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COMPUTER SCIENCE EDUCATION, ZONE OF PROXIMAL DEVELOPMENT FOR PRIMARY SCHOOL PUPILS

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Abstract

It is currently under discussion the imminent digitalization strategy of education in Romania. Our interest was to collect a set of indicators of the skills and motivations expressed by the first grade pupils in the interaction with digital and which also reflect a level of development on this dimension. These data, related to other international curricular approaches, could be an argument or a future vision on the depth and organization of content, on in-depth levels, so that they can be delivered at the level of Romanian primary education through computer science education. Indicators of the presence of pupil digital skills, as input in primary education, were considered in relation with the current zone of actual development (ZAD), reflecting the potential and premises for developing an elementary level of digital competence, as output and zone of proximal development (ZPD) in primary education. These aspects of micro-research, together with theoretical considerations, advise us to place computer science education in the zone of proximal development for primary school students. The data were collected through the opinion of the parents of first grade pupils, who played the role of learning partners of their children, in a school semester conducted online, under the restrictions marked by the Covid-19 pandemic.

Keywords: Computer science education, digital education, primary school, zone of proximal development, zone of actual development

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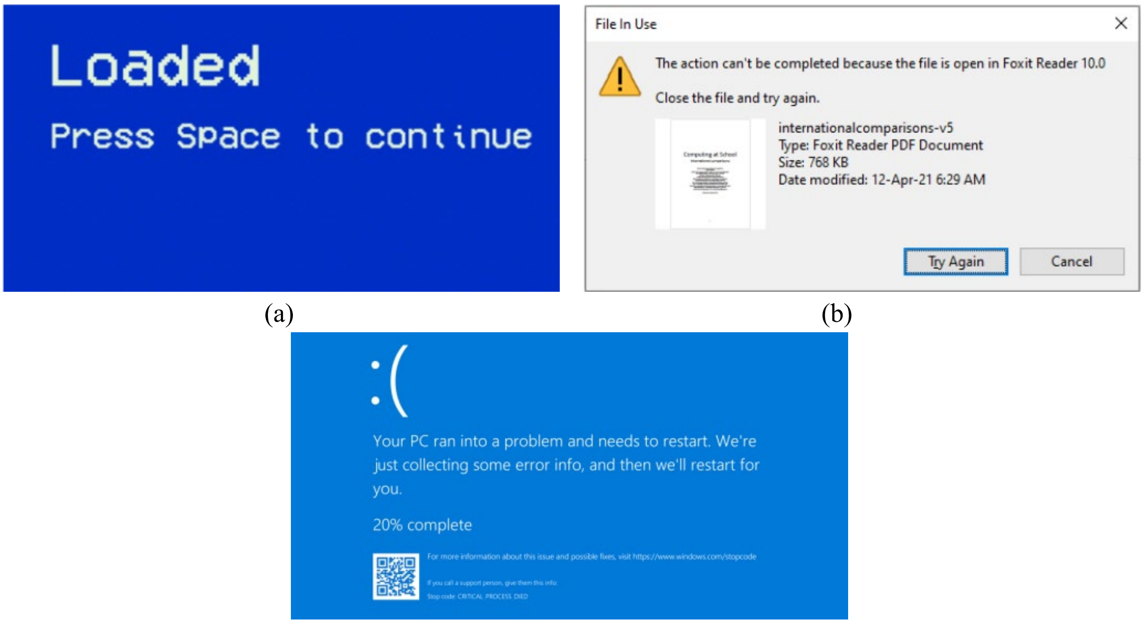
1. Introduction

With the advent of computing, society benefits from solutions to various problems that were not solved in the past, but digital technologies bring with them new types of problems and difficulties, arising even from their use or operation, which must be overcome to make this loop work efficiently, continuosly: digital technologies solve the problems of individuals, and individuals manage and solve the problems they face with the digital technologies. These aspects related to the functionality or stringing of digital technologies are transmitted to us by the computer through messages, warnings or errors such as those displayed in the Figure 1:



(a) (b)

(c)

Figure 1. (a) & (b) & (c) Three cases of messages in computer-human being communication

In this way and in many other ways, the computer communicates with us and we have to react because:

> Computing is now ubiquitous. It facilitates, shapes, and enhances most aspects of our lives. And while it is difficult to predict the future, it is safe to surmise that individuals who do not understand computing or how to harness its power for human good are far more likely to be excluded from its potential benefits. (Gal-Ezer & Stephenson, 2014, p. 2)

Thus, individuals who do not speak computer language will be deprived of the benefits that can be offered by it, referring to the use of power conversion, from the power of digital technologies to human power.

The use of the computer and the adaptation to its thinking and language aims and includes even young school children, all the more so as Prensky (2001) calls the new generations, digital native generations, because "kids born into any new culture learn the new language easily, and forcefully resist

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using the old" (p. 3). As it becomes a kind of mother tongue, those who manage to develop it, to know more than what comes with the experience of handling digital devices, to know how it works what they are using, it is more plausible that it can harness the benefits that digital technologies are offering to subordinate it to personal purposes. Inevitably, the immersion of digital in education takes place and "future content is to a large extent, not surprisingly, digital and technological. But while it includes software, hardware, robotics, nanotechnology, genomics etc., it also includes the ethics, politics, sociology, languages and other things that go with them" (Prensky, 2001, p. 4). This shapes digital education, which means more than using this equipments, hardware or software, because this aspect is imminent, it means learning about digital equipment, along with the implications of using it. Learning about and using digital technology is translated into priorities at EU level, which are expressed as follows in the *Digital Education Action Plan* (2021-2027) (European Commission, 2020a):

- "Priority 1: Fostering the development of a high-performing digital education ecosystem";
- "Priority 2: Enhancing digital skills and competences for the digital transformation".

The two priorities reflect the two different but complementary perspectives of *digital education*, an expression defined and used to highlight: "the development of learners' and teachers' digital competences on the one hand, and the pedagogical use of digital technologies to support, enhance and transform learning and teaching on the other" (European Commission/ Eurydice, 2019, p. 20). While digital education encompasses both perspectives and both mentioned priorities, computer science education is limited to the formation of digital skills, and strategic priority no. 2, aiming for an increased level of depth because "computing education in schools allows young people to gain a sound understanding of the digital world" (European Commission, 2020a, p. 13) and then the proposed path is "introducing pupils to computing from an early age" (European Commission, 2020a, p. 13). This provides continuity for the projection made through *Digital Education Action Plan (2018-2020)*, which specifies the same needs, where "acquiring digital skills needs to start at early age and carry on throughout life" (European Commission, 2018, p. 7), and for this a suggestion is to "bring coding classes to all schools in Europe, including by increasing schools' participation in EU Code Week" (European Commission, 2018, p. 9).

The report on *Digital education at school in Europe*, at the level of 2019, shows about one of the 21 specific competencies of the DigComp framework, ie *3.4 Programming* from digital content creation competence area (Carretero et al., 2017), that "while less than half of the European education systems explicitly include this competence in terms of learning outcomes in primary education, around 30 countries do so in lower and upper secondary education. It is the third most frequently referred to competence coming after *digital content creation* and *evaluating data, information and digital content*" (European Commission/ Eurydice, 2019, p. 11). Thus, from the 43 European education systems covered by the report, 28 of them being EU Member States, almost half address a rigorous content of computer science education since primary education.

For example, in France, according to the same Eurydice report, "Digital competence is defined along two lines. The first refers to it as a language: programming languages and algorithms. The second refers to it as a tool, namely to use digital technologies to search and access information and to produce digital content" (European Commission/ Eurydice, 2019, p. 26).

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Broadly speaking, according to the EU Council, digital competence is a set of knowledge, skills and attitudes with multiple functions and transferable into learning and work contexts, where knowledge refers to those ideas and definitions needed to "understand the general principles, mechanisms and logic underlying evolving digital technologies and know the basic function and use of different devices, software, and networks" (European Council, 2018, p. 9). Starting from the general principles to the mechanisms and logic underlying digital technologies, an in-depth level of the digital competence approach in education is described.

Digital competence in the set of key competences, promoted by the EU Council Recommendation, underlies the conceptualization of the *Digital Competence Framework for Citizens* (DigComp) which starts from the reasoning that being digitally competent is a task for the 21st century. DigComp 1.0, launched in 2013 and updated to version 2.0 in 2016, respectively 2.1 in 2017, provides a conceptual reference model for digital competence which, at national level, is found in the form of actions in the action plan of the proposal for public debate, for the *Strategy on the digitalization of education in Romania 2021-2027*, as well "Promoting DigComp as a minimum standard in the assessment of digital skills" (Romanian Ministry of Education and Research, 2020b, p. 45).

In detail, digital competence according to DigComp is organized around 5 areas of competence that include 21 distinct competences. The 5 areas of competence are: Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Safety and Problem Solving (Carretero et al., 2017). These areas are explained more specifically through 21 distinct competencies. Some of them are closer to the skills of digital native students, such as: 1.1 Browsing, searching, filtering data, information and digital content, 1.3 Managing data, information and digital content, 2.1 Interacting through digital technologies, 2.4 Collaboration through digital technologies, while others require a higher level of in-depth knowledge, for example: 3.4 Programming or 5.2 Identifying needs and technological responses. DigComp update 2.1 does not change the 21 competencies, but explains them on 8 levels of skill that take into account the complexity of the tasks, the autonomy of the person involved in the task and the type of cognitive effort that underpinnes the task approached, which represents the internal or vertical coherence within a competence.

The Eurydice report also gives us data on the approach to digital competence in primary education in Europe and shows us that out of the 43 education systems analysed:

> In 11 education systems, digital competence is addressed as a compulsory separate subject and in ten it is integrated in other compulsory subjects. A quarter of the education systems combine two approaches, while in Czechia and Liechtenstein all three exist at the same time. (European Commission/ Eurydice, 2019, p. 28)

Cross-curricular theme, integrated into other disciplines or separate discipline. Thus, DigComp teaching can be achieved through one, more or all disciplines.

As for digital natives, the grid which students once assessed reality with, is today an algorithm that includes the use of digital technologies or is implemented on them. Thus, development for life and for the future depends on the development of digital competences and more specifically the ability to do

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programming. The emphasis on this element of digital competence is specific to computer science education.

1.1. Worldwide computer science education mapping

Analyzing 14 articles about the peculiarities of computer science education in 12 countries, Hubwieser and collaborators have "found 40 different terms for fields of computing education" (Hubwieser et al., 2015b, p. 70). These terms were grouped into 5 categories, terms referring to: name of study discipline, processes within the discipline, technological aspects, education and educational objectives. For each of these categories we will select, in Table 1, only those terms relevant to the present micro-research:

Table 1. 9 of the 40 terms for fields included in computer education (Hubwieser et al., 2015b)

Academic discipline	Processes within the discipline	Technology aspect	Education	Educational goals
Computer science	Computing	Digital technology	Computer science education (CSE)	Digital literacy (DL)
Informatics	Programming	Information and communication technology (ICT)		Computational thinking

A synthesis of the Hubwieser et al analysis show that countries such as Korea and the UK see the phrase of computer science education as a compound of three areas: digital literacy, ICT and computer science. A similar situation is in France, with the difference that the term computer science education includes only two components: ICT and computer science (Hubwieser et al., 2015b).

In the UK, starting with 2015, the new form of the curriculum is applied where, at the process level, ICT is rebranded in *Computing* and "The National Curriculum for Computing incorporates the teaching of Computer Science as compulsory from ages 5–16" (Brown et al., 2014, p. 9), so including the primary education. At the content level, three areas of the curriculum oriented towards computing are crystallized: computer science (CS), information technology (IT) and digital literacy (DL) (Berry, 2013).

From the structure point of view, computing makes that three domains to relate and interfere: CS, IT, DL. By analogy, computing is structured on a design that crosses three objects of study, if a comparison is allowed, similar to mechatronics (electronics, mechanics and computer science).

According to Berry, this way of thinking about computer science education, as a whole, is to look at CS as fundamentals, ICT as application and DL as implications of computer science. In detail, he describes these areas like:

> [All pupils] can understand and apply the fundamental principles and concepts of computer science, including abstraction, logic, algorithms and data representation. (CS) | [All pupils] can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve such problems. (CS) | [All pupils] can evaluate and apply information technology, including new or unfamiliar technologies, analytically to solve problems.

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> (IT) | [All pupils] are responsible, competent, confident and creative users of information and communication technology. (DL) (Berry, 2013, p. 5).

Continuing the comparison of the vision on the terms of computing education, in the articles analyzed by Hubwieser et al. (2015), we find that other states appeal or would prefer to teach the contents of the IT field in an integrated manner within other disciplines: Russia and Finland.

> In the Finnish paper the term CS refers to the scientific aspects of the discipline. … Moreover, the paper refers to the opinion that ICT should be integrated in all existing subjects and should not be taught as an independent subject. … In elementary schools [în Rusia], elements of Informatics are taught within the subjects *Mathematics* and *Technology.* (Hubwieser et al., 2015b, p. 72)

According to the same study, it is revealed that in some situations, terms such as CS, informatics, computing, ICT and DL are seen as synonymous. In Russia and the Bavarian region, CS and informatics are perceived as synonyms, in Israel CS, computing and informatics are seen as synonyms, and in India CS, informatics, ICT and DL are also seen as synonyms.

> The authors of the paper [regarding the situation in India] mention the concern that the interchangeable use of the terms CS, Informatics, ICT, and digital literacy creates the illusion that CS is already being taught and integrated at the school level. (Hubwieser et al., 2015b, p. 72)

After all, computer science education is a must to intellectually involve the digital generation and states like "Australia, USA, UK, have committed or initiated computer science as a subject, whilst the Czech Republic, Denmark, Lithuania, Poland and the Netherlands are in the process of doing so, mostly from the first classes of primary school" (Fluck et al., 2016, p. 43). Meanwhile:

> In Poland, the new core curriculum on digital education includes the introduction of programming from the first grade of primary school. The recommendations include the use of ICT skills in classes other than computer science and increasing the number of teaching hours for computer science. (European Commission/ Eurydice, 2019)

As for the purposes of this curriculum published in 2015 and applied since 2016, "one of the goals of the Polish curriculum is to motivate students to go *beyond the screen* and investigate how computers work and how software is designed so they can create their own solutions" (Balanskat & Engelhardt, 2015, p. 17). In Korea "universities of education teach all the subjects that students in elementary schools learn, including CS" (Hubwieser et al., 2015, p. 78).

The importance of programming is recognized and supported at the level of European forums, an example being the annual event *European CodeWeek*, launched in 2013 by the European Commission and which enjoys, from the schools, of an interest that grows from year to year, reaching in 2019 the involvement of schools in over 80 countries with over 4,200,000 participating students. According to the

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official website https://codeweek.eu, “the average participant was 11 years old and 49% of participants in 2019 were women or girls. 92% of EU Code Week events took place in schools” (European Commission, 2020b). More detailed statistics, on the editions made between 2015-2019, are presented in the Figure 2:

Figure 2. CodeWeek event in numbers (2015-2019): countries, participants and activities (European Commission, 2020b)

The integration of computer science education in primary school, at a global level, is on an increasing trend and firm opinions wich say that “we are convinced that learning programming on an adequate level of abstraction is a very effective didactic approach to Computational Thinking, independent of the age of the pupils” (Serafini, 2011, p. 143) become palpable. Computational thinking becomes valuable by the fact that is subordinated to curricular policy principles such as the principle of relevance and connection to social, shaping this cognitive ability is opening professional perspectives in the economy of the future and to the principle of student centered learning, by offering to the children a holistic approach to learning from the cybernetic perspective of reality, from the point of view of the common aspects in the functioning of technical/ digital systems and organic systems. Moreover, a study that investigates and highlights the reasoning behind the importance of introducing programming into the curriculum, also highlights how “computer science lessons should prepare students for further study instead of leaving them satisfied with the knowledge and skills they have already learned” (Balanskat & Engelhardt, 2015, p. 17).

1.2. The Romanian pupils’ debut in computer science education

At the end of 2020, the document of educational policies was approved at national level, by ministerial order, as a Reference Framework of the National Curriculum in Romania, named *Guidelines for designing, updating and evaluating the National Curriculum* (Romanian Ministry of Education and Research, 2020a). It outlines the framework for restructuring and implementing the curriculum where its vertical coherence is outlined by the profile of the graduate at various levels of schooling in relation to the key competencies defined by the 2018 EU Council Recommendation. This framework is the result of long-term efforts and continues the systemic perspective of *Educational policy document* (Romanian Institute of Educational Sciences, 2015) presented by the Institute of Education Sciences in 2015, as a working version, both forms having a similar vision on the development of digital competence, focused on the use of digital devices and the creation of digital content, in learning contexts, respecting safety rules in the digital environment and differentiation of capacities in approaching the degree of difficulty of

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work tasks and content, on an axis from simple to varied, in the expectations that the system has towards primary and secondary education graduates. What brings the new final form of the educational policy document, on the dimension of digital competence, are the additional descriptors: “applying simple rules of collaboration and interaction in online communities” (Romanian Ministry of Education and Research, 2020a, p. 60), for the elementary level of development associated with the profile of the primary school graduate, respectively “manifestation of active citizenship through interactions and collaboration in digital environments” (Romanian Ministry of Education and Research, 2020a, p. 60), for the functional level of development associated with the profile of the secondary education graduate.

Specifically, in the current operational plan, digital competence is approached in Romania starting with secondary education, but it is approached in a rigorous way, in a form that allows the deepening in computer science education. ”Through OMENCS no. 3590/05.04.2016, the Curriculum Framework for the gymnasium was approved, which provides the introduction beginning from the next school year, of the subject *Informatics and ICT*, as a compulsory subject in the gymnasium, having allocated one hour per week. In the process of curricular development for all subjects in the gymnasium, the school curriculum for the subject *Informatics and ICT* was also elaborated (approved by MEN Order no. 3393/28.02.2017)” (Romanian Ministry of Education and Research, 2020b, p. 17).

According to the MENCS Order no. 3590/05 April 2016 on the approval of the curricula for secondary education, the new discipline *Informatics and ICT* belongs to the category of compulsory subjects, of the common core, in the category of curricular area Technologies. The time budget of 1 hour/ week is allocated throughout all years of schooling for the level of secondary education, from the 5th grade to the 8th grade. The discipline of *Informatics and ICT* aims at the development of some “skills for efficient use of computing and communication techniques, development of critical and creative spirit through the development of digital products, construction of algorithms for information processing” (Romanian Ministry of Education, 2017, p. 2). Thus, it contributes to the development of digital competence, part of the set of key competences for lifelong learning, which is promoted by the EU Council Recommendation of 22 May 2018.

But, regarding the educational process as a whole, horizontally, at the level of each year of study, “most students do not have access to a computer or mobile device during classes, and when this happens it is almost exclusively during *Informatics and ICT* hours” (Romanian Ministry of Education and Research, 2020b, p. 18). In order to improve these aspects and put them into practice, including at primary education level, the proposal for public debate on *Strategy on the digitalization of education in Romania 2021-2027,* provides in the operational plan of measures, on segment no. I., of the Strengthening of the acquisition of digital competences by all pupils and students, at point 1.2 “Introducing in the primary education curriculum some elements of compulsory and novelty character aiming the acquisition of digital competences, in accordance with the development profile specific to this level” (Romanian Ministry of Education and Research, 2020b, p. 21) and in point 1.3. “Elaboration/ revision of the curricula for the *Informatics and ICT* discipline, for the secondary education level, simultaneously with the capitalization of the elements of digital ability of the students at the level of all the curricula specific to the other study disciplines” (Romanian Ministry of Education and Research, 2020b, p. 21).

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"Because of the student-centered nature of CS work, keeping all students engaged and focused in the course content can be difficult" (Yadav et al., 2016, p. 241) and this remark, which supports the perspective of capitalizing on the elements of digital ability for students in all school curricula, refers to those moments when students are involved in offline activities, being aware that next to them are computers connected to the Internet that attracts them. The conclusion of the statement is that computer science has the advantage of keeping digital generation students involved and connected.

1.3. Zone of proximal development

The concept of Zone of Proximal Development (ZPD), introduced by Vygotsky, marks the ZPD as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers" (Anderson & Gegg-Harrison, 2013, p. 496; McLeod, 2019, p. 1).

Also:

> The ZPD emerges as a zone of human development, the frontier territory which we have become familiar with, through the work of Vygotsky; the territory where we can find the links between the situated-embodied mind and the cognitive mind, the individual mind and the social mind, the development already attained and the development to be attained. (del Río & Álvarez 2007, p. 301)

Focused on this frontier territory that has the links in human development, before and after a temporary moment, "Vygotsky called the rarefied area between a learner's present performance level and just beyond the learner's grasp the zone of proximal development. In his research, he observed optimal motivation in his study participants when they were asked to reach just beyond their present state" (Silver, 2011, p. 30). Therefore, this area of imminent development resonates with an optimal level of motivation, involving students to step beyond the border already visible in their own development. "Thus, the term proximal refers those skills that the learner is close to mastering" (McLeod, 2019, p. 1).

ZPD theory is a lasting concept, things unchanging so far, over time, what differs today, at students, compared to 50 years ago, is their background shaped by the digital technologies that they use daily. Because every student, in the informal and non-formal environment, interferes with different types of digital technology "the ZPD is unique to each individual, and varies according to her capabilities and the environment and context in which the development is occurring" (Anderson & Gegg-Harrison, 2013, p. 496). From this point of view, each student having an experience and a different level of development on the dimension of digital competence, more skilled colleagues have a strategic role in the classroom.

ZPD has instructional implications, for this reason we refer to ZPD in the perspective of approaching computer science education for primary education, the more so as Vygotsky's statement, reiterated by Shabani et al. (2010) and collaborators, says that teaching guidelines must be focused "not on yesterday's development in the child but on tomorrow's" (p. 244), that includes today the use of digital technologies for future development.

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"Vygotsky formulated the concept of Zone of Proximal Development in order to deal methodologically with the need to anticipate the course of development. This appears in principle a simple idea, requiring nothing more than fixing a particular point in a general sequence of development" (del Río & Álvarez, 2007, p. 280). In the case of the present micro-research, we will look at this particular point, in the general development sequence of primary school pupils, in relation to computer science education.

"The traditional testing reflected only the current level of learners' achievement, rather than learner's potential for development in future .The zone of actual development (ZAD) does not sufficiently describe development. Rather, it reflects what is already developed or achieved" (Shabani et al., 2010, p. 239). Therefore, ZAD describes the development up to a certain point, up to the present moment, referring to the current level of performance, which is delimited by ZPD through that border territory where it is realizing the links between the level of development already accessed and the level accessible through a more or less minimum of support.

2. Problem Statement

Hubwiser and the coauthors recall the British Royal Society (BRS) report, *Shut down or restart? The way forward for computing in UK schools*, published in January 2012, which mirrors the concerns about computer science education policies in the UK, at that time. "This report raised important issues on K-12-CSE, caused significant political awareness, and most importantly, led to initiatives of reintroducing Computing in schools with rigorous contents of Computer Science" (Hubwieser et al., 2015a, p. 3). The emphasis on informatics or on a certain level of development of digital competence is the first issue to be analyzed, and the second is the one related to the terminology used internationally.

About the last issue:

> In accordance with many other countries, in India there is also a confusion regarding the name and nature of the subject called *Computer Science* in K-12 education, since terms like CS, Informatics, ICT, and digital literacy are used interchangeably—without any difference in their actual meaning. (Hubwieser et al., 2015a, p. 4)

A schematic comparison of how some terms in the field of computer science education are used as synonyms, in certain areas of the world, is made by Hubwieser and the team and is illustrated in the Figure 3:

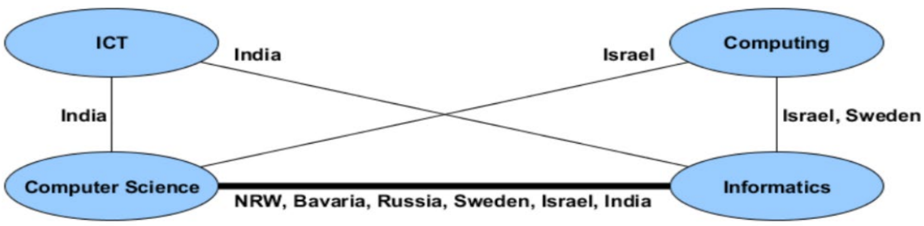

Figure 3. Synonymously used terms in some countries (Hubwieser et al., 2015b, p. 73)

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Even more, "computer science is typically confounded with other subject areas, such as Technology Education/Educational Technology, Industrial or Instructional Technology, Management Information Systems, or even the use of computers to support learning in other subject areas" (Yadav et al., 2016, p. 237).

To the terms of Hubwieser et al. (2015b), if we add the term digital education, as considered in Table 2, through which digital competence is addressed at EU level, the issue of interfering with the terms expands.

Table 2. Digital education, a term added to the list of Hubwieser et al. (2015b) as a field related to computer science education

Academic discipline	Processes within the discipline	Technology aspect	Education	Educational goals
Computer science	Computing	Digital technology	Computer science education (CSE)	Digital literacy (DL)
Informatics	Programming	Information and communication technology (ICT)	Digital education	Computational thinking

By placing the student in this matrix of digital education, there also are opinions which state that: "today's primary-age children are not digital natives and so cannot be expected to have gleaned or absorbed the attributes necessary to easily use digital devices or learn computing simply from having grown up in the digital age" (Larke, 2019, p. 11). Then, there is the problem of delimiting the boundary between what current generations of students can and cannot do, respectively between ZAD and ZPD, and thus the problem is led to the levels of deepening in computer science education, to the vertical coherence of digital competence, actually on levels of education and this issue is deepened in a library of terms in the field of computer science education that are seen as synonymous. It is plausible that the term digital natives resonates with a lower level of depth, namely digital literacy and in some cases interspersed with ICT and then the attributes acquired by growing alongside digital technology represent a potential available and exploitable through an in-depth superior level of knowledge, computer science. It is these aspects that have led to the shift in emphasis, in the British curriculum, from ICT to computer science/ programming.

Regarding the previous curriculum, "while digital literacy skills are useful for most contemporary jobs, England's ICT program during this period added little value to students'education. The Royal Society (2012) concludes that students would likely have learned digital literacy skills by themselves without school instruction" (Fowler & Vegas, 2021, p. 5). Given that digital literacy tends to be achieved more without the input of the school, it is important to set priorities according to the needs of students, and for this reason, "for the last two decades university CS departments have been utterly disengaged from school ICT, because the subject was of no interest or relevance to them" (Jones et al., 2013, p. 10), ICT has been rebranded with *Computing* in the United Kingdom National Curriculum. The 2012 report of the Royal Society, an institution founded in 1660, which promotes science and which Isaac Newton was a member of (Jones et al., 2013), also notes that:

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> ICT was suffering from a problem of a worsening reputation among pupils and other stakeholders for being dull and unchallenging [Royal Society 2012] and being regarded as a low-value discipline, especially compared to other STEM subjects. With ICT now embedded across the curriculum at primary schools in the UK, pupils in secondary school increasingly found ICT unstimulating if they already had the skills that were being taught. (Brown et al., 2014, p. 2)

This reasoning is not singular, because “this new focus also suggests a conscious shift in some countries away from a focus on students’ ICT user skills in traditional ICT subjects, towards an approach as part of computer science subjects that focuses on teaching underlying computer and design principles and puts students in a role where they create their own programs” (Balanskat & Engelhardt, 2015, p. 15). With the rebranding of ICT in *Computing*, the topic or emphasis placed within the discipline has changed and (Department for Education) “the DfE now understands and supports the importance of Computer Science, as a school subject that every child should learn at least at an elementary level, with opportunities for later specialisation” (Jones et al., 2013, p. 11). “UK have had a long history in the integration of ICT in schools, and shifted the focus to coding and computer science in 2014. Portugal had already done so in 2012” (Balanskat & Engelhardt, 2015, p. 37).

To capitalize this type of approach:

> We believe that play for a child or an adult, as well as specifically for a computer science student includes two key factors. The first is exploring something that is relevant and interesting to the individual, and the second is doing this in a social environment. (Anderson & Gegg-Harrison, 2013, p. 499)

Thus, the development of digital competence is integrated into ZPD theory, because the exploration of something that is interesting exceeds the limit of the current proformance level, ie ZAD.

Signs that the potential level of development of young students, on the line of digital competence, exceeds the characteristics of digital literacy and ICT are multiple. Another example in which the workload is added to the ZPD comes from Switzerland, where “we focus on our school projects aiming to introduce primary school pupils to Computational Thinking by teaching them how to program. The pupils usually attend grade 3 to 7 and are roughly between 8 and 13 years” (Serafini, 2011, p. 143). Also as an example “in Korea a new specification is being announced that will include computing as a subject in all primary schools from 2018” (Hubwieser et al., 2015b, p. 79). All of these are examples with well-articulated purposes that include rigorous computer science content in a discipline dedicated to developing a high level of digital competence.

The importance of setting priorities according to the needs of students is also visible in Romania, where studies based on the online educational process, during the Covid-19 pandemic, show that:

> Although the views of students, parents and teachers on students digital competences are divergent, there is still a need to develop them, especially for primary and secondary school

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students in rural and small urban areas, and the importance of ICT discipline within the national curriculum. (Romanian Ministry of Education and Research, 2020b, p. 20)

The way in which will be introduced, in the primary education curriculum, those elements of obligatory and novelty character that aims the development of digital competence, referring to the possibilities of approaching digital education, is interesting, but also problematic, thinking to the level of deepening of knowledge in an extended range of terms for specific fields of computer science education, correlated with the age peculiarities of the students, particularities reflected in ZAD and ZPD.

Than "we therefore promote the idea that a computer science subject relying on Computational Thinking should be mandatory at every school stage, including the primary school" (Serafini, 2011, p. 145).

3. Research Questions

Starting from the assumption that if the current generations are digital natives and have a baggage of digital literacy and use of electronic devices, this representing ZAD, then what is motivating and useful for these generations is that teaching and learning to target the potential level of their development, equivalent to ZPD, by deepening the knowledge of computer science education, this being the hypothesis of this mini-research.

The research questions take into account the digital skills and preferences of first grade students, correlated with the usefulness of digital technologies in capitalizing on such indicators, so as to ensure consistency horizontally, within digital competence, on an axis from ZAD to ZPD (vertical coherence being handled by DigComp 2.1.).

Do primary school students show, from the first grade, skills and interest in the digital field, so that a ZAD that supports the idea that they are digital natives is highlighted? If the answer to the first question is Yes, then these indicators (skills, digital preferences and educational needs) are, in turn, indicators for the need for deeper understanding of new technologies, from the principles underlying their use to concepts that are based on the operation of the tools. Then a second question arises: rigorous content, at a higher level of depth, but accessible to the age peculiarities of primary school students, with support from more advanced colleagues or guidance from the teacher, to which areas of computer science education should focus?

4. Purpose of the Study

Each new generation seems to be able to do more. However, the limits must take into account the principle of correlation with the age peculiarities of students and "we need to be talking about something of interest in an environment that motivates them and it needs to be concepts that the students are capable of understanding" (Anderson & Gegg-Harrison, 2013, p. 495) and to be motivating we have to refer to ZPD.

The aim of this micro-research was to take indicators for the presence of pupils digital skills (ZAD), as input in lower levels of primary education, prerequisites for the development of an elementary

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level of digital competence, as output in primary education. We consider this output in relation to the potential of first grade students, with their zone of proximal development, outlining the second objective in the sphere of deepening levels of knowledge and looking for a meaning, if not a consensus, for specific terms in specific areas of computer science education that are sometimes used interchangeably.

Then, we find a starting point for students, in relation to digital competence, to determine what recommends them to study, at the level of primary education, fundamental concepts in programming, which are currently taught, at national level in Romania, in the seventh grade. Therefore, the purpose of this micro-research, correlated with input indicators and output expectations in primary education, is to capitalize the potential of pupils to maximize their level of development, based on teir own available resources: skills and motivations/ preferences. Given that the educational system in Romania is a competitive one, we also propose to consider performance in a different way. As in the automotive field, a performance criterion of the produced vehicles refers to the times when they reach 100 km/h, wich means time when they reach higher levels of their potential, we propose the similar conceptualization of considering the performance of the education system and implicitly the generations educated through the educational process. The invoked performance refers to the time required for pupils in state education schools to operationalize certain objectives, established by the specific competencies of the discipline of Informatics and ICT, taught in high school, associating them with ZPD of primary school pupils. Reaching higher levels of one's own potential, on this time axis, would mean orienting towards the programming paradigm and not being bound to a certain programming language, for example, mastering from the level of primary education of some programming concepts taught in the seventh grade, which should also reflect qualitative changes through the development of transversal skills with which future adults can address future challenges of the digital age, which come daily and need updates.

5. Research Methods

There was no better time to analyze pupils activity in the computer interaction than the one determined by the global epidemiological situation caused by the Covid-19 virus. A questionnaire was applied at the end of the first semester, between February 1st-10th, 2021. The participants were the parents of first grade students from a single school in the urban area, Cluj-Napoca. The educational activities carried out by the students depended by the online environment, in the first 4 weeks of school the classes operated in the hybrid teaching variant, half of the students of one class being at school and the other half online, in most cases at home, roles that they changed weekly, until October 19th when all students went exclusively online, under the political decision constraints caused by the Covid-19 pandemic.

5.1. Participants and micro-research design

In conducting this study, an online questionnaire was created, which was answered by 39 parents, 29 mothers (74.35%) and 10 fathers (25.65%) of pupils who attended first grade in the new conditions and forms of organization specific to virtual classes. The parents opinions reflected the developmental characteristics of their own children, also numbering 39, ie 22 boys (56.41%) and 17 girls (43.59%).

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The data collected through the questionnaire were analyzed and translated into results through the JASP statistical interpretation software (Version 0.14.1; JASP Team, 2020), looking for indicators for the objectives of micro-research to prefigure an already developed area for pupils of first grade, in relation to their digital competence or, in other words, an area that develops straight away, based on the characteristics of pupils with the profile of digital natives and to look at future stages of their development, regarding their own potential.

The questions were divided into categories to capture broad perspectives on issues arising from learning with and about digital technologies by primary school pupils. These categories are: digital skills of first grade students, students preferences in relation to digital devices and the usefulness of digital technologies in the lives of primary school students.

5.2. Digital skills of first grade pupils

The items of the questionnaire correlated to the digital skills of the first grade students have followed elements that reveal aspects related to: the training of independence in the use of digital devices and the adaptation to the IT routines described by the use of some specific ICT products.

5.3. The preferences of the same pupils in relation to the digitalized surrounding reality

These items were used to find out whether digital technologies are considered relevant and of interest to students, along with their use in a social context. The items also reflect the emotions and preferences of students, in relation to the motivations brought by a digitized environment.

5.4. The usefulness of digital technologies in the lives of primary school pupils

The usefulness of digital technologies is an important component in the lives of primary school students that nurtures the need for relationships in this process and the use of technologies in specific contexts, and these data were collected through the answers to three questions.

6. Findings

The opinions expressed, through the questionnaire, by parents regarding the interaction of their own children with digital technologies, girls or boys, first grade pupils, form the following possible combinations: mother of boy or girl as well as father of boy or girl. All 4 situations are covered so that the representation of each of these situations is reflected, through Figure 4, in the results obtained.

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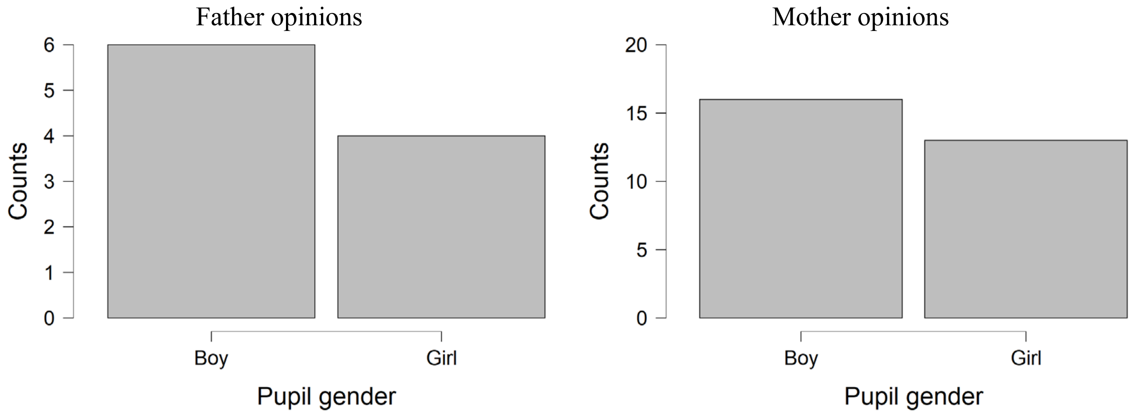

Figure 4. Demographic representation in parent-child pairs

This connection between child and parent has another facet that is related to the need or training for independence in the use of digital technologies and as parents describe the situation, presented in Fugure 5, their children are confident explorers of the virtual environment, most (87.17%) using various applications on computer/ tablet/ phone (including games) mostly alone, without fear of making mistakes and only 12.82% ask for support.

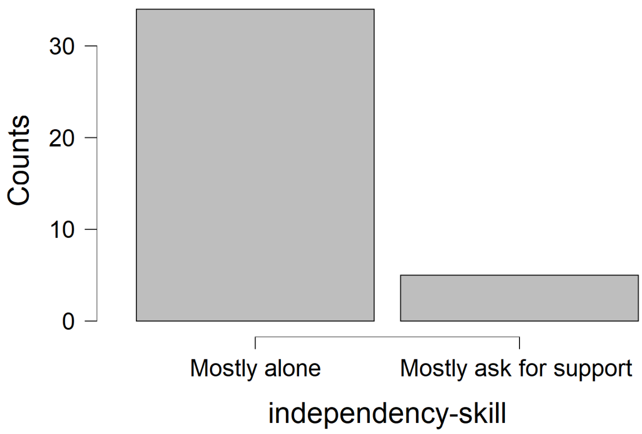

Figure 5. Degree of independence in the use of various digital technologies

The evolving trend of society is that it is currently crossing the digital age and in terms of the ability to use specific ICT products for online school, the interest was to follow a general trend of adapting students to IT routines, carried out over a period of time, like: 1-2 weeks, 1 month, 2-3 months and a semester, then transposed in number of days, from 10 to 120 days. This general trend with which the young generation, more precisely the first grade pupilss, who express their accommodation both in the use of a digital technology, with reference to the ability to authenticate in the videoconferencing system (login-skill) and to the sub-tools on which they offer, in the case of videoconferencing systems the closing/ opening of the microphone, the video camera, the chat section (tools-skill), are distributed around the shortest period of time (Table 3), which is translated into a high learning speed.

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Table 3. The central tendency in accommodation with digital school tools, expressed in number of days

	tools-skill	login-skill
Valid	39	39
Missing	0	0
Mean	15.000	14.359
Median	10.000	10.000
Mode	10.000	10.000
Std. Deviation	20.359	18.180
Minimum	10.000	10.000
Maximum	120.000	120.000

Therefore, the time period of 1-2 weeks of school (approx. 10 days), necessary to accommodate with specific ICT tools in education, is the value with the highest frequency of response, as shown in Table 04. Notably here is the high percentage of first grade students who reach to quickly and easily use digital technology for online school, 92.30% (Table 4) for the use of videoconferencing system options and 89.74% (Table 5) for authentication in this system.

Table 4. Frequencies of responses for accommodation with options within video conferencing system

tool-skills	Frequency	Percent	Valid Percent	Cumulative Percent
1-2 weeks	36	92.308	92.308	92.308
1 month	1	2.564	2.564	94.872
2-3 months	1	2.564	2.564	97.436
1 semester	1	2.564	2.564	100.000
Missing	0	0.000		
Total	39	100.000		

Table 5. Frequencies of responses to master authentication procedures in e-Learning applications

login-skills	Frequency	Percent	Valid Percent	Cumulative Percent
1-2 weeks	35	89.744	89.744	89.744
1 month	3	7.692	7.692	97.436
1 semester	1	2.564	2.564	100.000
Missing	0	0.000		
Total	39	100.000		

Considering the aspects related to the abilities and preferences of the first grade pupils on which this study focuses, the Pearson correlation was further calculated to examine the relationship between these skills quickly acquired, of training the digital technologies and pupils preferences to orient towards digital devices in their activities. This positive correlation has a direct link between pupils preferences and the two variables that describe their abilities, but without an important statistical significance. Pearson correlation data are given in the Table 6.

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Table 6. Pearson's Correlations

			Pearson's r		p
tool-skills	-	login-skills	0.892	***	< .001
tool-skills	-	preferences	0.084		0.611
login-skills	-	preferences	0.082		0.619

* p < .05, ** p < .01, *** p < .001

Preferences about integrating digital technologies into pupils activities, in a non-formal context, are reasons that lead them to take certain actions and outline factors of influence over extrinsic motivations that lead to requests for their parents to get a consent to access digital devices after the school program. Students come with such requests quite often, 21 cases out of 39 (53.84%), and 8 cases (20.51%) always ask to remain at the computer, while behaviors that do not involve such requests have not been reported by any parent. How often pupils request access to a computer or tablet in a non-formal context is presented in Figure 6.

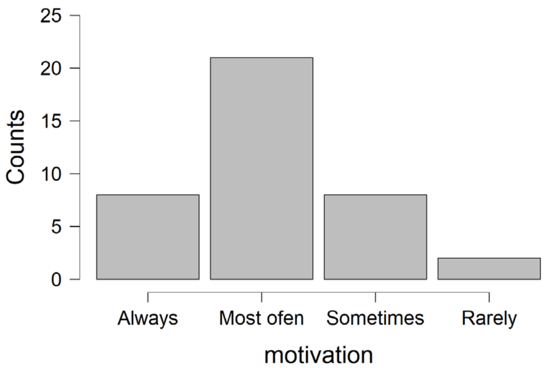

Figure 6. Levels of access requirements for digital devices

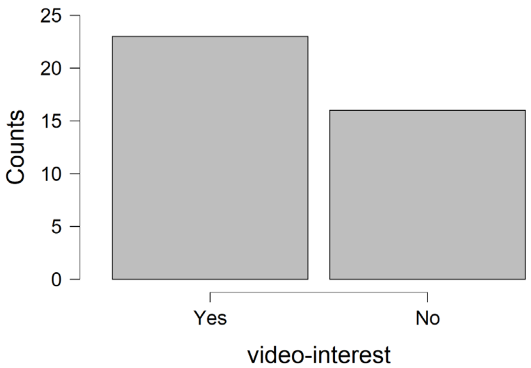

Figure 7. The interest shown for intercollegiate video meetings, in a non-formal context

In the context in which the classes during the first semester were hold online, Figure 7 reveals the pupils interest to see each-other through videoconferencing system, outside the school program, 23 people (58.97%) feeling the need to use digital technology for socialization, while 41.02% of the parents surveyed answered that they did not receive such requests from their own children. The transposition of this interest in concrete actions which represents, at the same time, the transposition to concrete forms of utility of digital technologies is analyzed below.

Observing the frequency with which pupils used video meetings, intercollegiate, in a non-formal context, we note that 46.15% of them did not participate in such meetings, but 53.85% of students took advantage of videoconferencing tools and transferred their usefulness in their social and personal life, taking part in at least 1-2 such activities, as shown in Table 7.

Table 7. Frequencies for social and non-formal use of digital technologies

soc-util	Frequency	Percent	Valid Percent	Cumulative Percent
0 (I did not participate)	18	46.154	46.154	46.154
1-2 meetings	15	38.462	38.462	84.615
3-5 meetings	2	5.128	5.128	89.744

soc-util	Frequency	Percent	Valid Percent	Cumulative Percent
6-8 meetings	3	7.692	7.692	97.436
Over 10 meetings	1	2.564	2.564	100.000
Missing	0	0.000		
Total	39	100.000		

In the same terms of actions frequency, we find it interesting that there were pupils who used the circumstance and the advantages offered by technology, finding utility not only for relaxation purposes but also in the interest of learning and collaboration on school tasks. Although in a small percentage, sometimes the solutions for various problems are accessible and close to us, but we do not see them. Table 8 shows that 10.25% of the pupils included in this sample have chosen to solve their homework for school, through videoconferencing system, with other colleagues.

Table 8. The balance of communication and collaboration on homeworks, through online meetings

hmw-util	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	4	10.256	10.256	10.256
No	35	89.744	89.744	100.000
Missing	0	0.000		
Total	39	100.000		

The usefulness of digital technologies is seen not only from the perspective of their use by the student but also in terms of contribution in the teaching-learning process. There are some disciplines the content of which is easier to transmit through the relatively new online communication channel, in a pandemic context this being the ideal solution for communication and collaboration, and others that require more creativity, innovation, inspiration and new methods of delivering content to learners. Figure 8 presents one such case, of the discipline *Music and movement*, where in 12.82% of the answers no alternatives were found for the online classes and 30.76% of the respondents said that these classes were held, however, online. In the rest of the cases, 56.60%, the discipline was covered individually by the pupils, through worksheets provided by the teacher on a weekly or occasional basis.

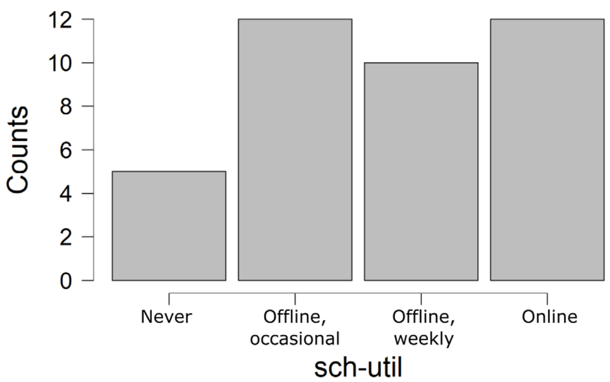

Figure 8. *Music and* movement classes in emergency situations caused by the Covid-19 pandemic

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Students have potential, but the tradition of teaching this subject does not give them the framework to fully express their potential, even when they are face-to-face, because not everyone has vocal talent and the tradition of teaching *Music and movement* discipline emphasizes vocal interpretation. Digital technologies have the ability to provide a balance in the equity of the chances to perform in this field, through digital solutions for music expression, for all pupils, whether they have vocal talent or not.

7. Conclusion

This micro-research provides indicators on how quickly and easily first grade pupils absorb digital literacy (DL) as they use specific ICT products and how the charm and the offer of digital technologies is an interest that turns into reasons to use them. The rapid adjustment to the routine of using specific ICT tools resonates with what Fowler and Vegas (2021) highlighted in the conclusions of the 2012 Royal Society report that students acquire digital literacy skills on their own rather than through school contribution. From the perspective of these empirical and bibliographical references, we consider that the zone of actual development (ZAD) of first grade students includes a variety of elements from the DL area and the use of specific ICT products.

The reasoning that the majority influences over the pupils ZAD, on the dimension of digital competence, come from the non-formal and informal environment and determine the evolution outside ZAD, lead to the conclusion of Anderson and Gegg-Harrison (2013), who state that zone of proximal development (ZPD) is unique. In these background and mastery of manipulating digital devices, different and specific to each pupil, computer science education is the ideal social environment where they can reach their potential level of development with the support of a more skilled colleague, this being the first notable aspect for which we consider computer science education a ZDP for primary school pupils.

The interaction of students with the computer will involve overcoming some levels of difficulty in computer-human communication and which, from the perspective of computer science education, represent various in-depth knowledge levels in the domain. Figure 9 reveals three such examples where the familiarity with the terms, the electronic environment and the simple use of the right keys resonate with specific areas of DL. Creative and successful use of applications supported by computers, overcoming some errors with simple solutions based on logic or simply consulting the user guide of that application are activities that involve the use of ICT tools. The (b) case from the Figure 9 shows such a scenario that requires a sequence and ordering of actions for deleting an open file with a working application, one action (deleting the document) being conditioned by the other (closing the document), not being able to complete in another order. On the other hand, understanding how computers work, finding technical solutions to their problems, computer programming, is a higher level of digital competence, accessible through the study of computer science.

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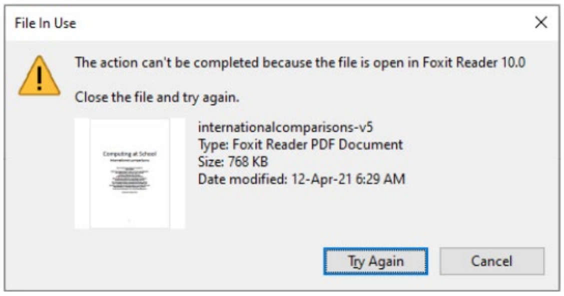
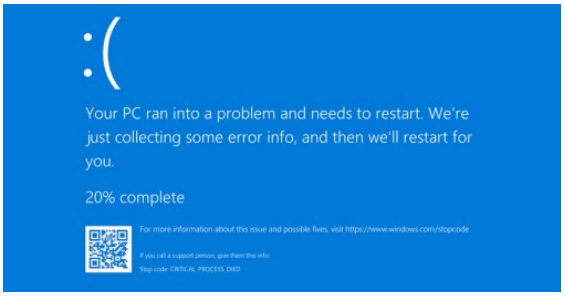
(a) Digital Literacy (DL)



(b) Using of specific ICT tools



(c) Computer science (CS)

Figure 9. (a) & (b) & (c) Different contexts that require different levels of deepening digital knowledge and competence

In the coordinates described above and based on the results of the study showing that first grade pupils adapt almost instantly or in ultra-short term, to the interface and functions of the used application options, we consider this horizontal route from DL, at ICT and then to computer science, a route from ZDA to ZDP. "Obviously, the teaching of coding skills implies the development of digital literacy and the competent use of ICT" (Balanskat & Engelhardt, 2015, p. 8), so the path is a two-way route, computer science education subordinating DL and ICT and developing them, simultaneously and automatically, through the teaching-learning process specific to the CS discipline. If in the first grade, pupils have acquired basic skills to use the software that mediates online classes, future research on digital education can focus on the degree to which it can increase the workload, in primary school, on the route from ICT to computer science. A didactic content that is aware of the source of digital technologies, this source being human knowledge, which includes basic concepts about programming, thinking (logical and computational), but doesn't focus on a particular type of digital product, has effects on learning longevity, despite technological evolution.

Whether students of the current generation are labeled or not, as digital natives, they certainly have a new profile. It was seen in the micro-research that the digital skills of first grade pupils have a predominant specificity, most of them adapting to IT routines, to be present and active in online lessons, in an extremely short time. Given the characteristics of the students of the digital age, the discreet transition to CS is an emerging and necessary process for them to achieve their goals, to progress, to enjoy success and then, as a student, "you had to give up some things—a safe zone" (Silver, 2011, p. 29). Giving up this comfort zone is associated to overcoming the ZAD and accessing the next level resulting a future orientation, as a strong point, common to computer science education and ZPD. Shabani et al. (2010) argued that teaching guidelines should be directed towards the future development of students, ie towards the ZPD of students, and Balanskat and Engelhardt (2015) emphasized that computer science

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should prepare students for further studies rather than satisfy them with the skills and knowledge they have already learned. Thus, we note the placement of computer science education and the concept of ZPD at a future time, this being the second aspect for which we consider computer science education an ZPD for primary school pupils.

Another notable aspect for the same reason is related to pupils' preferences in relation to the digitalized surrounding reality. It was seen through this micro-research that there is a direct link between pupils' preferences to orient themselves towards digital devices in their activities, 89.74% of respondents confirming that the child's favorite activities include digital devices and rapidly develop digital technology skills. Although in this measurement, the direct link does not enjoy an important statistical significance, this lack is supplemented by other conclusions, such as the Royal Society report of 2012, mentioned by Brown et al. (2014) and which sees the same link between students' preferences and their abilities in terms of computer science in the sense that secondary school students, who are taught how to use specific ICT tools, had developed these skills, aspects that were reflected into students' preferences, looking for something more stimulating, activating and motivating. These views led to the introduction of the subject Computing in the British curriculum (England) which was thought "to be taught throughout primary school and pupils are to be taught to think algorithmically and to learn to write simple programs before they reach 11 years old" (Brown et al., 2014, p. 9). Computer science education, placed in ZPD even at the level of primary school, is an investment in the socio-economic development of the community.

Because there is a different perception, a potential point of confusion about the terms, it has been seen that in various situations, terms specific to the computer science field are used interchangeably, students can achieve discrete transition from digital literacy (DL) to the use of specific ICT product, then to computer science (CS) through computer science education. Because Hubwieser et al. (2015b) saw DL as an educational goal, which can be achieved through both CS and ICT, we consider that those who dealt with educational policies in Romania in 2016, and introduced the new discipline with the name of Informatics and ICT, have chosen the appropriate and relevant name for this field, even if, in the consulted literature, no other state uses this form of naming this discipline of study. As the Romanian curriculum is structured at the level of primary education, the potential in terms of pupils' digital competence remains unexploited until the fifth grade, a period in which it stand hidden, in a latent state. This potential exists, we have seen in the first grade pupils a set of indicators for their digital skills, but it does not manifest itself externally, in the formal framework, because there are no conditions to highlight it and to cause changes, in a positive way.

Regarding the usefulness of digital technologies in the lives of primary school pupils, given the fact that almost everything that we hear today is passed through a digital processing signal, computers dominating audio production, digital technologies facilitate the development of musical improvisation, music creation, reproduce a wide variety of instrumental timbres and last but not least, make accessible the degree of in-deepth musical knowledge. Because musical expression through digital technologies provides a contextualized framework for applying knowledge, where all students can activate and express ideas without being conditioned by vocal talent, but only by their own learning, the online environment is a space that allows classes even for the subject Music and movement, one of the subjects where the teaching tradition would make us believe that it is much more difficult to integrate it in the online school. Then, the item that included the conduct of Music and movement classes, in online format under the restrictions imposed by the Covid-19 pandemic, aimed the level at which the usefulness of digital technologies in the lives of primary school students was exploited, aspects that inspire us for future research directions.

Informatics addresses to problem solving. Given the skills quickly acquired by students and highlighted by this study, as well as the fact that some states have computing as a discipline for primary education, the question arise is no longer pupils at what age should start learning computer science, but "which content, learning objectives, methods, and media are suitable to learn CSE concepts in primary schools" (Hubwieser et al., 2015a, p. 5), as part of the ZPD for these pupils? Here the limit is the sky, because it is based on the boundless human creativity that can be exercised in: the design of the school curriculum by educational policy developers, by the strategy approached by the teacher to deliver the curriculum or by the pupils insight in subordinating computer knowledge to solve various problems.

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