RoSE
Research on Steiner Education

Volume 15 Number 1
pp. 60-77

Hosted at www.rosejourn.com

Influence of Wi-Fi Exposure on Cognitive and Artistic Perfor-mances as well as Social and Individual Behaviour on a Class of Pupils in Elementary School

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ABSTRACT. During the experiments it was investigated the effect of Wi-Fi exposure on a class of pupils in the second grade primary school (8-9 years old). To the external Wi-Fi background level from the neighborhood and the Wi-Fi network in the school, an additional router installed in the classroom was used. The exposure effects were studied on pupil's cognitive, artistic and creative abilities and also on their individual and social behavior through written tests, drawings and direct observations using qualitative and also quantitative methods. The examination took place on four dates, two dates with Wi-Fi exposure and two dates without Wi-Fi exposure. No significant effects were observed with the quantitative methods. There was only a trend towards fewer errors without exposure. The qualitative observation of behavior indicates an effect. Pupils in the control situation displayed a more relaxed behavior.

In the same setup with the identical class, the effect of a room harmonizer was tested independently a few months later. The situation was examined under Wi-Fi exposure with and without a room harmonizer. While the observation of cognitive performance and creative abilities showed no effect of Wi-Fi in our experimental design, there was a no-ticeable change in social behavior.

We strongly recommend further studies on the effects of radiofrequency electromagnetic fields on children, with particular emphasis on social behavior.

Keywords: radio frequency electromagnetic fields; cognitive performances, artistic and creative performances, social behavior, Wi-Fi.

1. Introduction

In the last decade, but especially in the pandemic and after pandemic period the number of Wi-Fi networks and devices using by default Wi-Fi signals (from laptops and printers to smart phones and smart watches)

increased with a high pace in work and educational environments. The education itself changed in its specific activities, being more orientated to use digital devices in virtual environment. Through them, the pupils and students in schools and universities are exposed to an increasing level of RF-EMF radiation. The overall effects on their abilities and health are still to be investigated and there is a scarcity of scientific studies made on this topic.

(Mortazavi et al. 2011) studied 469 students for the consequences of mobile phone use. There was a statistically sig-nificant correlation between call duration and the frequency of headaches, muscle aches, palpitations, fatigue, tinnitus, dizziness and sleep problems. Problems with attention, concentration and nervousness were also greater than expected among frequent users. The result of the study conducted by the Swiss Tropical and Public Health Institute made on almost 700 young people in Switzerland: the high-frequency electromagnetic fields from mobile phones have a det-rimental effect on the development of memory performance of certain brain regions, especially figurative memory (Foerster et al. 2018). The finding that non-ionising radiation opens the blood-brain barrier through oxidative stress and thus toxins enter the brain underpins the potential for damage (Belpomme et al. 2018). Studies on WLAN show a significant association with headaches and fatigue (Chiu et al. 2015; Redmayne et al. 2013).

(Papageorgiou et al. 2011) tested the responses of 15 men and 15 women (mean age ca. 24 years), using EEG to record the P300 waves. The P300 component is active during thought and memory processes. The subjects heard incomplete sentences via headphones and were instructed to complete the sentences with a sensible response. There were sig-nificant differences in the responses between exposed and non-exposed persons, but also between women and men.

While there were no differences between the genders in non-exposed subjects, the P300 amplitude significantly in-creased in men and significantly decreased in women when the Wi-Fi signals were activated (0.49 V / m).

Children are at greater risk of RF-EMF exposure compared to adults. Due to their physiology, children have a greater RF-EMF absorption compared to adults. Due to their smaller heads, RF radiation has to travel shorter distances to reach critical brain regions (Davis et al. 2023)

To the best of our knowledge, there is no study to date that has investigated the behavior of primary school children exposed to Wi-Fi. The study presented here tested various abilities of the children on two days with and two days without Wi-Fi exposure (study A). The hypothesis was that the children‘s behavior would change when exposed to Wi-Fi.

There are numerous products on the market that are supposed to have a harmonizing or balancing effect against electro-smog, including for use with smartphones, in cars or in rooms. Scientific publications on the effects of only a few products are available, e.g. (Henz et al. 2018; Henz 2022), here on the use on smartphones and in cars.

To the best of our current knowledge, there is also no scientific publication on whether a room harmonizer alters the effects of RF-EMF exposure on children. In a comparable experimental setup, the effect of a room harmonizer on the behavior of school children was measured. Under Wi-Fi exposure, the classroom received a room harmonizer on two study days and a placebo on two days (study B). The hypothesis was: with the room harmonizer under Wi-Fi exposure, the behavior of the children changed in the same direction as without Wi-Fi exposure.

2. Materials and Methods

2.1. Technical design

The location for the experiment was a classroom in Elementary School no. 16, situated in Oradea, Romania. The classroom was placed at the second floor (the highest) of the school building, corresponding to the average dimension of a regular classroom in Romanian schools, with around 50m2 floor surface and 3m high.

There were Wi-Fi networks in the school and in the neighborhood and other equipment producing radiofrequency radiation in the 2.4 GHz band as smart phones, smart watches, laptops and Wi-Fi printers. To generate the signals corresponding to an additional Wi-Fi network in the classroom, it was sufficient to use a single wireless access point (a router) and a laptop connected to it. Traffic was forced through the network with the purpose of maximizing the radio-frequency level. Traffic generation is done by transmitting data quickly over the network at the maximum speed the network can provide, given the local conditions at a given time – e.g. by downloading a large file or using spe-cialized software for traffic generation or network speed measurement. The additional equipment used during the experiments was a usual Wi-Fi router that is commonly encountered in school environment. No modifications of any kind have been made to this equipment, in order to comply with current standards.

In order to achieve a high level of traffic, a large file was downloaded over the network. The iperf software package was used for the traffic generation experiments (Gueant 2023; Dale et al 2024). The measured Wi-Fi exposure, in relation with the topology of the classroom is depicted in Figure 1.

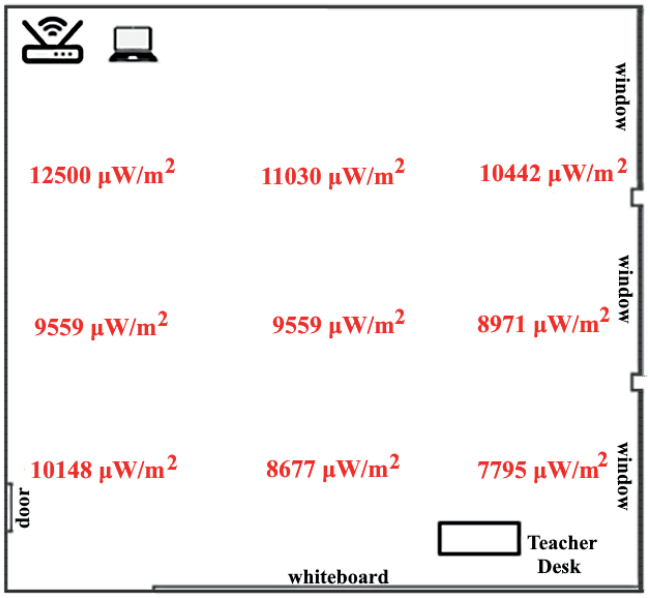

Figure 1: Classroom topology with measurements

Table 1. Power flux density measured during the phases of the experiment*

	Power flux density values in μW/m2	Method	Percentage from ICNIRP limits**	Duty factor for Wi-Fi router transmission
OFF phase, just ex-ternal background	200	Peak hold	-	0%
	7	RMS	0.0000175 %	
OFF phase, back-ground Wi-Fi in the school***	2500	Peak hold		0 %
	15	RMS	0.0000375%	
ON phase, back-ground Wi-Fi in the school and router	12 500	Peak hold	-	100 %
	60	RMS	0.00015 %	

* The measurements are considered at approx. 1 m from the Wi-Fi router used to generate electromagnetic field during the exper-iment (NW corner in the classroom). The other measurements are according to Figure 1.

** The limit was considered as 40W/m2 (Reference levels for local exposure, averaged over 6 min, to electromagnetic fields from 100 kHz to 300 GHz - unperturbed RMS values (Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz) 2020)

*** This situation was not exactly met during the experiments, it is considered just for comparative analyze reasons, to emphasize the difference between the background Wi-Fi external to the school and the added Wi-Fi network and devices in the school and classroom (laptops, Wi-Fi printers, Smart Phones, Smart Watches etc.), as usual Wi-Fi exposure.

2.2 Experiments with pupil

2.2.1 Study A (Factor Wi-Fi)

It was of interest to develop an experimental design to determine potential effects of Wi-Fi - on the behavior on the one hand and cognitive and artistic abilities on the other hand -, of a class of children in primary school (8-9 years old).

The experiment was performed in 4 different days with usual activities, including tests for the pupils, as follows: 2 days with no Wi-Fi exposure and 2 days with Wi-Fi (2.45 GHz) exposure. Hence, in a regular classroom subjects were observed during usual class activities. The pupils were seating in the classroom in their usual places.

The pupils listened a short story (with animals involved as characters: wolf, bear, snake, fox) and they had to answer to specific questions related to the story, to form words etc. They are 5 items with one or several sub-points which try to explore their ability to memorize, to express, to relate or connect information. Also they were invited to draw what they consider about the story they listened. The children were aware the results of the test are not taken into account in their scholar assessment. The types of the subjects on the test were familiar to them.

The test duration was about 1 hour in all days. In the days with Wi-Fi the Wi-Fi was ON all the time. The router was installed with 1 hour before the test and was ON for 2 hours (1 hour before and 1 hour during the test). Wi-Fi radiation distribution (with router in the classroom) is represented in Figure 1. The measurements took place over 120 minutes. In the days with no Wi-Fi, one hour prior to the test the Wi-Fi network in the school was OFF, no other Wi-Fi sources were present neither in the classroom or in the school and the situation stayed like this for another 1 hour during the test (2 hours in total).

The following aspects were taken into consideration:

1. The change in the cognitive abilities (concentration, memory, focus on the task, mistakes). Grades were given (from 1 to 10) to quantify the answers on the written test.
2. The drawings were analyzed, if changes appear, from the color using, page filling, page layout, creativity, "tidiness" in relation with the story.
3. The behavior of the children was studied by the psychologist of the school and the teacher during the test and compared (changes between days with Wi-Fi and days without Wi-Fi and also compared with the regular behavior of the class).

The entire procedure was managed and supervised by the teacher and the school psychologist. The pupils were having their activities, having no information about the aim of the test or when the signals were ON or OFF. The maximum flux density on the subjects was approx. 12500 µW/m2 on the ON phase of the experiment and almost negligible during the OFF phases. A technical staff member was also present during the entire experiment in the classroom to ensure the experiment runs correctly and identical during each test.

The following main hypotheses were formulated:

1. They will be differences between the results on the written tests in the days with Wi-Fi exposure and the days with no exposure.
2. The Wi-Fi exposure will affect the artistic abilities and creativity of the pupils.
3. ,The absence of Wi-Fi exposure will affect the individual and social behavior of the pupils, increasing the human interactions and changing individual state of mind of the pupils.

The measurements were carried out in the first half of June 2021 with 21 subjects. The testing sessions were developed during daylight, between 11:00 and 12:00 a.m.

2.2.2 Study B (Factor room harmonizer)

The test duration was about 1 hour. The Wi-Fi was ON all the time. The router was installed with 1 hour before the test and was ON for 2 hours (1 hour before and 1 hour during the test). They were 2 days only with Wi-Fi ON and no real ReLux objects in the classroom (just placebo objects) and another 2 days with the Wi-Fi ON and 4 ReLux objects in the classroom (1 cube – Energie-Skulptur, 1 Aurum harmonizing panel and 2 electro-smog dedicated panels). The products were obtained from the company ReLux GmbH, 88699 Frickingen, Germany.

Wi-Fi radiation distribution (with router in the classroom) and the ReLux objects installed is represented in the figure 2.

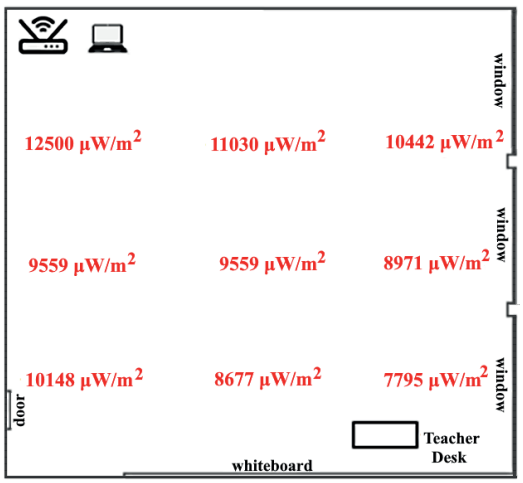

Figure 2: Classroom topology with measurements and ReLux objects

2.3 Participants

2.3.1 Study A: Factor Wi-Fi

A class of 24 pupils attended the experiment, all of them in 2nd grade primary school, 8-9 years old. One of the 24 is with Down syndrome and he didn‘t follow the usual tests, but he completed some special tasks under the surveillance of the psychologist.

21 of 23 were present to all 4 tests (accomplishing the written test and drawing). One of them is having also special needs, in a mild form, he was able to complete some of the tasks but the results were extreme (outlier). Hence, the results and statistics considered data from the remaining 20 participants, 12 boys and 8 girls.

The legal tutors of the participants in the experiment completed the consent form.

2.3.2 Study B: Factor room harmonizer

A class of 24 pupils attended the experiment, all of them in 3rd grade primary school (the same classroom and the same pupils as in June study A experiment). One of the 24 is with Down syndrome and he didn‘t follow the usual tests, but he completed some special tasks under the surveillance of the psychologist.

20 of 23 were present to all 4 tests (accomplishing the written test and drawing). Hence, the results and statistics considered data from the remaining 20 participants, 10 boys and 10 girls.

The legal tutors of the participants in the experiment completed the consent form.

2.4. Statistical analysis

To compare text evaluation data a repeated measures anova analysis was used. For the drawings ratings statistical analysis of the parameters was performed using a Cochran-Q-test for binary paired samples. All analysis were done with the program Jamovi. Statistical significance was assumed for $p < 0.05$.

3. Results

Three types of results are considered, according to the three aspects followed in the methodology: cognitive perfor-mances, artistic and creative performances, individual and social behavior.

3.1 Study A: Factor Wi-Fi

3.1.1 Cognitive performances

For the cognitive performances of the pupils based on written test five exercises (items) were considered for the assessment in all 4 days and also the number of grammatical and spelling mistakes made by pupils. The items were identical and the questions asked were similar for all 4 tests.

Hence, the written test gathers the results on different specific criteria (memory, creativity, pure cognition). The written tests contain 3 exercises (items) testing the memory ability combined with cognitive tasks (exercise 1 ask the pupil to fill out the sentences with information from the story they just listened; exercise 2 ask for forming questions regarding the story; exercise 3 ask for numbering the episodes in the order that happened in the story), 1 exercise for creativity (challenging the pupils to imagine another ending for the story) and an exercise for pure cognitive abilities (asking to form words from specific vowels and consonants).

A repeated measures anova analysis was used to compare text evaluation data between On1, On2, Off1 and Off2 sessions. The results of the parameter Creativity criteria and Cognitive criteria do not show any significant differences (tabel 2). The analyses of the memory criteria show significant differences between session On1 and On2. The mean value of session On2 shows significantly higher values compared to Off1 and Off2. Session Off1 has significantly higher values compared to Off2.

The data analyses of the number of mistakes in the text evaluation show significant differences between session On1 compared to On2 and significantly higher mistake scores of On1 compared to Off1 and Off2. Session On2 has a significant higher error rate than Off1. On the two dates without Wi-Fi, the mean values show less errors than on the days with Wi-Fi.

Table 2: Ratings of text evaluation with and without Wi-Fi exposure. Mean ± 95 % confidence interval and the p-value of the pair-wise comparison.

Memory criteria	Mean (95% CI)		ON1	ON2	OFF1	OFF2
ON1	9.23 (8.81 - 9.65)	P-Value	--	**0.014**	0.888	0.06
ON2	9.9 (9.79 - 10.01)	P-Value		--	**0.013**	**0.001**
OFF1	9.2 (8.81 - 9.59)	P-Value			--	**0.027**
OFF2	8.63 (8.08 - 9.18)	P-Value				--

Creativity criteria	Mean (95% CI)		ON1	ON2	OFF1	OFF2
ON1	9.4 (8.34 - 10.5)	P-Value	--	0.673	1	1
ON2	8.7 (7.31 - 10.1)	P-Value		--	0.673	0.649
OFF1	9.4 (8.34 - 10.5)	P-Value			--	1
OFF2	9.8 (9.38 - 10.2)	P-Value				--

Cognitive criteria	Mean (95% CI)		ON1	ON2	OFF1	OFF2
ON1	8.65 (7.62 - 9.68)	P-Value	--	0.149	0.149	0.389
ON2	7.65 (6.28 - 9.02)	P-Value		--	1	1
OFF1	7.35 (5.97 - 8.73)	P-Value			--	0.276
OFF2	7.95 (6.68 - 9.22)	P-Value				--

Mistakes	Mean (95% CI)		ON1	ON2	OFF1	OFF2
ON1	3.35 (2.02 - 4.68)	P-Value	--	**0.033**	**0.006**	**0.033**
ON2	2.1 (1.24 - 2.96)	P-Value		--	**0.033**	0.453
OFF1	1.4 (0.68 - 2.12)	P-Value			--	0.325
OFF2	1.8 (0.79 - 2.81)	P-Value				--

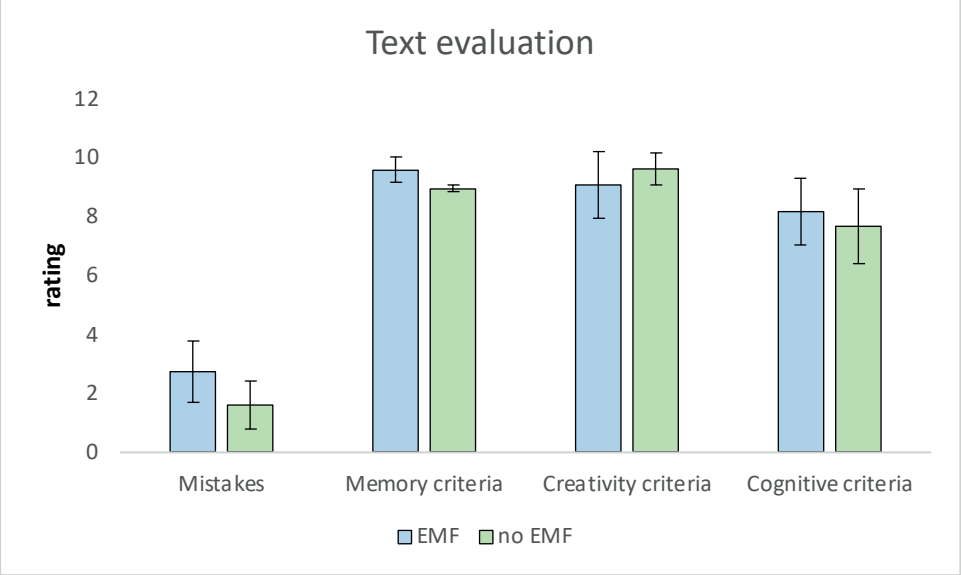

Figure 3: Rating of the parameters mistakes, memory criteria, creativity criteria, cognitive criteria.

As there are significant effects between the results of the days, the four days must be reported individually. Never-theless, the results of both dates are summarised in Figure 3 to show possible trends.

3.1.2. Artistic and creative performances

Looking overall and comparatively the drawings in days with Wi-Fi and days with no Wi-Fi at all, some differences were noticed by the psychologist and also by the art teacher: in the days with Wi-Fi the drawings are focused on details related to the content (cognitive level), limits and uncertainty (erased portions) and in the days with no Wi-Fi the pupils concentrated more on the characters and proportions, the drawings are more balanced, colorful, realistic, present time oriented, the page is filled more. What emerge from the drawings in the days with Wi-Fi is tension, competition with themselves, task orientation, restlessness, order, some aggressiveness and in the days with no Wi-Fi harmony, em-pathy, friendship, hope.

In order to quantify the differences in the drawings pupils made in the experiment, some aspects were taken into account: the layout of the drawing: portrait or landscape; the colors: mono-colored or more colors; the presence of the sun symbol in the drawings; page filling: all the page or just a part of it. Hence, the following bivalent items were used, identical in all 4 tests: it1 – portrait (1/0), it2 – landscape (1/0), it3 – colored/mono-colored (1/0), it4 – presence of the sun (1/0), it5 – completeness in filling the page (1/0). Table 3 shows the relative frequency of the parameters landscape, colored, sun-symbol present and drawing complete.

Table 3: Relative frequency of the drawing quality parameters.

Wi-Fi	landscape	Coloured	Sun-symbol existence	Drawing complete
On1	76.19%	61.90%	33.33%	85.71%
On2	76.19%	85.71%	23.81%	61.90%
OFF1	76.19%	76.19%	47.62%	85.71%
OFF2	76.19%	85.71%	52.38%	85.71%

The overall test (Cochran-Q-test) shows no significant differences between parameters **Portrait/Landscape, Drawing complete/incomplete with** and **without Wi-Fi**. There were some statistical trends for the parameters **coloured/mono-coloured** (total p-value = 0.09) and **sun symbol/no sun symbol** (total p-value 0.096)

Figure 4 summarizes the results of both days per factor to show possible trends. Three of the four parameters indicate advantages for the Wi-Fi option, but as reported above, not significant.

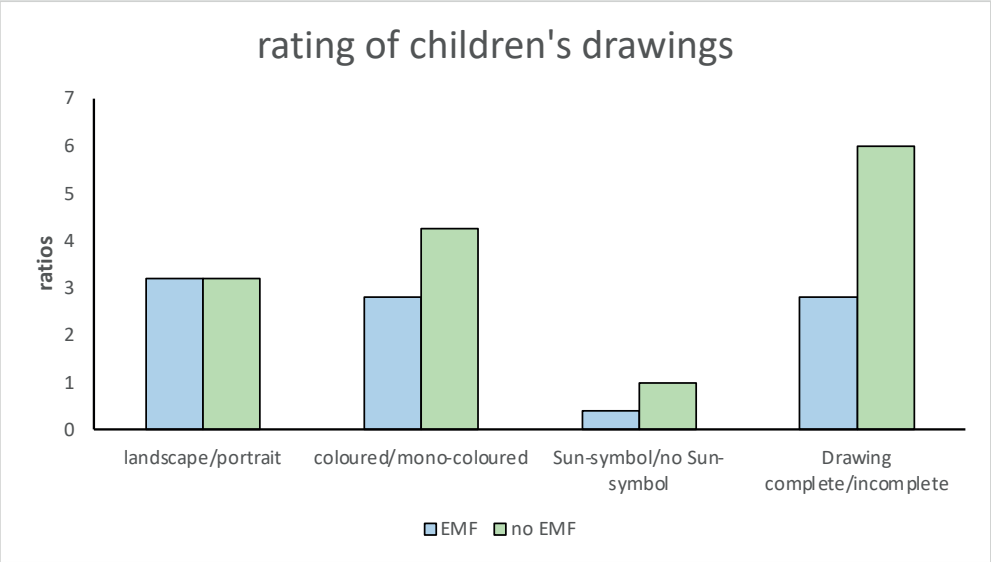

Figure 4: Rating of children´s drawing: Ratio between the different parameters with and without EMF

Individual Analysis – study case

A particular situation will be considered in the following: the drawings of the pupil situated in front of the router, in the NW corner of the classroom – the spot with the highest Wi-Fi radiation power (10.000 mW/m2). The drawings on all four days are presented in Figure 5.

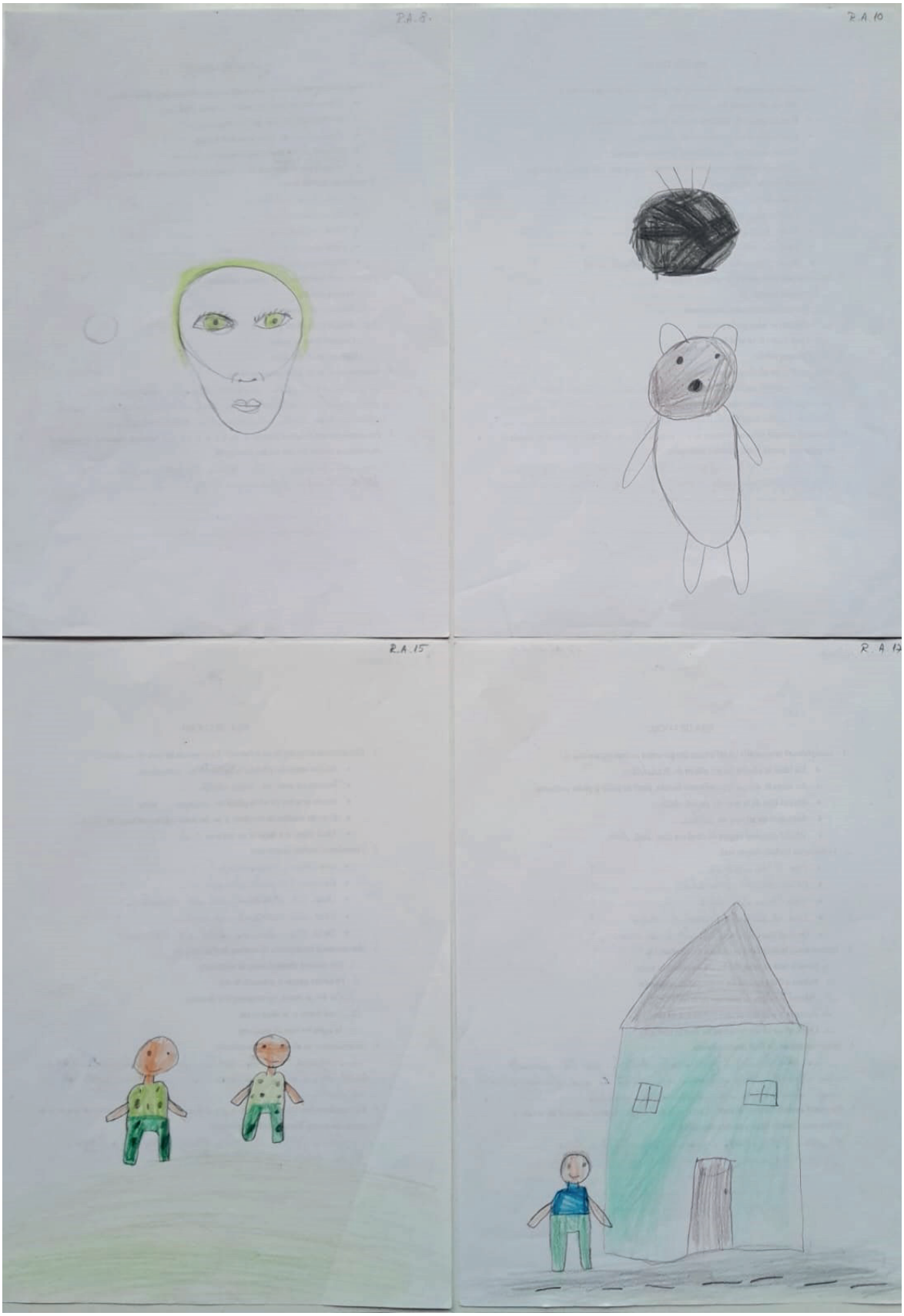

Figure 5: Drawings of the pupil situated in the spot with the highest Wi-Fi level (up: On1 and On2, down: Off1 and Off2).

3.1.3. Observation on the individual and social behavior of the pupils

Over the experiments, in all 4 days, during the tests but also previously and after, the behavior of the pupils was observed by the professor psychologist and the teacher. These observations are summarized in the followings.

Day 1 (On1): background Wi-Fi and a transmitting Wi-Fi router in the classroom.

External conditions: 260 C, nice weather, sun with no clouds.

The children are very focused on the task, they ask a lot of questions, they are restless and when they succeed to concentrate they are focused only on the tests. During the test the pupils make a lot of noise moving objects, moving their feet and dropping objects on the floor.

The kid with Down syndrome did his task (scissors cutout on a contour), not paying very much attention on the correctitude of the result.

Day 2 (On2: background Wi-Fi and a transmitting Wi-Fi router in the classroom

External conditions: 210 C, nice weather, sun with clouds.

The pupils are restless, agitated, uncertain about what they have to do. They find themselves reasons to walk in the front of the classroom to the garbage bin, to get water, or a tissue or to disinfect their hands. The children move compulsively their feet under the desk, they ask a lot of questions.

As in the previous day, the kid with Down syndrome had to perform eye-hand coordination tasks (scissors cutout on a contour). He was very focused on the task, wanting to work harder and harder. He was upset when comments were made by the psychologist about quality.

Day 3 (Off1): no W-Fi, neither in the classroom or in the school, only with the external background Wi-Fi exposure

External conditions: 170 C, cloudy with sun from time to time.

At the beginning of the test the children are quiet. For the first time, the noise in the street disturbed them and they asked to close the window. They look more relaxed, finished their written test quite early, some of them took their shoes off - gestures that suggest familiarity with space and the environment, un-inhibited behavior, release from the con-straints imposed by school rules, all of which are manifested in a way without hostility. They are talking with the others, wanting to share experiences with snakes. They raise their hands when they want to ask a question or to speak.

The pupil with Down syndrome was quite joyful and after the experiment, he hugged the engineer from the technical team, a behavior quite special on his behalf.

Day 4 (Off2): no EMF. No Wi-Fi, neither in the classroom or in the school, only with the external background Wi-Fi exposure.

External conditions: 200 C, nice weather, sun with no clouds.

The pupils formulated just a few questions to the teacher, they look relaxed and they are quiet. The children‘s movements during the test were more natural, playful and jovial, reflecting the intention to interact with others. Pupils who finished completing the test did not get up from the bench to move, were no longer vocal, began to communicate with colleagues nearby, whispering, respecting the need for silence for others to complete the test. Some of them, after finishing the tests find themselves an occupation (reading, drawing). They talk about how was the test, showing their drawings.

The pupil with Down syndrome was more creative - he cut creatively, he discovered new utilities and possibilities to use scissors: for example he wanted to cut his hair, the curtain, he wanted to cut the string on the shirt of the psychologist sitting next to him, but at the slightest observation or explanation he slow down and reoriented himself to another activity.

3.2. Results of study B: Factor room harmonizer

3.2.1 Cognitive performances

A repeated measures anova analysis was used to compare text evaluation data between Wi-Fi 1 (without Relux), Wi-Fi 2 (without Relux), Wi-Fi with Relux 1 and Wi-Fi with Relux 2 sessions. Only the analyses of the memory criteria show some significant differences between the dates, namely Wi-Fi with Relux 2 differs from Wi-Fi with Relux 1 and Wi-Fi 2 (without Relux).

Table 4: Ratings of text evaluation. With and without room harmonizer (Relux). Mean ± 95 % confidence interval and the p-value of the pair-wise comparison.

Memory criteria	Mean (95% CI)		WiFi no ReLux1	WiFi no ReLux2	WiFi with ReLux1	WiFi with ReLux2
WiFi no ReLux1	8.67 (7.97 -9.37)	P-Value	--	0.223	0.223	0.718
WiFi no ReLux2	9.47 (8.79 -10.14)	P-Value		--	0.718	**0.038**
WiFi with ReLux1	9.37 (8.82 - 9.92)	P-Value			--	**0.015**
WiFi with ReLux2	8.37 (7.78 - 8.95)	P-Value				--

Creativity criteria	Mean (95% CI)		WiFi no ReLux1	WiFi no ReLux2	WiFi with ReLux1	WiFi with ReLux2
WiFi no ReLux1	7.8 (6.17 - 9.43)	P-Value	--	0.107	0.881	0.778
WiFi no ReLux2	9.6 (8.95 - 10.25)	P-Value		--	0.216	0.617
WiFi with ReLux1	7.9 (6.09 - 9.71)	P-Value			--	0.778
WiFi with ReLux2	8.7 (7.17 - 10.23)	P-Value				--

Cognitive criteria	Mean (95% CI)		WiFi no ReLux1	WiFi no ReLux2	WiFi with ReLux1	WiFi with ReLux2
WiFi no ReLux1	7.23 (6.12 -8.33)	P-Value	--	1	1	0.997
WiFi no ReLux2	7.1 (5.94 -8.26)	P-Value		--	1	1
WiFi with ReLux1	7.05 (5-92 - 8.18)	P-Value			--	1
WiFi with ReLux2	6.67 (5.29 - 8.06)	P-Value				--

Mistakes	Mean (95% CI)		WiFi no ReLux1	WiFi no ReLux2	WiFi with ReLux1	WiFi with ReLux2
WiFi no ReLux1	2.25 (1.35 - 3.15)	P-Value	--	0.977	1	0.819
WiFi no ReLux2	2.8 (1.69 -3.91)	P-Value		--	0.977	0.121
WiFi with ReLux1	2.25 (1.12 - 3.39)	P-Value			--	0.819
WiFi with ReLux2	1.6 (0.6 - 2.6)	P-Value				--

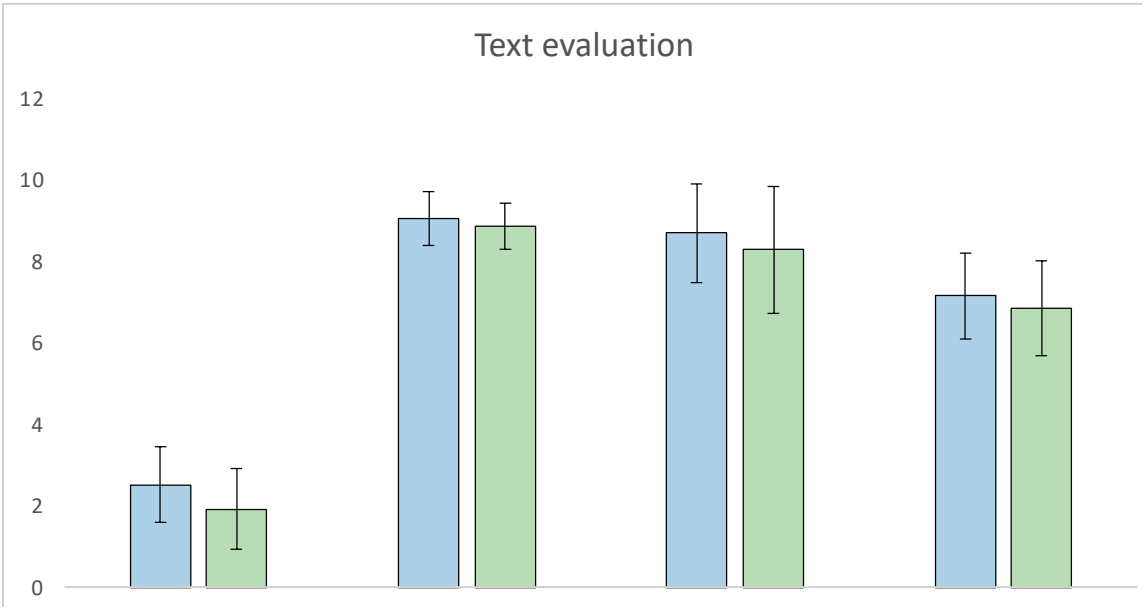

Figure 6: Rating of the parameters mistakes, memory criteria, creativity criteria, cognitive criteria.

3.2.2. Artistic and creative performances

Overall test (Cochran-Q-test) shows no significant differences between parameters Portrait/Landscape, Drawing complete/incomplete with and without WiFi. There were some statistical trends for the parameters sun symbol/no sun symbol (total p-value 0.069)

Table 5: Relative frequency of the drawing quality parameters.

	landscape	Coloured	Sun-symbol existence	Drawing complete
WiFi no ReLux 1	76.19%	71.43%	9.52%	71.43%
WiFi no ReLux 2	80.95%	80.95%	33.33%	76.19%
WiFi with ReLux 1	90.48%	95.24%	28.57%	85.71%
WiFi with ReLux 2	95.24%	80.95%	42.86%	90.48%

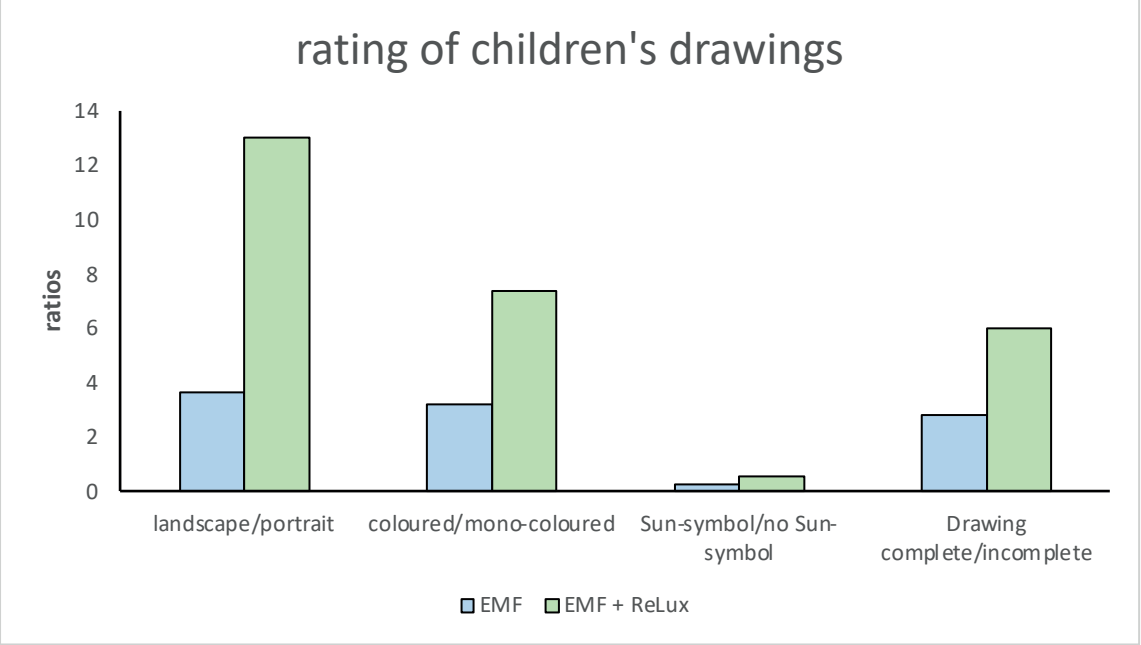

Figure 7: Rating of children´s drawing: Ratio between the different parameters with and without room harmonizer

Figure 7 summarizes the results of both days of the variants with and without room harmonizer. Although the Cochran-Q-test shows no significant differences, the columns of all four parameters indicate a tendency towards better drawing quality with room harmonizer.

3.2.3. Observation on the individual and social behavior of the pupils

Day 1: Wi-Fi without real ReLux objects, just placebo panels

External conditions: 23oC, nice weather, sun with a few clouds

The children are very quiet, they are concentrated only on the tests. They do not inter-act each other. After 20 minutes they started to ask questions to the teacher. Many of them are moving their feet compulsively and after 30 minutes they start to move on the chairs and to find something to do with their own stuff. They cannot wait to leave the classroom.

Day 2: Wi-Fi without real ReLux objects, just placebo panels

External conditions: 24oC, nice weather, sun with clouds

The children cannot decide to sit on their places, they find themselves something to do in front of the classroom: water, tissues etc. They move all the time on the chairs. Many of them are moving their feet compulsively. Some of them are speaking with themselves about the requirements of the test. They look tired and they often drop things on the floor. After 25 minutes the pupils become nervous, they started to move their objects on the bench and in the backpack. They are in a hurry to pack and leave the classroom. They cannot concentrate on what the teacher is saying. They are bringing their tests to the teacher, even if the teacher said to wait.

The pupil with Down syndrome is restless, he put a tissue on his head, he concentrated 10 minutes on the task (to find some symbols on a piece of paper) and then he started to eat and to organize his backpack.

Day 3: Wi-Fi with 4 ReLux objects: the cube, 1 Aurum harmonizing panel and 2 electro-smog panels

External conditions: 20oC, nice weather, sun with clouds

In the break prior to the test, the kids were playing all over the classroom, they let themselves to drop from the chairs on the floor, they laughed a lot.

The children are talkative, but when they receive the tests they get quiet. The atmosphere is more relaxed and they collaborate. After 20 minutes they start to ask and share with the others about the exercises or they are telling their opinion about this and that. They are not moving their feet compulsively anymore. They wait, after finishing the test, for the teacher to collect them. They are talking with the others or just do things in silence. They finish quite quickly the drawings and afterwards they are showing them one to the other and share funny opinions about them. They ask about the cube and "his friends", the panels.

The pupil with Down syndrome gave a neck and back massage to one of the engineers present for the experiment during the brake, after thet he played with the other kids on the floor.

Day 4: Wi-Fi with 4 ReLux objects: the cube, 1 Aurum harmonizing panel and 2 electro-smog panels

External conditions: 16oC, nice weather, sun with clouds

The children gathered quite hard, then they received the tests and get quiet. When they finish, look arround to see who else is in the same situation, they are paying attention to that. Some of them are talking with the others, some also play with the colleagues in front or back. The kids did not ask about the test. They are looking to the other kids drawings, having fun and trying to make their drawings funny. They started to dance with the hands when a phone was ringing outside. At some point the pupils start to talk about what they did in the previous days and about homeworks. They expresed the idea to make an exhibition with the drawings.

The pupil with Down syndrome collaborates very well with the psychologist. He needs to stay very close to her. He is also talking with one of the engineers pesent for the experiment and with the girls in front of him.

4. Discussion

In sub-study A (factor Wi-Fi), the cognitive performance, creativity and social behavior of pupils with and without Wi-Fi in the classroom were measured.

The assessment on cognitive abilities was done by the class teacher, the evaluation on the drawings by the professor psychologist of the school and the art teacher and the observation on individual and social behavior by the professor psychologist and reinforced by an external consultant, with experience in special needs children and adults psycho-logical clinical and educational practice. The 4 stories read by teacher were different every day in order to discourage the learning effect.

There were no significant effects on cognitive performance and creativity (ability to draw pictures), even though the mean values for the frequency of errors and the ability to draw pictures were more favorable in the control group. One interesting individual result is that the child sitting directly next to the router painted very differently with and without Wi-Fi exposure.

However, there were differences in social behavior: the class with Wi-Fi exposure behaved more restlessly. The children without Wi-Fi exposure were more relaxed and creative, initiating activities, paying attention to the col-leagues, playing more in the brakes. They felt free to share and to communicate with the others. The pupil with Down syndrome was also more creative, more relaxed and willing to collaborate and he even has initiatives of his own involving new activities.

We are not aware of any studies on the behavior of children exposed to Wi-Fi. While there are some studies on changes in health and behavior of infants due to prenatal mobile phone use (Papadopoulou et al. 2017; Li et al. 2017), there are only a few studies on postnatal behavioral changes. (Foerster et al. 2018) and (Schoeni et al. 2015) negative effects of RF radiation and memory performance in adolescents.

We are also not aware of any scientific studies that directly measure the effects of room harmonizers on people‘s be-havior. In our second sub-study, we tested the possible effects of a room harmonizer (from the company ReLux, Frickingen, Germany) under Wi-Fi exposure compared to a placebo under otherwise identical conditions as in our first sub-study. The results are comparable to those of the first sub-study: There are no significant effects on cognitive performance and creativity, but there are in social behavior. The control variant of sub-study A (no Wi-Fi) and the variant with room harmonizers of sub-study B show a similar pattern, namely a tendency towards fewer errors, more elaborate pictures and calmer behavior of the children.

In the days with the presence of ReLux objects in the classroom the children were more natural, relaxed and they felt free to express themselves and to play more in the classroom, creativity also was enhanced and they had new ideas about how to spend time together. They noticed the presence of the ReLux objects only in the day when the real ones were there and they considered them as ‘friends that are working together’. Also the social interaction increased in the days when the ReLux objects were in the classroom. The pupil with Down syndrome reacted well to their presence also, becoming more active and open to the others.

Our study has a number of limitations, such as overly simple questions in the cognitive tests and strong day effects.

The subjects on the written tests were too easy for the pupil’s level of knowledge and abilities. Hence, the results obtained on the tests were almost all at the top level (a lot of 10’s), it was difficult or almost impossible to differentiate between the results in different days and the assessment less sharp. A more complicated test should be used in order to emphasize such differences.

Familiar tests were chosen instead of standard tests. All types of exercises considered in the test, including free drawing on a subject based on a story, were performed on other occasions during the semester, so the work tasks were not new to the pupils. Standard tests are offering maybe more accuracy in results assessment but on the other hand they can generate undesired pressure on the pupils.

The period chosen for the experiment should be longer – maybe the entire day – in order to study the effects on a deeper level, especially the lack of Wi-Fi exposure on longer periods of time could be interesting.

The switching sequence was intended to be: On1, Off1, On2, Off2, but from technical reasons we were obliged to reconsider it on the spot and to have On1, On2 followed by Off1, Off2 phases, because it was impossible to switch off the Wi-Fi in the school in the second day of the experiment.

The observed effects on social behavior should definitely be given more consideration in future studies on HF-EMF and children.

In light of the scientific literature on adverse health effects of RF-EMF, our results on behavioral changes should be considered in future studies on children and RF-EMF.

Author Contributions: Conceptualization: J.U.G. and S.D.; methodology: J.U.G., S.D., I.B., G.C.; software: R.R.; formal analysis: J.K.; investigation: S.D, R.R., S.P., I.B., G.C.; writing—original draft preparation: S.D., J.U.G. and R.R.; writing—review and editing: S.D. and J.U.G. All authors have read and agreed with the published version of the manuscript.

Funding: This research was funded by Software AG Stiftung (Darmstadt) grant number RA-P 13550.

Institutional Review Board Statement: The study was approved by the Research Ethical Committee of the University of Oradea (the decision was registered at the Research Programs and Projects Office with nr. 660/5.11.2020).

Informed Consent Statement: Informed consent was obtained from all legal tutors of subjects involved in the study. All legal tutors of the participants signed a written informed consent before the pupils took part voluntarily in the study. Each member of the implementation research team signed a confidentiality declaration regarding the participants' data.

Acknowledgments: We want to express our gratitude to Software AG Stiftung (Darmstadt) for funding this project and to Ama-lia Gabor, consultant psychologist and Anca Bulc, consultant art professor.

Conflicts of Interest: The authors declare no conflict of interest.

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