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LOŠI EFEKTI SAVREMENIH KOMUNIKACIONIH TEHNOLOGIJA U ŽIVOTU I RADU UČENIKA OSNOVNIH I SREDNJIH ŠKOLA U NIŠKOM REGIONU[1]

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ADVERSE EFFECTS OF MODERN COMMUNICATION TECHNOLOGIES ON THE SERBIAN ELEMENTARY AND SECONDARY SCHOOL PUPILS IN NIŠ REGION*

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Sažetak

Uvod/Cilj: Ovo longitudinalno istraživanje imalo je tri cilja. Prvi cilj je bio da se pokaže uticaj različitih uređaja u životu i radu učenika osnovnih i srednjih škola, njihov odnos i racionalnost prema tim uređajima i izloženost tim uređajima. Drugi cilj je bio da se pokaže ponašanje na internetu kao preduslov za izlaganje učenika digitalnom nasilju. Treći cilj je bio da se pokaže prisustvo digitalnog nasilja među učenicima.

Metode: Korišćen je metod istraživanja na populaciji od 1500 ispitanika u četiri godine: 2021., 2022., 2023. i 2024. (750 učenika osnovnih škola i 750 učenika srednjih škola u Nišu). Takođe, pri uređenju rezultata korišćene su statističke i matematičke metode.

Rezultati: Ostvareni rezultati su pokazali da učenici u svom životu i radu dosta koriste savremene digitalne uređaje, posebno mobilni telefon (svaki učenik je imao mobilni telefon). Izloženost digitalnom nasilju ispitanika bila je veoma visoka (svaki učenik koristi neku društvenu mrežu). Digitalno nasilje postoji među ispitanicima u velikom stepenu (učenici su uznemiravani e-mailom, telefonom ili preko društvenih mreža u različitim procentima, od 30% do 90%).

Zaključak: Savremeni digitalni uređaji se veoma koriste među decom školskog uzrasta, što direktno implicira povećane količine elektromagnetnog zračenja i izloženost digitalnom nasilju. Digitalno nasilje predstavlja savremen, ozbiljan i sve veći problem savremenog društva, kao direktna posledica korišćenja digitalnih uređaja i društvenih mreža i mora se zaustaviti i eliminisati na najbolji mogući način.

Ključne reči: učenici, istraživanje, elektromagnetno zračenje, digitalno nasilje, posledice

Abstract

Introduction/Objective: This longitudinal research had three aims. The first aim was to show the influence of different devices in the life and work of elementary and secondary school pupils, their relationship and rationality about those devices, and their exposure to those devices. The second aim was to show the behaviour on the Internet as a prerequisite for exposure to digital violence for pupils. The third aim was to show the presence of digital violence among pupils.

Methods: The survey method on a population of 1,500 respondents over four years, 2021, 2022, 2023, and 2024 (750 pupils from elementary schools and 750 pupils from secondary schools in Niš) was used. Also, in the calculation of results, statistical and mathematical methods were used.

Results: The obtained results showed that pupils use modern digital devices in their life and work significantly, especially mobile phones (every pupil had a mobile phone). The exposure to digital violence among respondents was very high (every pupil uses some kind of social network). Digital violence exists among respondents in a high degree (pupils were harassed by e-mail, phone, or social networks with different percentages, from 30% to 90%).

Conclusion: Modern digital devices are widely used among school-age children, which directly implies increased quantities of electromagnetic radiation and exposure to digital violence. Digital violence presents a serious and increasing problem in the modern society, as a direct consequence of the usage of digital devices and social networks and therefore must be stopped and eliminated in the best possible way.

Key words: pupils, research, electromagnetic radiation, digital violence, consequence

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Introduction

Modern technologies are present everywhere today, in every potential social or natural sphere. Computers, the Internet, wireless technology, robotics, artificial intelligence, and other forms of new technologies are already in use. With a more detailed analysis, there is an impression that people have not paid attention to potential "bad" effects, but only to benefits. Of course, the use of modern technologies has brought a lot of benefits in many different senses and in many different spheres of human work and life. Related to historical facts, at the beginning, no one thought about any kind of harm. It was also noted that the first serious research on potential bad impacts of new technologies was conducted in the sphere of electromagnetic radiation, by studying and measuring electromagnetic fields and their influence on human work and life. From a global perspective, the fast electrification of the world has brought about the occurrence of electromagnetic radiation, specifically low-frequency electromagnetic radiation (it is known that the frequency of alternating voltage is 50 Hz). Additionally, it is very important to note that the first research was prompted by occurrences of some illnesses that could not be logically explained. Furthermore, with the appearance of mobile phones, wireless routers, and high-frequency electromagnetic radiation (frequencies in the range of MHz up to GHz), research has increased and taken different directions.

a) b)

Figure 1. Measuring of the electromagnetic smog at different locations, outside (a) and inside from antennas and routers

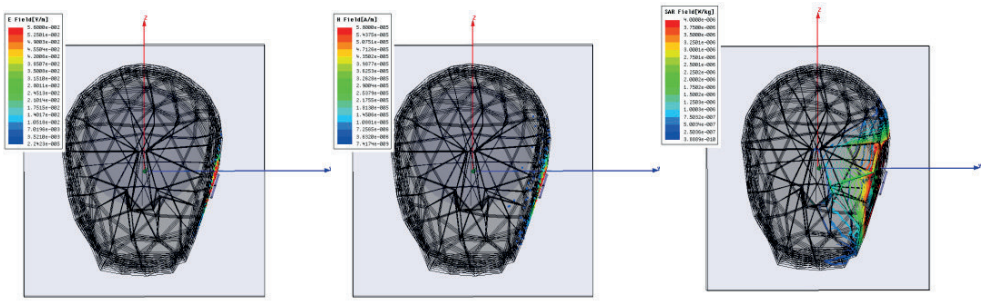
Because modern electrical devices demand and create electromagnetic radiation, today's level of electromagnetic radiation presence and exposure is indeed very serious and concerning.

Because of those facts, it is obvious that today, humans live in so called "electromagnetic smog". Measuring of the electromagnetic smog is presented in figure 1 (a, b). Electromagnetic smog presents huge problem of the modern society because it is impossible for human to avoid it. Involving 5G and future 6G nets will significantly improve present possibilities of modern devices, life and work but it will also increase quantities of electromagnetic radiation, which is a problem for not only humans but animals and plants.

After that, there was an appearance of the new "bad" effect related to social sphere and it has been reflected in the different forms of digital violence, addiction to new technologies etc. Digital violence or cyberbullying has become huge problem in the last years, especially in children and pupil`s population. The latest research has shown very clearly that digital violence is constantly increasing, although there were many different measures, strategies and procedures in the sense of the reducing and elimination of digital violence. These results are confirmed in whole world, including Europe, including Serbia. It is inevitable fact that humans at all life ages are exposed to noted "bad" impacts of the new technologies. Of course, the most important devices "deserving" for this fact are, at the first place, mobile phones, laptop and desktop computers, tablets, and after them almost every electrical device used in human`s life and work. The noise can also be a very serious problem, designed from the new technologies [1-5].

Mobile phone present one of the most frequently used devices in the whole population. Related

to the period when the mobile phones appeared, these devices today should be multimedia devices used instead of mobile phone. Their potentials are much bigger and more powerful but so are their bad effects. These bad effects refer to the physical and social aspect. In the physical aspect, mobile phones as devices that use energy for their work and functioning, so they present sources of high frequency electromagnetic radiation. Electromagnetic values that are important for mobile phone users and that can be seen in mobile phone`s documentation, are the strength of electric field [V/m], the strength of magnetic field [A/m] and SAR-specific absorption rate [W/kg]. These values are defined by different standards and they must not be exceeded. Electromagnetic field of mobile phone (the strength of electric field, the strength of magnetic field and SAR) are presented in figure 2 on simulation model of the human's head.



a) b) c)

Figure 2. Electromagnetic dimensions important for human`s health and regulated by different standards: the strength of electric field (a), the strength of magnetic field (b) and SAR (c) on simulation model of the human`s head

Beside mobile phones, there are a lot of other electrical devices in everyday use: laptop computers, desktop computers, tablets, TVs, radios, etc., and each of them has its own electromagnetic field and electromagnetic radiation. The biggest problem related to electromagnetic radiation is the so-called cumulative effect, human organisms "memorize" all radiation to which they have been exposed, and it cannot be deleted. In today's conditions, the human body is under electromagnetic radiation without pause, low-frequency electromagnetic fields from the city network and high-frequency electromagnetic fields from mobile phones, routers, and antennas, no matter where it is located, at home or at the workplace.

a) b)

Figure 3. The position of the routers in the corridor (a) and in the classroom (b) in the same school

As an example, modern Wi-Fi routers are arranged everywhere in the school, in the corridors and in the classrooms, as it is presented in figure 3[5-7].

From the social aspect, a very serious and important consequences of modern technology usage is digital violence, also called cyberbullying. The high increase in the development of hardware and software enables a new form of violence to appear, which is digital violence. This occurrence is not strictly related to adults; it has been noted among school-age children and students. It means that digital violence involves the use of mobile phones, laptop computers, desktop computers, and tablets, primarily as tools needed for criminal activity. These devices enable children to access many different contents and to use that content in various forms to hurt someone. The development and usage of different social networks have only increased the potential for these negative effects. Although there have been various intentions to indicate this problem, the modern consumer society, primarily for reasons of making profit, has not provided support. It is a known fact that school-age children and students represent the largest portion of the buyers of these devices. From a physical aspect, there have also been many intentions that have shown and proven that children do not have complete awareness of how powerful a "weapon" they possess. Although many regulations and laws have been established in Europe and all over the world, research, evidence, and facts have shown that this form of violence is on the rise, especially among pupils and students [8-11].

It is very important to note that new technologies have brought many known benefits in various spheres, but no one has ever established where the borders between good and bad effects and consequences lie. The use of mobile phones has many benefits, but, in contrast, research has shown that children and adults are becoming totally dependent on these devices and cannot imagine their lives without them. The Internet, as a great product, has huge importance in everyday human life and work, but it can very easily lead to the wrong path, primarily due to the excessive amount of time spent using the device, and subsequently in many other forms. Sometimes it is very hard even for an adult to determine and define the boundary between what is good and what is bad for them. Related to that, school-age children are in a much worse position because of their age and lack of experience; school-age children, even students, are very easily manipulated. From an early age, children get used to mobile phones, the Internet, and social networks, and over time, they develop a strong type of addiction. Of course, the Internet and social networks can be accessed not only through mobile phones but also through laptops, desktop computers, tablets, and TV devices; however, mobile phones are especially appropriate devices (due to their dimensions, capabilities, price, and other properties) for such usage [12, 13].

The events on a global level, such as the COVID-19 pandemic, have greatly influenced the increased usage of these devices and the Internet. For school-age and student-age children, this was the only way to have classes, as it was for their teachers and professors. They were forced to use this method of connection because, at that moment, it was the only option, but many of them suggest that in the future, this type of learning has many disadvantages, mostly related to school-age children, and that teaching must be conducted in person whenever possible [14]. This paper was written to show the negative effects of modern technologies through a four-year-long research study conducted on school-age children in elementary and secondary schools in Niš.

Methodology

The longitudinal research included the pupil population in 2021, 2022, 2023, and 2024 in Niš. It consisted of 1,500 pupils: 750 pupils from elementary schools in Niš and 750 pupils from secondary schools in Niš. Both genders from all ages were included in the research. Ages of respondents from elementary schools ranged from the first class to the eighth class (7 to 14 years). Ages of respondents from secondary schools ranged from the first class to the fourth class (15 to 18 years). The research was conducted in the form of an anonymous questionnaire. The questionnaire consisted of 19 questions, classified into three groups.

The first group of nine questions was about the general influence related to mobile phones, laptop computers, desktop computers, tablets, and other devices in the life and work of pupils. These questions addressed the possession of the mentioned devices, average time spent on the devices, the way mobile phones are used, and types of usage, which are in direct connection with the electromagnetic radiation of those devices—the more a device is used, the more electromagnetic radiation is absorbed.

The second group of the next six questions was about Internet access and potential exposure to digital violence for pupils. It is very important to have some kind of protocol or regulation regarding behaviour on the Internet, whether written or unwritten, in order to determine behaviour online and to protect users from potential threats.

The third group of the last four questions was about the influence and existence of digital violence among pupils, types of digital violence, and attitudes regarding reporting and sanctions related to digital violence.

The results presented in this paper are just a small part of various large longitudinal research studies, physical and software simulated measurements related to the usage and impact of modern technologies and devices on pupils, students, and adults, conducted and designed by the authors over the past 15 years. This included different measurements of electromagnetic parameters of so-called digital devices, as well as many potential influences and consequences of exposure, presence, and influence of digital violence among pupils, students, and adults. Various mathematical, statistical, and survey methods were used to obtain the results of this paper and the research.

Results of research

The first question was about the possession of modern media-digital devices by pupils and the research results in the period of four years are presented in table 1.

Table 1. The obtained results of the research about the possession of modern media-digital devices by pupils and students in the period of four years

Possessions of devices 2021		possess				Do not possess			
		2022	2023	2024	2021	2022	2023	2024	
Elementary school pupils	Mobile phone	744	750	750	750	6	0	0	0
	Desktop computer	716	731	738	750	34	19	12	0
	Laptop computer	661	683	694	727	89	67	56	23
	Tablet	238	283	348	421	512	467	402	329
	TV	750	750	750	750	0	0	0	0
	Radio	750	750	750	750	0	0	0	0
Secondary school pupils	Mobile phone	747	750	750	750	3	0	0	0
	Desktop computer	739	745	750	750	11	5	0	0
	Laptop computer	705	714	733	746	45	36	17	4
	Tablet	186	272	317	439	564	478	433	311
	TV	750	750	750	750	0	0	0	0
	Radio	750	750	750	750	0	0	0	0

The second question was about the average time spent on some devices (mobile phone, laptop, desktop computer and tablet) in one day (whether this time exceeded 180 minutes in one day or not), which is a very important and valid parameter in many aspects (physical, social, emotive, etc.) and research results about that in the period of four years are presented in table 2.

Table 2. The results of the research about the average time spent on some devices (mobile phone, laptop, desktop computer and tablet) in one day in the period of four years

Average time spent on particular device per day in different years 2021		up to 180 minutes per day				over 180 minutes per day			
		2022	2023	2024	2021	2022	2023	2024	
Elementary school pupils	Mobile phone	211	195	46	2	533	555	704	748
	Desktop computer	675	694	703	711	41	37	35	39
	Laptop computer	602	616	632	646	59	67	62	81
	Tablet	216	252	329	401	22	31	19	20
	TV	734	735	711	738	16	15	39	12
	Radio	742	740	746	750	8	10	4	0
Secondary school pupils	Mobile phone	156	134	67	52	591	616	683	698
	Desktop computer	678	670	659	664	61	75	91	86
	Laptop computer	629	627	622	614	76	87	111	132
	Tablet	184	269	311	436	2	3	6	3
	TV	739	723	707	721	11	27	43	29
	Radio	740	745	750	750	10	5	0	0

The third question was about how the school age children use the mobile phone in the period of four years, and these results are presented in table 3. There are different ways of how to use mobile phone for simple conversation, with drastic difference related to absorbed radiation.

Table 3. The results of the research about the way of mobile phone use in the period of four years

	Year	directly to the ear (n/%)		headphones/ Bluetooth (n/%)		Speakerphone (n/%)		do not possess (n/%)		Total	Total (%)
Elementary school pupils	2021	638	85.07	72	9.60	34	4.53	6	0.80	750	100
	2022	645	86.00	68	9.07	37	4.93	0	0.00	750	100
	2023	612	81.60	98	13.07	40	5.33	0	0.00	750	100
	2024	600	80.00	111	14.80	39	5.20	0	0.00	750	100
Secondary school pupils	2021	533	71.07	103	13.73	111	14.80	3	0.40	750	100
	2022	559	74.53	68	9.07	123	16.40	0	0.00	750	100
	2023	537	71.60	79	10.53	134	17.87	0	0.00	750	100
	2024	518	69.07	93	12.40	139	18.53	0	0.00	750	100

The fourth question was about the way of power supply for mobile phone use, whether they turn it off after charging or not in the period of four years and these results about that are presented in table 4.

Table 4. The results of the research about the way of how power supply for mobile phone was used in the period of four years

	Year	turn off power supply after charging (n/%)		do not turn off power supply after charging (n/%)		do not possess		Total	Total (%)
Elementary school pupils	2021	34	4.53	710	94.67	6	0.80	750	100
	2022	37	4.93	713	95.07	0	0.00	750	100
	2023	29	3.87	721	96.13	0	0.00	750	100
	2024	33	4.40	717	95.60	0	0.00	750	100
Secondary school pupils	2021	37	4.93	710	94.67	3	0.40	750	100
	2022	32	4.27	718	95.73	0	0.00	750	100
	2023	47	6.27	703	93.73	0	0.00	750	100
	2024	51	6.80	699	93.20	0	0.00	750	100

The fifth question was about the make of mobile phone that school age children use in the last four years and these results are presented in table 5.

Table 5. The results of the make of mobile phone that school age children used the period of four years

	Year	Samsung	iPhone	Xiaomi	Motorola	Nokia	Honor	Realme	Huawei	Other
Elementary school pupils	2021	245	89	203	34	29	2	1	123	24
	2022	247	90	198	34	28	3	1	123	26
	2023	246	90	190	32	28	9	6	124	25
	2024	251	89	176	33	29	10	9	127	26
Secondary school pupils	2021	256	78	246	23	19	1	1	109	17
	2022	262	78	231	23	23	3	1	110	19
	2023	260	79	217	21	22	6	11	110	24
	2024	254	81	212	19	23	7	19	113	22

The sixth question was about the way of how school age children use laptop, whether they put it on the lap or on the desk or some other pod in the period of four years and these results are presented in table 6.

Table 6. The results of the research about the way of laptops used in the period of four years

	Year	on the lap (n/%)		on the desk or other pad (n/%)		do not possess (n/%)		Total	Total (%)
Elementary school pupils	2021	405	54.00	256	34.13	89	11.87	750	100
	2022	400	53.33	283	37.73	67	8.93	750	100
	2023	387	51.60	307	40.93	56	7.47	750	100
	2024	356	47.47	371	49.47	23	3.07	750	100
Secondary school pupils	2021	209	27.87	496	66.13	45	6.00	750	100
	2022	178	23.73	536	71.47	36	4.80	750	100
	2023	145	19.33	588	78.40	17	2.27	750	100
	2024	78	10.40	668	89.07	4	0.53	750	100

The seventh question was about the type of laptop computer that school age children use in the period of four years and these results are presented in table 7.

Table 7. The results of the type of laptop computers that school age children used the period of four years

	Year	HP	Dell	Lenovo	Asus	Acer	Toshiba	Fujitsu	GibaByte	Other
Elementary school pupils	2021	122	145	156	34	74	9	11	23	87
	2022	121	147	157	35	85	11	13	23	91
	2023	119	148	158	34	89	17	14	23	92
	2024	126	154	167	32	96	18	16	25	93
Secondary school pupils	2021	102	134	141	67	89	41	20	22	89
	2022	101	137	149	66	91	42	20	22	86
	2023	102	141	156	63	93	40	19	23	96
	2024	102	146	164	63	96	39	20	22	94

The eighth question was about the purpose of use of mobile phone, laptop computer, desktop computer and tablet in the period of four years and these results are presented in figure 4.

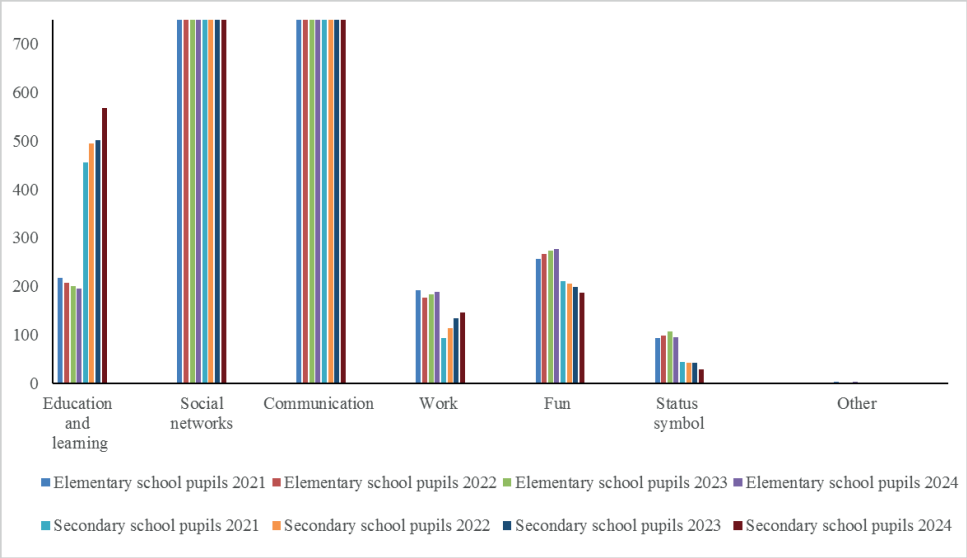


Figure 4. The results of the research about purpose of use of mobile phone, desktop computer, laptop computer and tablet in period of four years

The ninth question was about the most frequently used device for Internet access in the period of four years and these results are presented in table 8.

Table 8. The results of the most frequently used device for the Internet access in the period of four years

	Year	Mobile phone (n/%)		Desktop computer (n/%)		Laptop computer (n/%)		Tablet (n/%)		Total	Total (%)
Elementary school pupils	2021	646	86.1	23	3.07	78	10.4	3	0.4	750	100
	2022	644	85.9	24	3.2	80	10.7	2	0.27	750	100
	2023	650	86.7	18	2.4	75	10	7	0.93	750	100
	2024	639	85.2	21	2.8	79	10.5	11	1.47	750	100
Secondary school pupils	2021	604	80.5	43	5.73	92	12.3	11	1.47	750	100
	2022	571	76.1	68	9.07	107	14.3	4	0.53	750	100
	2023	567	75.6	75	10	100	13.3	8	1.07	750	100
	2024	604	80.5	33	4.4	104	13.9	9	1.2	750	100

The tenth question was about social networks presence between pupils in the period of four years and these results are presented on figure 5.

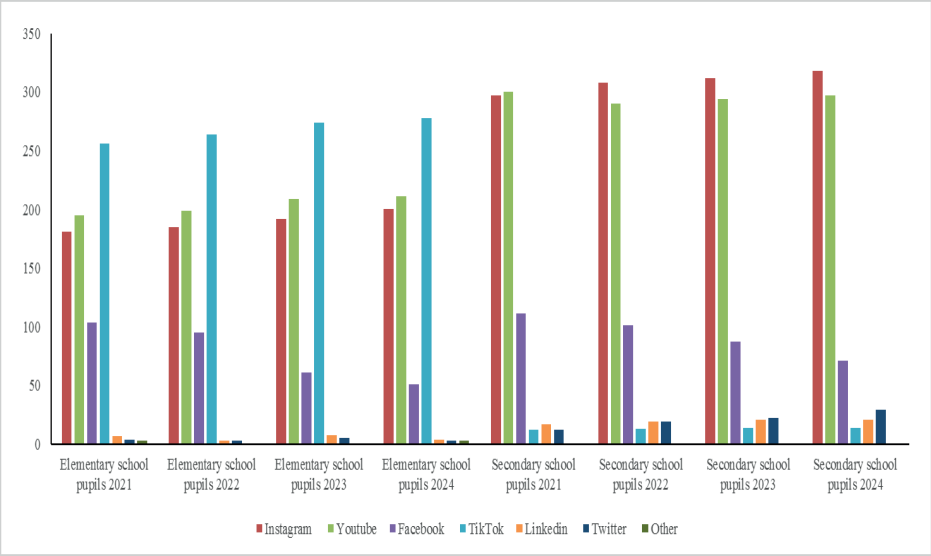


Figure 5. The results of the social networks presence between pupils in the period of four years

The eleventh question was about personal information that school age children put on Internet in a period of four years and these results are presented in table 9.

Table 9. The results about personal information of school age children on Internet in the period of years and these results are presented in table 10.

	Year	Name, surname or nickname	Home address	e-mail	School name	Profile photo (own)	Profile photo (picture)	Video clip (own)	Video clip (any)
Elementary school pupils	2021	697	198	707	411	396	354	204	546
	2022	719	200	729	456	408	342	245	505
	2023	734	208	734	469	422	328	243	507
	2024	747	221	747	495	456	294	289	461
Secondary school pupils	2021	708	189	729	504	411	339	178	572
	2022	734	202	740	527	419	331	205	545
	2023	741	221	741	539	439	311	199	551
	2024	743	239	743	577	462	288	234	516

The twelfth question was about digital devices are used, their protection and taking care between elementary and secondary pupils in the period of four years and these results are presented in table 10.

Table 10. The results about the way of use of digital devices, their protection and take care of those devices in period of four years

	Year	I use only my devices	I use other`s device and allow someone to use my devices	I use other`s device but don't allow someone to use my devices	My devices are password protected	I am taking care of my devices
Elementary school pupils	2021	657	478	316	693	511
	2022	689	489	332	715	578
	2023	716	501	345	732	590
	2024	723	552	356	746	603
Secondary school pupils	2021	701	401	407	711	567
	2022	727	429	445	729	609
	2023	734	441	489	737	677
	2024	741	456	512	746	689

The thirteenth question was about the way profiles are used on the Internet and their protection between elementary and secondary pupils in the period of four years and these results are presented in table 11.

Table 11. The results about the way profiles are used on the Internet, sharing information and shared groups in a period of four years

	Year	I use only my profiles on Internet	I use other`s profiles on Internet	I allow someone to use my profiles on Internet	I share information from my profiles	I don't share information from my profiles	I have shared groups or profiles
Elementary school pupils	2021	661	89	193	630	120	729
	2022	694	56	201	632	118	734
	2023	719	31	209	641	109	742
	2024	732	18	219	639	111	750
Secondary school pupils	2021	709	41	156	602	148	732
	2022	735	15	134	607	143	750
	2023	739	11	130	596	154	750
	2024	743	7	111	599	151	750

The fourteenth question was about requests that can occur on the Internet between elementary and secondary pupils in the period of four years and these results are presented in table 12.

Table 12. The results about requests on the Internet in the period of four years

	Year	Accept requests from anyone	Accept requests only in the case when mutual friends exist	Accept requests only if they are well known
Elementary school pupils	2021	123	456	171
	2022	111	467	172
	2023	92	467	191
	2024	87	478	185
Secondary school pupils	2021	77	511	162
	2022	78	518	154
	2023	72	519	159
	2024	67	534	149

The fifteenth question was about the behaviour on the Internet between elementary and secondary pupils in the period of four years and these results are presented in table 13.

Table 13. The results about behaviour on the Internet in the period of four years

	Year	Visit site or page with suspicious content	Download unknown content	Got a virus from Internet	Posted text on Internet	Posted video or audio material on Internet
Elementary school pupils	2021	256	536	656	434	732
	2022	278	545	658	434	734
	2023	270	556	673	449	741
	2024	283	578	692	461	740
Secondary school pupils	2021	234	532	649	511	723
	2022	242	527	664	513	737
	2023	258	567	678	522	744
	2024	271	574	689	527	745

The sixteenth question was about the understanding of the "digital violence-cyberbullying" term between elementary and secondary pupils in the period of four years and these results are presented in table 14.

Table 14. The results about understanding of the term "digital violence-cyberbullying" in the period of four years

	Year	I know what digital violence is	I don't know what digital violence is	I am aware that I suffer from digital violence	I am not aware that I suffer from digital violence
Elementary school pupils	2021	670	80	611	139
	2022	677	73	614	136
	2023	689	61	634	116
	2024	724	26	676	74
Secondary school pupils	2021	727	23	701	49
	2022	741	9	734	16
	2023	750	0	748	2
	2024	750	0	750	0

The seventeenth question was about the understanding of some characteristic types of digital violence between elementary and secondary pupils in the period of four years and these results are presented in table 15.

Table 15. The results of the research about the understanding of some types of digital violence in the period of four years

Type of digital violence	Year	Elementary school pupils			Secondary school pupils		
		I know what that is	I don't know what that is	I am not sure what that is	I know what that is	I don't know what that is	I am not sure what that is
Flaming	2021	217	428	105	349	345	56
	2022	219	431	100	367	340	43
	2023	227	417	106	379	329	42
	2024	245	411	94	410	299	41
Harassment	2021	411	227	112	489	200	61
	2022	426	216	108	508	183	59
	2023	449	198	103	535	161	54
	2024	467	189	94	584	127	39
Outing	2021	178	436	136	246	401	103
	2022	182	433	135	254	389	107
	2023	193	430	127	278	376	96
	2024	212	427	111	289	354	107
Exclusion	2021	619	99	32	701	39	10
	2022	639	83	28	709	35	6
	2023	659	63	28	712	29	9
	2024	687	42	21	723	19	8
Impersonation	2021	659	69	22	701	32	17
	2022	678	55	17	713	22	15
	2023	691	46	13	715	21	14
	2024	703	36	11	721	19	10

The eighteenth question was about the attitude about digital violence between elementary and secondary pupils in the period of four years and these results are presented in table 16.

Table 16. The results of the attitude on digital violence in the period of four years

Attitude about digital violence	Year	Elementary school pupils	Secondary school pupils
Digital violence should be reported and sanctioned	2021	501	678
	2022	519	692
	2023	547	705
	2024	598	734
Digital violence should be reported but not sanctioned	2021	200	45
	2022	186	41
	2023	164	33
	2024	124	12
Digital violence should not be reported	2021	45	27
	2022	43	17
	2023	39	12
	2024	28	4
Digital violence should not be sanctioned	2021	4	0
	2022	2	0
	2023	0	0
	2024	0	0

The nineteenth question was about the ways of harassment pupils experience in the period of four years and these results are presented in table 17.

Table 17. The results of the research about the ways of harassment in the period of four years

Ways of harassment	Year	Elementary school pupils	Secondary school pupils
Harassed by SMS messages	2021	455	420
	2022	459	424
	2023	467	431
	2024	471	434
Harassed by e-mails	2021	615	624
	2022	622	626
	2023	639	646
	2024	643	652
Harassed by phone calls	2021	543	527
	2022	549	536
	2023	559	540
	2024	571	559
Harassed by social networks	2021	667	661
	2022	679	678
	2023	691	690
	2024	698	699
Harassed by viruses	2021	378	345
	2022	374	332
	2023	361	330
	2024	377	321

Discussion

The research results related to the general use and influence of modern technologies showed a great influence of these devices on elementary and secondary school pupils, and the general conclusion is that they use these devices very much. The research results related to the possession of modern media—mobile phones, laptops, desktop computers, tablets, TVs, and radios—in the period of four years as presented in Table 1, showed that the most popular digital device among pupils is the mobile phone, and all of them have it. It can also be seen that the number of desktop and laptop computers, TVs, and radio devices was significant, while the number of tablets was the lowest (according to research results, in 2024 about 56% of elementary school pupils and about 43% possessed this device). The research results related to the average time spent on some digital device in one day over the last four years as presented in Table 2, showed that the largest number of pupils from elementary and secondary schools spent time on their mobile phones (almost 100% of elementary school pupils and over 92% of secondary school pupils spent more than 180 minutes on their mobile phones in one day). The least amount of time was spent on tablets, TVs, and radio devices, according to both groups of pupils. It was expected that during the coronavirus pandemic, the usage of mentioned devices would increase, but after the pandemic, the negative trend of time spent on devices, especially on mobile phones, has continued. The research results related to how pupils use mobile phones as presented in Table 3, showed that the largest number of pupils from elementary and secondary schools use mobile phones close to the ear (80% of pupils in elementary and 69.07% in secondary school), which causes the highest absorption rate of electromagnetic radiation. Pupils use speakerphones (5.20% of pupils from elementary and 18.53% of pupils from secondary schools) the least, although it presents the safest mode of mobile phone usage with very little absorption of electromagnetic radiation. It is particularly interesting since they had opportunities to hear and read about safe usage of mobile phones, but still, they use them on the ear. The research results related to how

pupils use power supply for mobile phones as presented in Table 4, showed that most mobile phone users (over 95% of pupils from elementary and over 93% of pupils from secondary schools) do not turn off the power supply after charging. This can be very dangerous, primarily because it can cause fire. On the other hand, they usually put chargers near the place where they sleep, which also causes electromagnetic radiation. It is not a large quantity of radiationbut given that today we are living in electromagnetic smog, every additional electromagnetic radiation is surplus. The research results regarding the type of mobile phone that pupils use as presented in Table 5, showed that most pupils use Samsung (about 33%), followed by Xiaomi (about 25% and 31% in respective groups of pupils). Generally, many different types of mobile phones are represented (Motorola, Nokia, Honor, Huawei, Realme, etc.). It is interesting that research showed that pupils mostly change their mobile phones after two to three years. The research results regarding the way of laptop use as presented in Table 6, showed that most pupils use laptops on a desk or some other surface, which is the correct way to use a laptop (over 49% of pupils from elementary and over 89% of pupils from secondary schools). Also, the results showed that a large number of pupils possess laptops, which, in comparison with some earlier research, was not the case (only 23 pupils in elementary schools and only 4 pupils in secondary schools). The research results regarding the type of laptop that pupils use as presented in Table 7, showed that the most frequently used laptop was Lenovo (about 22% of pupils in both groups use this laptop), followed by Dell, HP, and others. Related to laptops, research also showed that many different types of laptops are represented (Asus, Acer, Toshiba, and others) and that pupils change their laptops every five to seven years. The research results related to what pupils use mobile phones, laptop computers, desktop computers, and tablets for as presented in Figure 4, showed that pupils from elementary and secondary schools use mentioned devices mostly for communication and social networks (100% in both groups). Pupils from elementary schools use listed devices less for education and learning compared to secondary school pupils (about 27% compared to about 75%), while in the fields of work and fun, research results are similar in both groups (about 19% for work and about 27% for fun). The research results related to how pupils access the Internet as presented in Table 9, showed that most pupils use mobile phones for Internet access (over 85% of pupils from elementary and over 80% of pupils from secondary schools). Laptop computers are used less (over 10% of pupils from elementary and over 13% of pupils from secondary schools), while desktop computers and tablets were the least used for Internet access. The research results related to the presence on social networks among pupils as presented in Figure 5, confirmed earlier results on this topic. Among elementary school pupils, the most represented social network is TikTok (over 30%), while among secondary school pupils, the most represented network is Instagram (over 42%). Generally, in both groups of pupils, YouTube is also a well-represented network. Other social networks (LinkedIn, Twitter, and others) are less represented. The research results related to personal information of school-age children available on the Internet as presented in Table 10, showed that the most frequently visible information on the Internet, in both groups of pupils, includes name, surname, nickname, and e-mail (about 98% for name, surname, and nickname and 98% for e-mail). Almost every pupil has some kind of picture on some profile; both groups of pupils have their own photo on some of their profiles (more than 61%), while fewer have some other picture, related to both groups of pupils (more than 33%). The name of the school also presents visible information (over 66% of pupils from elementary and over 76% of pupils from secondary schools). Over one third of both groups have posted some kind of video clip on the network. The research results related to the way of using profiles on the Internet, sharing information, and shared groups for contacts and friend requests on the Internet as presented in Table 11, showed that most pupils use their own profiles on the Internet (over 97% of pupils from elementary and over 99% of pupils from secondary schools). A very small number use others' profiles on the Internet, from both groups of pupils. A certain number allow someone else to use their profiles on the Internet (about 29% of pupils from elementary and about 15% of pupils from secondary schools). A large number of pupils share information from their profiles (over 85% of pupils from elementary and over 79% of pupils from secondary schools). Almost every pupil is a member of some shared group or profile on the Internet. The research results regarding accepting requests on the Internet as presented in Table 12, showed that the largest number of pupils accept requests on the Internet only if they have some mutual friend (about 63% of pupils from elementary and about 71% of

pupils from secondary schools). A smaller number accept requests on the Internet only if they are well known (about 24% of pupils from elementary and about 21% of pupils from secondary schools), while the smallest number accepts requests on the Internet from anyone (about 11% of pupils from elementary and about 8% of pupils from secondary schools). The research results related to behaviour on the Internet, regarding visiting sites or pages with suspicious content, downloading unknown content, getting a virus from the Internet, posting text on the Internet, and posting video or audio material on the Internet as presented in Table 13, showed that most pupils from both groups published some audio or video material on the Internet (about 98% of pupils from elementary and about 99% of pupils from secondary schools). Fewer pupils have posted texts on the Internet (about 61% of pupils from elementary and about 70% of pupils from secondary schools). A large number of pupils have gotten some virus from the Internet (more than 92% of pupils from elementary and more than 91% of pupils from secondary schools). About one third of both groups has visited some site or page with suspicious content, while more than 77% of both groups of pupils have downloaded some unknown content from an unknown source. The research results regarding understanding the term "digital violence-cyberbullying" as presented in Table 14, showed that the largest number of pupils from both groups knows what digital violence is (more than 96% of pupils from elementary and all pupils from secondary schools). Also, a large number of pupils from both groups knows that they suffer from digital violence (more than 90% of pupils from elementary and all pupils from secondary schools). The research results related to understanding some types of digital violence as presented in Table 15, showed that pupils from both groups more or less know and understand some types of digital violence. The most recognized type of digital violence among pupils is impersonation (this type is known by more than 93% of pupils from elementary and more than 95% of pupils from secondary schools). Exclusion is also a well-known and recognizable type of digital violence (more than 91% of pupils from elementary and more than 96% of pupils from secondary schools). The least understood and recognizable form of digital violence was outing (28.2% of pupils from elementary schools and 38.5% of pupils from secondary schools). The research results regarding attitudes toward digital violence as presented in Table 16, showed that the largest number of all pupils think that digital violence must be reported and sanctioned (more than 80% of pupils from elementary schools and more than 98% of pupils from secondary schools); a smaller number of pupils think that digital violence should be reported but not sanctioned (about 16.5% of pupils from elementary schools and barely more than 1.5% of pupils from secondary schools), while almost none of them think that digital violence should not be sanctioned. The research results related to the ways of harassment as presented in Table 17, showed that all pupils from both groups have suffered from at least one form of harassment on and from the Internet. The largest number of harassed pupils was harassed through social networks (over 93% from both groups of pupils, from elementary and secondary schools), while the smallest number of pupils was harassed by viruses (about 50% of pupils from elementary schools and about 42% of pupils from secondary schools). The connection between listed devices, electromagnetic radiation, and digital violence is obvious, and it must be treated and eliminated with powerful measures.

Conclusion and Future Research

The conducted research on the population of elementary and secondary pupils clearly showed, once more, the general influence of new technologies. It is a well-known fact that the modern world is constantly progressing, and it is necessary to follow and apply these changes and innovations. Some people accept these changes and innovations quickly, some slowly, and some very reluctantly. Children, especially school-age children, easily accept these changes and get used to them. Of course, it is important to have a complete insight into the noted changes; it is necessary to analyse the benefits and negative effects and, somehow, find the best way to achieve balance. As noted for a long time, it was considered that current and electrical energy have only benefits. Unfortunately, many research studies have shown that this was wrong. Regarding high-frequency electromagnetic radiation from mobile phones, opinions are quite divided. The number of mobile phones in use has exceeded several billion for a long time, and it is a clear fact that this device will be very important and widely used in the future, with significantly increased features. This also opens many other possibilities for mentioned negative effects. Because school-age children represent the largest group of users of mobile phones,

it is obvious that they will suffer from potential negative effects. The longitudinal research presented in this paper, many of which were conducted by the author, provides direct evidence for this assertion. School-age children use mobile phones extensively for different purposes, which exposes them to electromagnetic radiation and digital violence. A mobile phone is not only a communication device; it is a powerful multimedia device that can be used in criminal activities. Therefore, it is very important to set the boundaries between harmful and useful usage of mobile phones. School-age children are exposed to digital violence, and they mostly understand what it is; many of them suffer in at least several ways from digital violence, and many believe that this problem should be reported and sanctioned, which is positive. Of course, there are many examples of how mobile phones can be used in school and educational contexts [15-17].

Besides mobile phones, laptops also represent a frequently used device in the lives and work of elementary and secondary school pupils. Research results showed that this device was used improperly by more than 50% of elementary school pupils, while among secondary school pupils, this percentage has fallen by about 10% in the last several years, indicating a better understanding of potential negative effects. Additionally, many more pupils possess laptops compared to previous research and previous years.

From a social aspect, the results of the research are very alarming. Pupils are present on social networks and use them for different purposes. Many of them have suffered from digital violence in various forms. The most appropriate access to social networks and the Internet involves mobile phones and laptops.

This paper was written as part of a larger research project conducted on significant social groups over the last several years, with the aim of identifying, realizing, determining, and monitoring all aspects of the negative effects of modern technologies, primarily on school-age children from elementary and secondary schools.

Future investigations will focus on further research and tracking the use of modern technologies, with special attention to negative effects. Additionally, future intentions include designing regulations and rules for the use of mobile phones in schools, particularly for younger elementary school pupils, potential limitations, and mandatory education for teachers and parents, among others.

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