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TEACHER AND STUDENT RESPONSE TO THE REMOVAL OF DIRTY ELECTRICITY BY THE GRAHAM/STETZER FILTER AT WILLOW WOOD SCHOOL IN TORONTO, CANADA.

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Abstract

The purpose of this study was to test the effect of the Graham/Stetzer microsurge filters on the wellbeing of teachers and on the behavior of their students in a private school (grades 1 to 12) in Toronto, Canada. GS filters remove electromagnetic frequencies from 4 to 100 kHz on indoor wiring and they were installed in this school because one of the students is electrically sensitive. Teachers were asked in a single blind study to complete a questionnaire daily between January and March 2003 for a 6-week period (3 weeks with and 3 weeks without filters). Eighteen teachers out of 49 completed the questionnaire enough times to enable statistical analysis. Symptoms improved for 55% of the teachers and got worse for 11% of the teachers while the filters were installed. Three teachers (16%) had no response to the filters and another three (16%) had mixed reactions (some symptoms improved and some got worse). Overall teacher wellbeing improved while the filters were in place. Teachers were less frustrated, less tired, less irritable. They were better able to focus and had better health, improved mood, and greater sense of accomplishment. Student response appeared to be age-specific with younger students responding more favorably than older students. This preliminary study needs to be repeated in other schools. If the Graham/Stetzer filters are as effective as they appear to be, then the dirty electricity in schools, homes, and offices can be reduced until other methods are in place to minimize the production and distribution of this form of electrical pollution.

Introduction

Electrosensitivity, also known as electrical hypersensitivity, is a relative new phenomenon that first received public attention in the early 1970s [1]. Symptoms of electrosensitivity resemble radiation poisoning experienced by radar workers and include chronic fatigue, depression, headaches, body aches and pains, ringing in the ears, eye discomfort, skin irritations, unnatural warmth or burning sensation in the face, nausea, dizziness, cardiac palpitations, impaired sleep, memory loss, and confusion [2]. Individuals with severe symptoms may have difficulty in public places and seek relief by minimizing their electricity use or by turning off the power supply in their home. Those with less severe symptoms may associate the daily headache or the excessive fatigue with a stressful lifestyle. One study estimates that two percent of the population may be electrically sensitive [3].

Students or teachers who suffer from electrical sensitivity in a school with computers, energy efficiently lighting, photocopy machines and other electronic equipment are unlikely to do well in their work. Electrical sensitivity of one student at Willow Wood school prompted the present study and the recent commercial availability of the Graham/Stetzer filters made this study possible.

Graham/Stetzer filters are capacitors that remove microsurges on electrical wires within the range of 4 to 100 kHz [4,5]. These microsurges include transients and harmonics of the 60 Hz frequency and consist of variable spikes in the voltage that ride on top of the electrical distribution grid's 60 Hz sine wave. They are produced by computers, television, energy-efficient lighting, dimmer switches, telephones, photocopiers and other electrical appliances. Once generated these microsurges flow along electrical wires. In addition to the microsurges generated within buildings, they can also enter buildings through the power distribution lines or through water and gas pipelines by way of ground current. These high frequency microsurges flowing along the ground and along wires are a form of electrical pollution and are referred to as dirty power or dirty electricity.

In the present study we tested the effect of the Graham/Stetzer filters on the wellbeing of teachers and on the behavior of their students in Willow Wood School, a private school (grades 1 to 12) in Toronto, Canada.

Method

The Principal of Willow Wood agreed to having the Graham/Stetzer filters installed in her school and to participate in a study on the effectiveness of these filters. The study period extended from January 16th through March 3rd 2003. The GS filters were installed from February 4 to 24th inclusive and this provided a 2-week pre-filter and a 1-week post-filter reference period for comparison.

Teachers were asked to complete a questionnaire twice daily (at 11:30 am and 3:30 pm) regarding behaviour of students in their last class and they were asked to complete another questionnaire at the end of the school day regarding their own physical well being and performance. Teacher identity and individual responses to the questionnaire were kept confidential. The questionnaire was designed to test for internal consistency with redundant questions. Participation was voluntary and teachers completed these questionnaires without knowing the nature of the research that was being conducted (single blind study).

Questionnaire data were analyzed separately for each class and for each teacher since students in grades 1 through 6 (elementary school) spend most of their day in the same classroom and hence a reasonable estimate of electromagnetic exposure is possible, while students in both middle school and high school (grades 7 to 12) move to different classrooms each period and are exposed to a much more variable environment. Similarly, some teachers remain in one classroom while others rotate with the courses they teach. Pre- and post-filter data for individual teachers and classes were grouped and the results were compared to periods with the filters in place using a two-tailed t-test at $P \leq 0.05$. The effect of time (pre vs during vs post-filter) was assessed where sufficient data existed.

Power quality was measured weekly in each classroom, in the cafeteria, gym, library, front office and other places where either teachers or students were likely to spend part of their day. Measurements were taken with a Fluke 79 III meter (mV as rms, range to 20 KHz) connected to a Graham Ubiquitous Filter, which removes the 60 Hz sine wave. An example of poor power quality (microsurges) and a 60 Hz sine wave are shown in Fig. 1.

A total of 50 Graham/Stetzer filters (capacitors) were installed in outlets throughout the school on February 4th and left in place until February 24th. The filters are small box-like units (5x4x9 cm) that plug into an outlet. Each classroom had 1 or 2 filters and most of these probably went unnoticed. A school of this size with the number of computers and other office equipment requires approximately 150 GS filters and hence the dirty electricity in the school was reduced but not eliminated (Table 1). Filters improved quality by 50% for frequencies up to 20 kHz. Since these filters are effective for frequencies up to 100 kHz, additional improvements were likely but were not measured.

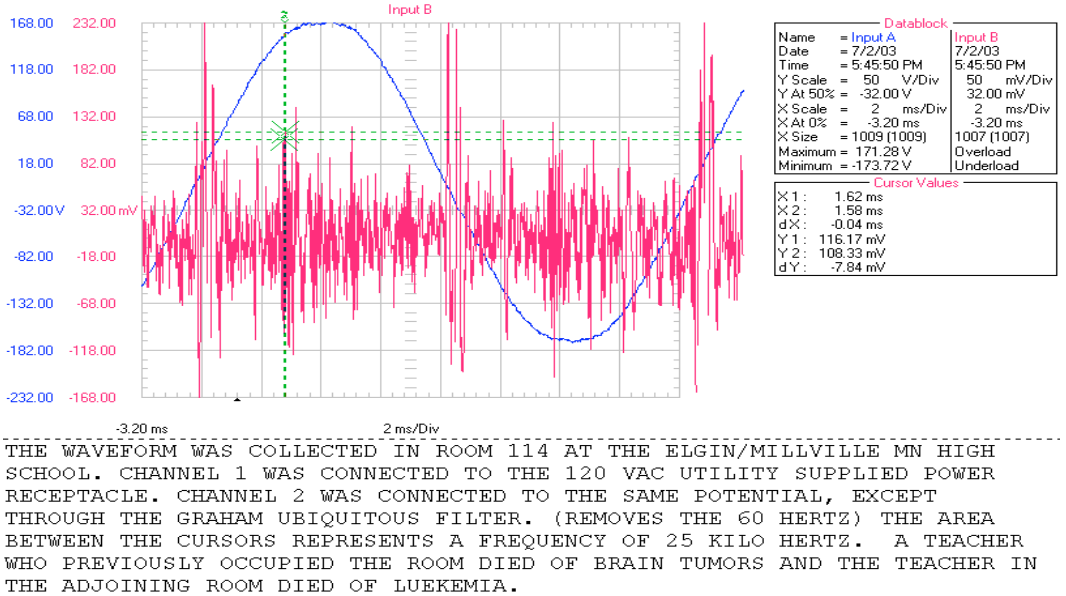

Figure 1. Example of microsurges in a school environment. Data courtesy of Dave Stetzer, Electrical Pollution: RF Frequencies and Your Health. Talk presented at Willow Wood School, January 2004.

Results & Discussion

The Graham/Stetzer filters improved power quality at Willow Wood School by filtering out high frequency transients on indoor wiring. The amplitude of frequencies below 20 kHz were reduced by approximately 50% from an average of 23 mV (range 13-101 mV rms) to 13 mV (range 8-24 mV rms) (Table 1).

Table 1. Dirty electricity monitored weekly in each classroom at Willow Wood School with and without Graham/Stetzer Filters.

Willow Wood School	Sample Size	Dirty Electricity (mV, rms) mean	range	% change
without GS filter	130	23	13 - 101	57%
with GS filter	97	13	8 - 24	

Although the amount of current in a transient is small, it changes rapidly and can generate large electromagnetic fields. These transients are likely to be more biologically active since they produce radio frequency signals that are emitted into the environment and that can penetrate more deeply into tissue than can 60-Hz sine waves [6,7].

Despite the fact that the microsurges were not eliminated within the school, as many as 45% of the teachers reported feeling less tired and less frustrated; 35% felt healthier; 30% were less irritable; 25% had improved mood, more energy and a greater sense of satisfaction with their work while the filters were installed (Figure 2). This was not a placebo effect since the teachers were unaware of the nature of the research that was being conducted.

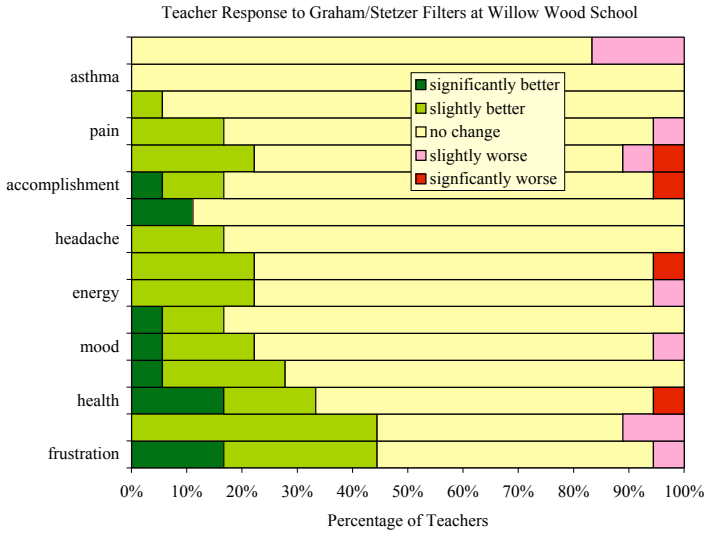

Figure 2. Response of teachers at Willow Wood School to improved power quality with Graham/Stetzer filters.

If the response of the teachers is a sign of electrical sensitivity then as many as 7 to 10 of the 18 teachers (39% to 56%) may have some degree of electrosensitivity based on the data in Table 2. The top candidate showed improvements while the filters were in place in 11 of the 16 questions asked (69%). These data are particularly interesting since the filters were installed during February, a month which people associate with symptoms of seasonal affective disorder (SAD). During the period the filters were installed three teachers showed no response and 2 teachers, both male, had a negative response.

Table 2. Individual teacher response to the Graham/Stetzer filters at Willow Wood School.

SYMPTOMS	Teacher: teacher ID	gender	school	Dirty Power: mV with GS Filter	% decrease with GS Filter	Teacher Response to Graham/Stetzer Filters: frustration	fatigue	health	irritable	mood	unfocussed	energy	satisfaction	headache	coughing	accomplishment	well-being	pain	medication	asthma	flu	Summary: significantly better	slightly better	no change	slightly worse	significantly worse	net response
						++	+	+	++	+	0	+	+	+	0	+	+	+	0	0	0			0	-	-	
BETTER 10 teachers (56%)	95	f	O	15	11%	++	+	+	++	+	0	+	+	+	0	+	+	+	0	0	0	13%	56%	31%	0%	0%	69%
	81	f	H	14	46%	0	+	++	0	++	++	+	0	0	++	0	0	0	0	0	0	25%	13%	63%	0%	0%	38%
	16	m	E	14	40%	0	+	++	0	0	+	0	+	0	++	0	0	+	0	0	0	13%	25%	63%	0%	0%	38%
	22	m	E	14	22%	+	0	+	0	0	0	0	+	0	0	++	+	+	0	0	0	6%	31%	63%	0%	0%	38%
	43	f	M	11	60%	+	+	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0%	25%	75%	0%	0%	25%
	56	m	H	9	47%	+	+	0	+	0	0	+	0	0	0	0	0	0	0	0	0	0%	25%	75%	0%	0%	25%
	32	m	M	13-17	21-33%	++	0	0	0	+	0	0	0	0	0	0	+	0	0	0	0	6%	13%	81%	0%	0%	19%
	15	f	M	14	19%	+	+	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0%	19%	81%	0%	0%	19%
	69	f	H	9	47%	+	+	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0%	19%	81%	0%	0%	19%
	53	f	H	12	27%	0	0	++	0	0	0	0	0	0	0	0	0	0	0	0	0	6%	0%	94%	0%	0%	6%
BETTER & WORSE 3 teachers (17%)	65	f	H	12	34%	++	+	0	+	+	0	+	0	0	0	0	0	0	+	0	-	6%	31%	56%	6%	0%	31%
	42	m	M	14-17	30-33%	0	0	--	+	0	+	0	0	0	0	0	0	0	0	0	0	0%	13%	81%	0%	6%	6%
	62	m	H	9-14	45-47%	0	-	0	0	0	0	0	+	0	0	0	0	-	0	0	-	0%	6%	75%	19%	0%	-13%
NO CHANGE 3 teachers (17%)	21	f	E	12	35%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%	0%	100%	0%	0%	0%
	11	f	E	12	45%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%	0%	100%	0%	0%	0%
	51	f	H	22	7%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%	0%	100%	0%	0%	0%
WORSE 2 teachers (11%)	12	m	E	11	48%	-	-	0	0	-	0	-	0	0	0	0	-	0	0	0	-	0%	0%	63%	38%	0%	-38%
	66	m	H	nd	nd	0	0	0	0	0	0	0	--	0	0	--	--	0	0	0	0	0%	0%	81%	0%	19%	-19%
			++	significantly better		17%	0%	17%	6%	6%	6%	0%	0%	0%	11%	6%	0%	0%	0%	0%	0%	4%						
			+	slightly better		28%	44%	17%	22%	17%	11%	22%	22%	17%	0%	11%	22%	17%	6%	0%	0%		15%					
			0	no change		50%	44%	61%	72%	72%	83%	72%	72%	83%	89%	78%	67%	78%	94%	100%	83%			76%				
			-	slightly worse		6%	11%	0%	0%	6%	0%	6%	0%	0%	0%	0%	6%	6%	0%	0%	17%				3%			
			--	signficantly worse		0%	0%	6%	0%	0%	0%	0%	6%	0%	0%	6%	6%	0%	0%	0%	0%					1%		
				net response		39%	33%	28%	28%	17%	17%	17%	17%	17%	11%	11%	11%	11%	6%	0%	-17%							15%

nd no data
m male
f female

H high school
M middle school
E elementary school
O office

Teachers also documented student behaviour (but not student health) in this questionnaire. In the lower school (grades 1 to 6) students spend most of their time in the same classroom. Sixty percent of the classes showed signficant improvements in student behaviour (Table 3). In grades 3 to 6, the time teachers had to spend dealing with disruptions or starting a new lesson was reduced by 2 to 6 minutes per class.

In middle school (represented by grade 7, Table 4), only one class showed statistically significant improvements. In two of the three classes, as much as 5 to 10 minutes were saved each period in unproductive activity while the filters were installed.

In high school (grades 9 to 12, Table 5) as in middle school, students change classrooms each period and hence their exposure to microsurges are likely to be much more varied than the data in Table 5 suggest. Although there were some positive responses (58% showed slight or signfiicant improvements in symptoms) there were also a considerable number of negative responses (39%).

One interesting observation is that the net response (postive minus negative symptoms) decreased with increasing grade level (Table 6). What this suggests is that younger students may be more sensitive than older students to poor power quality. Similar results were observed for childhood leukemia with residential exposure to magnetic fields. Younger children were at greater risk for developing leukemia than older children [8].

The need for teachers to repeat instructions, the ability of students to focus on class work, and active particiation by students in classes are shown in Figure 3 for all grades at Willow Wood School. This figure clearly shows that improved power quality is associated with behaviour that is more conducive to learning in the classroom. It also raises questions about students who may have learning disabilities or those with ADD or ADHD. To what degree are these symptoms associated with or exacerbated by poor power quality in the classroom?

Although Willow Wood is not the first school with Graham/Stetzer filters it is the first one that has been documented scientifically. More studies in schools, particularly elementary schools, are recommended.

Table 3. Response of students in grades 1 to 6 to improved power quality with Graham/Stetzer filters at Willow Wood School.

Lower School		Dirty Power (mV rms)				Student Response to Graham/Stetzer Filters							Summary					
Grade	Room	without G/S filters	with G/S filters	% of original	unproductive time/class (min)	time to start class	time dealing with distruptions	late for class (# students)	need to repeat instructions	students' ability to focus	active student participation	classroom noise	signficantly better	slightly better	no change	slightly worse	signficantly worse	net response
													++	+	0	-	--	
1&2	A1	24	14	60%	-0.9	-	+	0	+	+	+	++	14%	57%	14%	14%	0%	57%
3	A4	18	12	65%	2.6	+	+	+	++	-	++	+	29%	57%	0%	14%	0%	71%
4	A5	18	14	78%	4.1*	+	++	+	+	+	+	-	14%	71%	0%	14%	0%	71%
5	B7	22	12	55%	2.1	+	+	+	+	-	+	+	0%	86%	0%	14%	0%	71%
6	B6	21	11	52%	5.7	+	+	+	+	+	+	+	0%	100%	0%	0%	0%	100%
	++	significantly better			20%	0%	20%	0%	20%	0%	20%	20%	11%					
	+	slightly better			60%	80%	80%	80%	80%	60%	80%	60%		74%				
	0	no change			0%	0%	0%	20%	0%	0%	0%	0%			3%			
	-	slightly worse			20%	20%	0%	0%	0%	40%	0%	20%				11%		
	--	signficantly worse			0%	0%	0%	0%	0%	0%	0%	0%					0%	
		net response			60%	60%	100%	80%	100%	20%	100%	60%						74%

* = statistically significant (P≤0.05)

Table 4. Response of students in grades 7 to improved power quality with Graham/Stetzer filters at Willow Wood School.

Middle School			Dirty Power (mV rms)				Student Response to Graham/Stetzer Filters								Summary					
Grade	Room	Course		without G/S filters	with G/S filters	% of original	unproductive time/class (min)	time to start class	time dealing with distruptions	late for class (# students)	need to repeat instructions	students' ability to focus	active student participation	classroom noise	signficantly better	slightly better	no change	slightly worse	signficantly worse	net response
															++	+	0	-	--	
7	A2	math		20	13	68%	10	0	+	0	0	-	+	+	0%	43%	43%	14%	0%	29%
7	B4	math		20	14	67%	5.9	0	+	++	+	+	+	-	14%	57%	14%	14%	0%	57%
7	B5	math		28	11	40%	-1.8	-	+	-	-	+	+	-	0%	43%	0%	57%	0%	-14%
			++	significantly better			0%	0%	0%	33%	0%	0%	0%	0%	5%					
			+	slightly better			67%	0%	100%	0%	33%	67%	100%	33%		48%				
			0	no change			0%	67%	0%	33%	33%	0%	0%	0%			19%			
			-	slightly worse			33%	33%	0%	33%	33%	33%	0%	67%				29%		
			--	signficantly worse			0%	0%	0%	0%	0%	0%	0%	0%					0%	
				net response			33%	-33%	100%	0%	0%	33%	100%	-33%						24%

A school in the Melrose-Mindoro School District in western Wisconsin had previously been categorized as a "sick" building but attempts to remove mold, which was assumed to be the problem, did nothing to alleviate symptoms among the staff. After installation of the Graham/Stetzer filters both teachers and students had more energy. The school nurse documented these changes [9]. Of the 37 students with inhalers only 3 used them for exercise-induced asthma before physical education classes. Staff with allergies took less medication and students with migraines experienced less pain. Teacher absences for health-related reasons were dramatically reduced after the filters were installed. The increase in modern electronics inside the school and "dirty" power from similar sources outside the school were to blame.

Table 5. Response of high school students to improved power quality with Graham/Stetzer filters at Willow Wood School.

High School				Dirty Power (mV rms)				Student Response to Graham/Stetzer Filters							Summary					
Time	Grade	Room	Course	without G/S filters	with G/S filters	% of original	unproductive time/class (min)	time to start class	time dealing with distruptions	late for class (# students)	need to repeat instructions	students' ability to focus	active student participation	classroom noise	signficantly better	slightly better	no change	slightly worse	signficantly worse	net response
															++	+	0	-	--	
10:00	9	Annex	Science	nd	nd	nd	0.9	--	+	+	+	+	+	+	0%	86%	0%	0%	14%	71%
10:00	9	S Lab	SNCID	18	9	53%	1.8	++	+	+	+	-	+	-	14%	57%	0%	29%	0%	43%
10:00	11	D2	Law	24	22	93%	0	0	+	+	-	-	-	+	0%	43%	14%	43%	0%	0%
10:00	12	C1	Math	25	14	54%	-4.8	-	--	-	+	-	-	-	0%	14%	0%	71%	14%	-71%
11:30	10	D2	Careers	24	22	93%	1.2	+	+	+	++	-	-	-	14%	43%	0%	43%	0%	14%
11:30	10	D3	Civics	18	12	66%	0.6	+	+	++	-	++	+	+	29%	57%	0%	14%	0%	71%
11:30	11	C Lab	ICS3M	26	14	55%	1.1	++	+	-	-	+	+	++	29%	43%	0%	29%	0%	43%
11:30	11	S Lab	Chemistry	18	9	53%	-1.1	-	-	+	+	--	+	-	0%	43%	0%	43%	14%	-14%
11:30	12	C1	Math	25	14	54%	4.9	++	+	+	-	+	-	+	14%	57%	0%	29%	0%	43%
12:30	10	CIP	Math	nd	nd	nd	-0.8	--	++	-	+	+	+	+	14%	57%	0%	14%	14%	43%
12:30	10	D2	Business	24	22	93%	-0.4	--	-	-	+	++	-	-	14%	14%	0%	57%	14%	-43%
12:30	11	C1	Accounting	25	14	54%	-8.3	-	-	++	++	+	-	+	29%	29%	0%	43%	0%	14%
12:30	12	D3	World Issues	18	12	66%	-0.1	-	0	+	+	+	-	+	0%	57%	14%	29%	0%	29%
3:00	9	Annex	SNCID	nd	nd	nd	12.6	-	++	-	+	+	-	++	29%	29%	0%	43%	0%	14%
3:00	9	S Lab	Science	18	9	53%	4.3	+	+	+	++	+	-	-	14%	57%	0%	29%	0%	43%
3:00	12	A6	Co-op	17	13	77%	-0.8	+	-	0	-	-	+	+	0%	43%	14%	43%	0%	0%
3:00	12	CIP	Math	nd	nd	nd	-0.1	+	-	+	-	+	--	+	0%	57%	0%	29%	14%	14%
			++	significantly better			0%	18%	12%	12%	18%	12%	0%	12%	12%					
			+	slightly better			47%	29%	47%	53%	47%	53%	41%	53%		46%				
			0	no change			6%	6%	6%	6%	0%	0%	0%	0%			3%			
			-	slightly worse			47%	29%	29%	29%	35%	29%	53%	35%				34%		
			--	signficantly worse			0%	18%	6%	0%	0%	6%	6%	0%					5%	
				net response			0%	0%	24%	35%	29%	29%	-18%	29%						18%

nd = no data

Table 6. Summary data for students and staff to improved power quality with Graham/Stetzer filters at Willow Wood School.

Willow Wood	Better		no change	Worse		net change
	significantly	slightly		slightly	signficiantly	
lower school	11%	74%	3%	11%	0%	74%
middle school	5%	48%	19%	29%	0%	24%
high school	12%	46%	3%	34%	5%	18%
teachers	4%	15%	76%	3%	1%	15%
mean	8%	46%	25%	19%	2%	33%

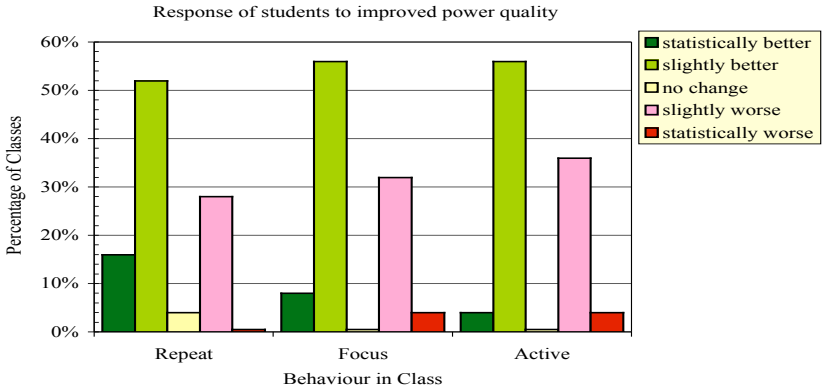

Figure 3. Response of students from grades 1 to 12 at Willow Wood school to improved power quality after installation of Graham/Stetzer filters. Results are based on 25 classes.

Conclusions

These data suggest that poor power quality may be interfering with the education of students, particularly younger students, and the performance of teachers. If the improvements in wellbeing, behaviour and performance that coincided with improved power quality at Willow Wood is a sign of electrical sensitivity then the proportion of electrically sensitive people in the population may be 20-60% than the 2% reported in Sweden [3]. This situation is likely to get worse as we continue to promote the use of computers in the classroom and as we move towards wireless computer and communication technologies that generate radio frequency radiation.

The Graham/Stetzer filters provide one method by which individuals can improve power quality in their home, work, or school environment. They also provide a tool that enables scientists to study the biological effects of poor power quality [10].

Acknowledgements

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