrastructure), which shows that teachers use their personal devices in labor interest; and ICT security was simply coded (+/− ICT security).
2. *Human resources* were divided into teaching personnel (herein teachers of ICT and computer science are included) and administrative staff who should support the educational process in terms of ICT infrastructure and secure use:

    - teaching personnel: (+/− teacher hardware competences), (+/− teacher software competences), (+/− teacher solution) expressing efforts made for digitalizing teaching and learning, (+/− teacher attitude) measuring intentions to digitalize, and (+/− teacher IT training) coding all ICT training;
    - support ICT specialists: (+ ICT service externalization, + Own ICT employee), showing the managerial solution for supporting a school's digital processes.

3. *Financial resources*: As education is or shall be student-centered, we considered the financial resources needed for the three constitutive parts of digitalization: to form (+ students' digital competences) and (+ teaching staff training) and acquire (+ appropriate infrastructure), which shall consist of (+ interactive contents) and (+ ICT security), everything resulting in a time-, quality- and cost-constrained digitalization process. With regard to costs, the last sub-topic of discussion was designed to result in an average cost of endowing an average Romanian school a schooling capacity with the necessary technology and specific training so as to deliver qualitative education, but also to have the ability of easily switching from face-to-face education to tele-education if needed.

4. Results

4.1. Digitalization of Romanian Education at the Beginning of the COVID-19 Crisis

Qualitative analysis showed that the digitalization of Romanian schools was very low, as stated by participants: "schools have no infrastructure, no Internet", "teachers' digital competences are obsolete", "some school have no digital infrastructure because of the management" and "no acquisitions for the ICT infrastructure were made in the last 10 years". The implementation of modern technology in learning had been a main objective of education [38] and of all its educational stakeholders, but in fact, ICT had not reached all students. The interviewed IT specialists considered that school management was mainly responsible for the digitalization or the lack of it, indicating that there were schools with no Internet connectivity and as far as they knew, in some remote villages there was not even a working computer in a school: "in schools everything is desired to be digitized and very well developed, but actually the ICT infrastructure is missing" and "each school manages its public funding the way it wants". There are very well-equipped schools with Computer Science laboratories and/or laptops, printers and video-projectors in every classroom and "smartboards in some classrooms". We identified two gaps between schools: rural versus urban (Asymmetry 1) and poor versus rich (Asymmetry 2), "as funding comes from the local council, in rural areas there is no money for schools", "usually only in central urban and high rated schools it is a priority", "teachers bring their own ICT equipment if they have", "people in rural areas are so poor that children don't have any electronic devices" and even in urban areas, there were poor and rich schools. Therefore, school management (Figure 3) emerges both as main factor of progress and obstacle of technological advancement in schools (Asymmetry 3): "each school decides what to buy", "teachers' interest in ICT helps with the introduction of new equipment" and "the school management is influenced by the local management", being the decision factor in accessing funding for infrastructure acquisition and development of human resources and implementing projects of development.

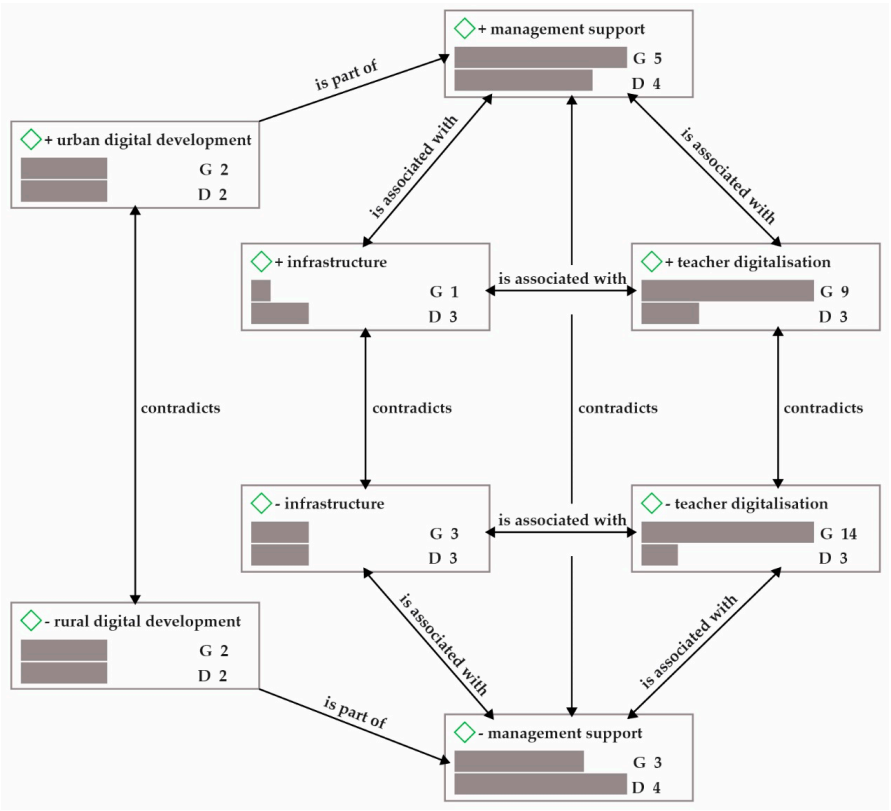

Figure 3. Asymmetries in the Romanian public education's digitalization.

The lack of ICT infrastructure (G = 3) is associated with the poor development of the ICT competences of teachers (G = 14). There are teachers with well-developed digital skills (Asymmetry 4), mainly as a result of their interest in this field (Asymmetry 5): "some teachers are really interested in digitalization" and "they enter their students in various e-contests". However, "many teachers can and use PowerPoint presentations, YouTube films and digital textbooks"; though some participants stated that "these activities are not enough to consider Romanian education digitalized".

The necessary infrastructure relies on the public funding of the school and on the principals' ability to access and attract funding: "the acquisition of ICT equipment depends on the managers' plan and vision", "all acquisitions depend on the local policy makers" and "it depends on the manager to attract funding" (Asymmetry 6). However well-endowed the school is, it comes down to the teachers' desire to use ICT in teaching and, more specifically, to their ability to do so.

In this regard, school management's openness and focus on digitalization shall be cultivated; as two subjects say, sometimes, computers used in some schools were donated by large companies, which renewed their infrastructure, but "students cannot benefit from their use as they might be outdated or out of service" (Asymmetry 7). To conclude, public policy in terms of funding infrastructure is needed after "school management would have done an inventory of ICT-assisted activities to respond to students' and teachers' needs", to increase digital intelligence at the national level.

4.2. Resources Needed to Enhance Digitalization in Romanian Public Schools

From this piece of research, a Romanian school would need three types of resources in order to become digital: logistics (infrastructure in terms of tangible and intangible assets), human resources and financial resources so as to support tele-education (this shows how oversimplified online education is). According to data collected from our subjects, Romanian schools were endowed with infrastructure for ICT activities, "PCs, laptops, video-projectors, smartboards, scanners and printers", especially the primary education levels, but they seemed not to be "enough" (Asymmetry 8).

As presented in Figure 4, infrastructure in Romanian schools is quantitatively centered on hardware: "we have computers but no all are functioning", "donated equipment is mostly outdated" and "old computers are kept"; little focus is also given to software and users' security (students' and teachers' security): "teachers do not know how to use an anti-virus software", "teachers use the Internet without any fear of being hacked", "school management does not support cyber-security software", "20% of the teachers know that they can protect information through antivirus software, but only 1% know the concept of firewall which, in terms of security, provides protection against external and internal attacks on the computer network (I consider the following phenomena very dangerous for students: pornography, theft of personal data, fraudulent use of online catalogs with addition/modification/deletion of information, access and modification of data in work folders) and internal (if a teacher presents online on a smart board a material stored on his phone, a student in the class can attack the network and copy, delete or modify the data of the two devices)" and "most teachers are unfamiliar with services such as software updates and virus scanning" (Asymmetry 9).

Most schools had old infrastructure (G = 6): "not new", "donated" and "second-hand", without the necessary software (G = 4); respondents stated that neither the hardware nor software was "enough" (G = 15). In general, infrastructure was located in Computer Science labs where access was given "only during specialized classes of Computer literacy", as a rule (Asymmetry 10). The lack of licensed software was even more strenuous (G = 5); for example, "the infrastructure was unable to support the security elements, the recommendations were not to make software updates because they would lead to the malfunction of the equipment that does not allow later versions of those initially installed", and the subjects complained about the severe lack of IT security (G = 11) for their work, confidential information and students. Hence, insufficient and/or inappropriate infrastructure, lack of access to infrastructure (kept only for the ICT Lab) and lack of cybersecurity determined teachers "use their own infrastructure" in teaching (G = 6), which clearly underlines the need to implement a national program to massively digitalize Romanian schools.

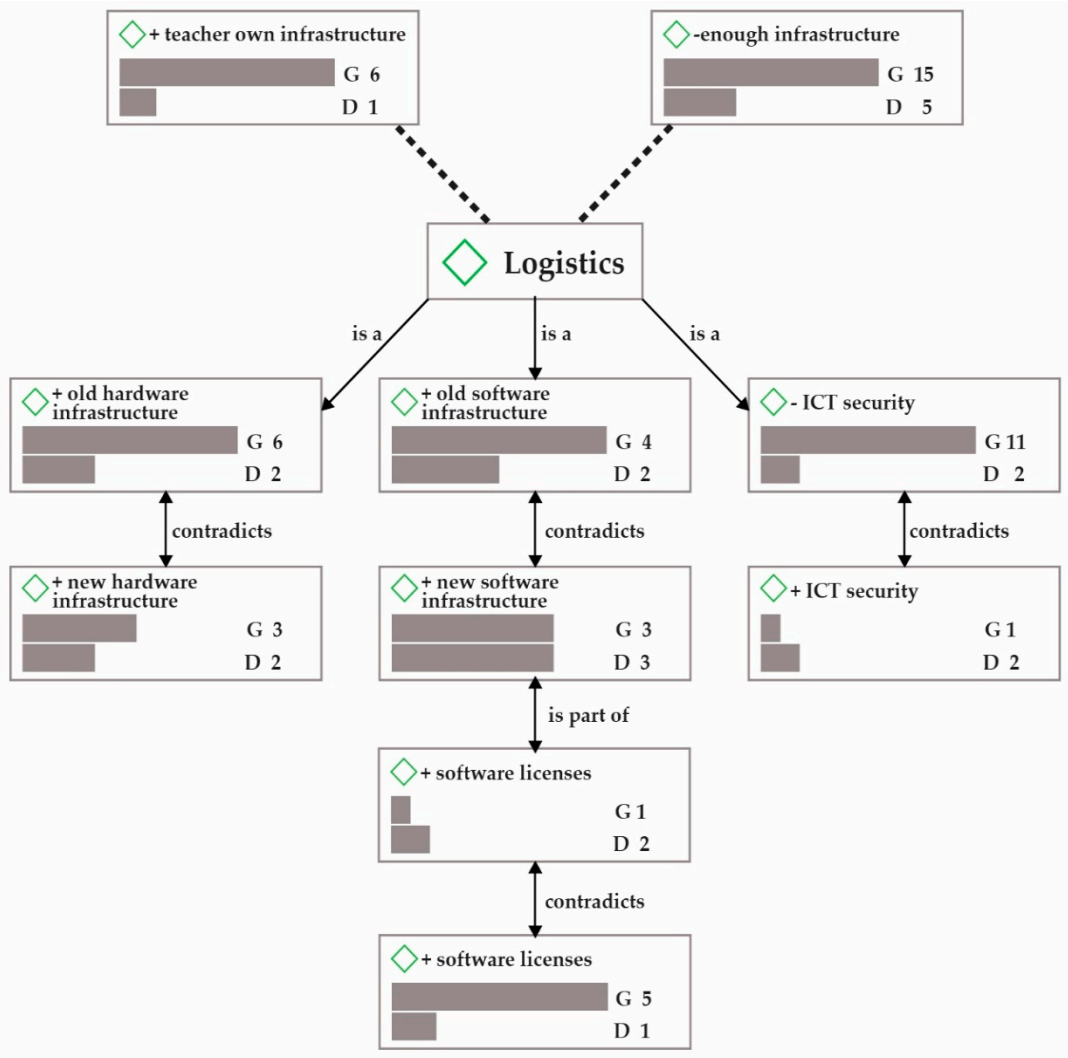

Figure 4. Asymmetries of the logistic resources in Romanian public schools.

Furthermore, a participant underlined that Romanian education lacks the equipment specialized for learning specific subjects (Asymmetry 11), such as science, technology, engineering and math (STEM). Large ICT providers sell a lot of physical devices and online synchronized and asynchronized applications and activities for education use at very affordable costs [39], which may also be purchased within a national program.

With regard to the human resources implied in the digitalization of education (Figure 5), apart from the use of infrastructure that was previously discussed, the respondents offered valuable information on the digital competences of teaching personnel and ICT specialists in order to properly support tele-education: "not all teachers have digital competences or interest towards developing them (especially for those who graduate more than 15 years ago, when ICT was not a compulsory subject matter)" and "teachers lack basic skills—how to save data, send students data by email, copy data to memory sticks or other storage media, such as the cloud (if I talk about the cloud, teachers don't know what it is, what it uses, they have no information about this concept)". Our participants referred to both teachers with very low digital competences and to "very few" teachers who were "highly interested in ICT and STEM" and who "changed whole schools" in terms of digitalization. One subject gave the example of a primary school teacher "who was involved in projects aiming at digitalizing education such as eTwinning or STEM projects" (Asymmetry 12) and "changed lives with innovative education methods offered with devices especially purchased to support them".

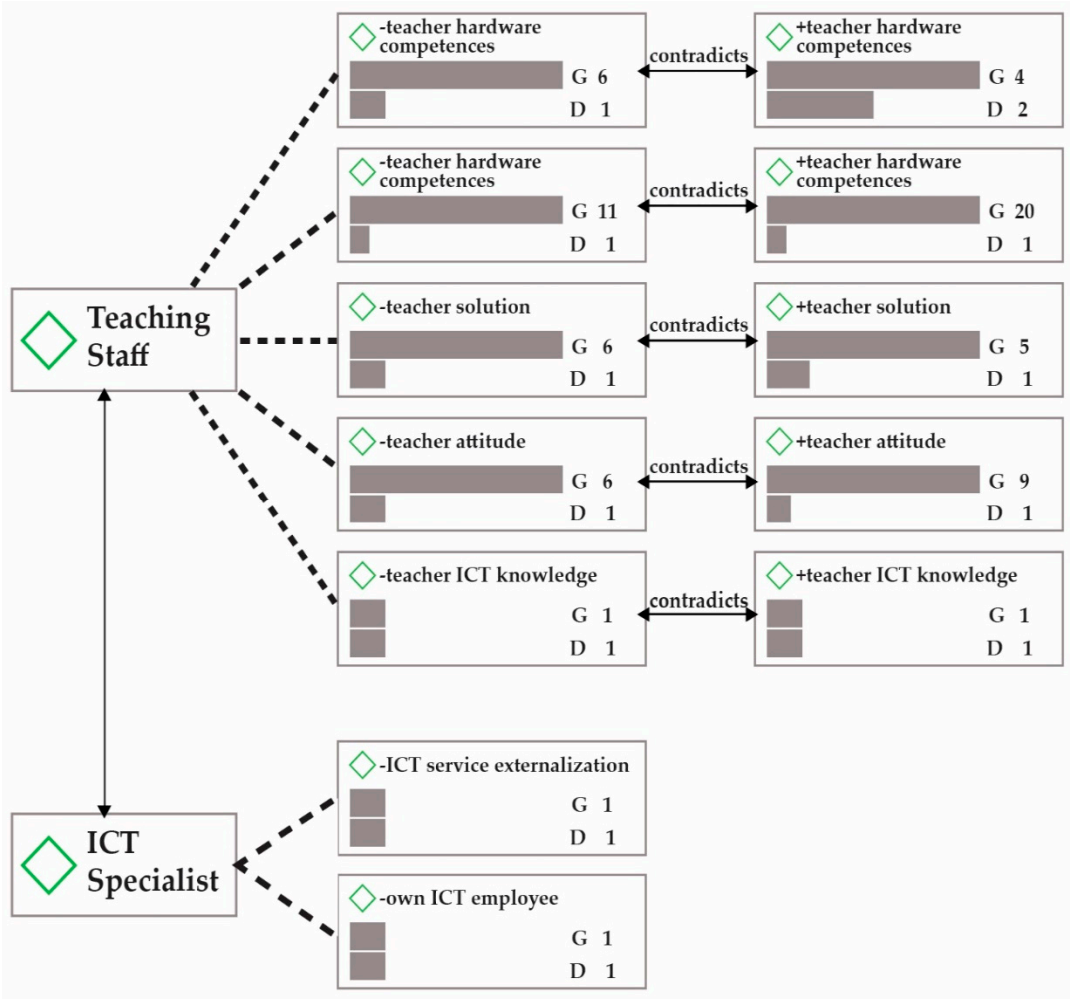

Figure 5. Asymmetries of human resources in Romanian public schools.

Moreover, a subject named three categories of teachers representative for Romania in terms of digitalization: those who have ICT competencies and "do everything themselves"; those "under the age of 35" who do not know and ask for specialized help (they "firstly try by themselves to solve the problem and ask for help only if they do not succeed, they are polite, accept online or remote assistance, offer a period for solving"); and those "over the age of 35 who do not have hardware or software competencies and are not interested from the beginning to have ICT knowledge or to develop their competences" (they are "authoritarian and show a superiority attitude, demanding solutions for their problems, they do not admit improper use of equipment"). Regardless of their age, "50% of teachers are totally disinterested in using digital education".

Teachers are not the only category of staff involved in the digitalization of education. Respondents also spoke about ICT specialists who should "support students and teachers undertaking digitalized activities". Our research showed that IT support (which "could not exist in many schools") was provided in two ways: by having an employee in charge of all the digital aspects of a school or by externalizing serviced to an IT company. Participants highlighted though the need of creating more ICT specialized jobs in public education that shall build a strong education-centered "cooperation between ICT specialist, teachers and students" resulting in an increase in students' learning outcomes (Asymmetry 13).

Furthermore, another major result of this research is that the main obstacle in the digitalization of Romanian schools is the lack of financial resources to acquire the needed infrastructure, increase cybersecurity, make learning interactive and properly develop students' and teachers' digital skills (Figure 6). Investment in digitalizing education shall be realistic in terms of (+time), (+costs) and

(+quality): "massive" and "short-term" investment in "appropriate", "sustainable" and "fair priced" products and services to "match the existent needs of the education system" is recommended by the sample. Two participants even made a forecast of costs to provide immediate access to digital education to a student:

(a) For a school with 25 classes of 25 students, the needs are as follows:

- basic digital infrastructure located in the school: one router and a firewall (Euro 3000), annual licensing (Euro 3900), a switch with management (Euro 1000), one server to keep an e-library, secretarial, accounting work, etc., (Euro 4000), two large printers (Euro 4000), and two small multifunctional printers (Euro 1200). It totals Euro 17,100 (Euro 27.36 per student);
- individual devices for every student (to be used at school or remote): one all-in-one (AIO) unit with licensed software and a mobile Internet device to use both at school and at home (Euro 600). It totals Euro 375,000.

(b) Basic infrastructure of approximately 1500 euro/classroom, "affordable costs for face-to-face education".

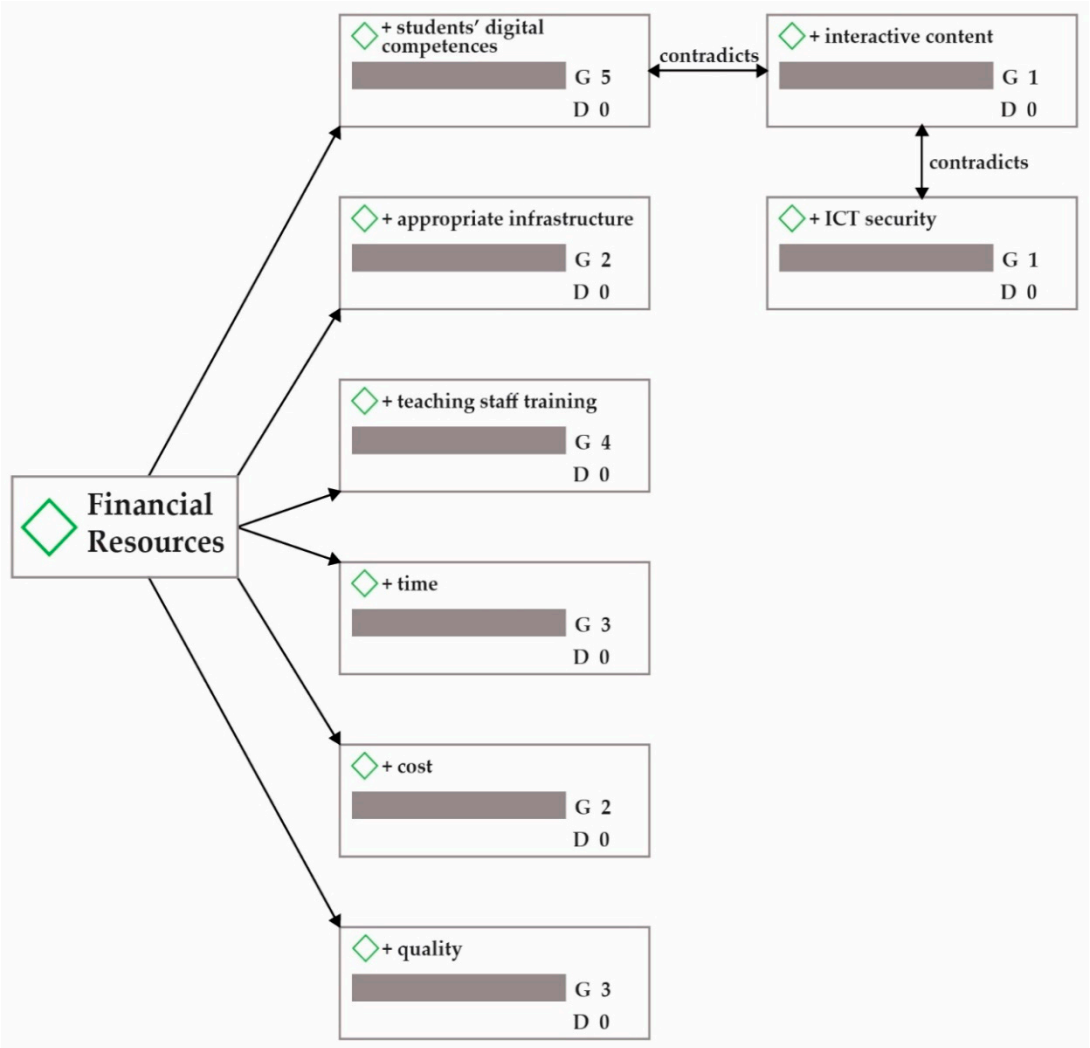

Figure 6. Qualitative analysis of financial resources in Romanian public schools.

4.3. Key Areas for Future Development of Tele-Education in Romania

The three major key areas of development highlighted in this research are the improvement of teachers' digital skills; support for education about applications, software and devices to animate and stimulate learning; and provisioning of fully online education.

The range of competences for further ICT training for the teachers within the Romanian education, which may help them reach intermediate to advance levels of digital competences, were, according to our respondents:

(a) Hardware:

- how to use a specific device: PC, laptop, printer, scanner, smart board and multifunctional projector;
- how to interconnect devices.

(b) Software:

- how to operate Windows, Microsoft Office (Excel, Office, PowerPoint), Adobe Reader and other operation systems and software (general and specific to a specific subject taught);
- how to work with archives, folders, files, etc., on a desktop, on physical devices (CDs, memory sticks, etc.) and in the cloud;
- how to synchronously teach by using online platforms and applications (Skype, Zoom, Google Meet, Microsoft Teams, Discord, WebEx, YouNow, etc.);
- how to use Internet, online platforms and online resources available to provide and produce interactive material, such as videos, music, presentations, digital textbooks, digital handouts, questionnaires, cards, etc.;
- how to update software, clean unnecessary contents, scan computer for viruses and work with cybersecurity;
- how to adjust settings when interconnecting devices (e.g., the resolution).

The teachers' digital skills can be inferred from the kind of support they ask from the ICT specialist. All subjects declared that some teachers could not even connect two devices whereas others had no difficulties in using state-of-the-art devices, these being indicators for the importance of personal involvement in self-development. Some teachers are pro-active in finding new ways to interact with students and to present new materials, they are creative and find solutions to introduce digital learning in the traditional school and, as revealed by these interviews, they bring their own devices to be used in teaching. Their positive attitude towards digitalization makes them find solutions and innovate school systems. However, not all teachers are interested in keeping their teaching updated with the evolution of technology, lacking in interest or having a negative attitude towards it.

Our interviews also revealed that there were surprising facts about ICT development in Romanian schools, one of the subjects calling it the "wow" factor: there are scattered situations of teachers using state-of-the-art technology and bringing their schools to the upper end of the educational offer in schools from all over the world. One subject considered that the real "wow" of Romanian education was represented by teaching staff who were considered hard to be replaced by technology. Participants were all in favour of tele-education, but they said it would never replace face-to-face education and, as one subject pointed out, it should not, as children "need to socialize without ICT and work in teams and groups".

5. Discussion

Our study proposed an innovative research methodology focused on analyzing the asymmetries in digitalization of developing countries. We applied it to Romanian public education in which the shift from face-to-face learning to tele-education forced by the COVID-19 pandemic has brought

major challenges. The results showed that digitalization depended on, one side, on the necessary infrastructure, on the teachers' and students' levels of digital competences and on capabilities of accessing and attracting funding to support digitalization (school management's and ministerial bodies' capabilities); on the other side, it depended on the stakeholders' motivations and needs to keep up with state-of-the art technology and to use and develop the latest digital skills.

For the identified challenges (1—students' lack of Internet connectivity and/or electric power; 2—students' lack of proper ICT infrastructure; 3—students' lack of digital competences or ICT support; 4—teaching staff's lack of Internet connectivity, proper ICT infrastructure and digital competences; 5—legal issues with remote and online job tasks; and 6—cyber risks), there appears to be a need for national infrastructure development (for Challenges 1 to 4), changes in the education curricula (for Challenges 3, 4 and 6) and new legal support (for Challenges 5 and 6).

In our view, these challenges led to an educational crisis. In Romania, the present educational crisis has three major players:

- tele-learners who are or should be/become skilled users of ICT devices;
- educational institutions that are improperly digitalized in terms of infrastructure;
- tele-teaching staff that are low skilled (according to the E-Didactics framework [13]).

Considering that today's students are digital natives, whereas most teachers are digital immigrants [40], the asymmetry is even deeper. However, the concepts of digital natives and digital immigrants imply that digital skills are innate [41] and, therefore, they should or could not be trained, making the differences between these two generations seem too deep to overcome. This is not the reality [41], as in both generations there are people with high and low digital skills. This approach better highlights our findings that in both younger and older generations there are skilled and unskilled users of digital instruments and the difference lies in the individual's digital literacy. We also identified asymmetries in the use of digital skills and infrastructure in learning (Table 4) that need to be addressed at the national policy level as the socio-economic and technical disparities lead to educational disparities and a lack of equality of chances for all students in Romania. The necessary infrastructure is still not enough as tele-teaching requires a completely different set of pedagogical competences than traditional teaching (Comenius's [42]), as well as specific personality traits [43].

Table 4. Asymmetries in the Romanian public education's digitalization.

Asymmetry	Consequences
Asymmetry 1—Rural versus urban (student residence and school location).	**Socio-economic and technical disparities**
Asymmetry 2—Poor versus rich (student wealth and school patrimony).	
Asymmetry 3—Managerial funding versus no funding.	
Asymmetry 4—Developed versus undeveloped digital skills.	
Asymmetry 5—Teachers' high versus no motivation to digitalize.	↓
Asymmetry 6—School management's high versus low capability of accessing/attracting funding.	
Asymmetry 7—High versus low sustainability.	
Asymmetry 8—Educational gaps between primary, secondary and tertiary levels of education (ISCED 1–4).	
Asymmetry 9—Hardware versus software infrastructure and security.	**Educational Disparities**
Asymmetry 10—Full versus no access to infrastructure.	
Asymmetry 11—Gaps between digitalization between taught subjects.	
Asymmetry 12—Extra-work (project management) versus ordinary tasks.	

Although many specialists may call the education required in times of a pandemic online education, in developing countries, it cannot be named so as online education requires not only certain equipment, but also a specific pedagogy. Schooling during COVID-19 pandemic has created a precedent and it will not be so utterly new and unknown to turn to tele-education when there is no longer the possibility of meeting in classrooms. How teachers started developing ICT skills during this period is a topic that needs to be addressed in further research as well as its impact on students and their parents.

The need for a digital school is also triggered by an exponential development of devices that can help or induce learning. Students learn best when they use virtual environments that bring the real world into the classroom. Technology must be embedded in teaching and the key words should be interactive (during a tele-class, real-time dialogue can emerge between the educational actors, teachers getting the students' feedback and responses instantly and responding to their questions, too, using the digital tools offered) and personalized (teaching/learning tailored to each student's personal interests, while the learning situations are offered to all students using the same contents and methods).

Tele-education development, regardless of the name of the concept used, will further advance the research of ICT product design, development, production and promotion to address the educational needs of specific individuals and to reduce the lack of symmetry.

6. Conclusions

To conclude, the teaching and learning process, accompanied by assessments, have undergone a profound change in Romania during the latest pandemic, challenging the core of the education system, which, like in many developing countries, used to be mainly face-to-face education. Teachers and all the other education stakeholders had to face the students' readiness to learn in virtual environments as opposed to many teachers' reluctance to teach in virtual environments. The entire teaching and training system should be rethought so as to include e-didactics—a new topic absolutely necessary for educating future generations.

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