POWER QUALITY AFFECTS TEACHER WELLBEING AND STUDENT BEHAVIOR IN THREE SCHOOLS

Abstract: Poor power quality (dirty electricity) is ubiquitous, especially in schools with fluorescent lights and computers. Previous studies have shown a relationship between power quality and student behavior/teacher health. The purpose of this study is to determine the ability of power line filters to reduce dirty electricity in a school environment and to document changes in health and behavior among teachers and students. We installed Graham Stetzer filters and dummy filters and measured power quality in three Minnesota Schools. Teachers completed a daily questionnaire regarding their health and the behavior of their students for an 8-week period. Teachers were unaware of which filters were installed at any one time (single blind study). Dirty electricity in schools may be adversely affecting wellbeing of teachers and behavior of their students, especially younger students in middle and elementary school. Power line filters improve power quality and may also protect those who are sensitive to this energy.

Tags: Power Quality, Dirty Electricity, Fluorescent Lights, Computers, Student Behavior, Graham Stetzer Filters, Electrohypersensitivity, Attention Deficit Disorder (ADD), Electromagnetic Fields (EMF), Radio Frequency Radiation (RFR), Microsurge Meter, Transients, Harmonics, Headaches, General Weakness, Dry Eyes, Facial Flushing, Depression, Mood, Dizziness, Asthma, Pain, Clarity of Thought, Energy, Psoriasis

Power quality affects teacher wellbeing and student behavior in three Minnesota Schools

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ABSTRACT

Background: Poor power quality (dirty electricity) is ubiquitous especially in schools with fluorescent lights and computers. Previous studies have shown a relationship between power quality and student behavior/teacher health.

Objectives: The purpose of this study is to determine the ability of power line filters to reduce dirty electricity in a school environment and to document changes in health and behavior among teachers and students.

Method: We installed Graham Stetzer filters and dummy filters and measured power quality in three Minnesota Schools. Teachers completed a daily questionnaire regarding their health and the behavior of their students for an 8-week period. Teachers were unaware of which filters were installed at any one time (single blind study).

Results: Dirty electricity was reduced by more than 90% in the three schools and during this period teacher health improved as did student behavior in the middle/elementary schools. Headaches, general weakness, dry eyes/mouth, facial flushing, asthma, skin irritations, overall mood including depression and anxiety improved significantly among staff. Of the 44 teachers who participated 64% were better, 30% were worse, and 6% did not change. Behavior of high school students did not improve but elementary/middle school students were more active in class; more responsive, more focused; had fewer health complaints; and had a better overall learning experience.

Conclusions: Dirty electricity in schools may be adversely affecting wellbeing of teachers and behavior of their students, especially younger students in middle and elementary school. Power line filters improve power quality and may also protect those who are sensitive to this energy. Work on electric and magnetic field metrics with and without Stetzer filters urgently needs to be carried out to determine just what characteristics of the dirty electricity may be interacting with the people.

1. Introduction

Poor power quality, commonly referred to as dirty electricity, is a growing concern for the electrical utility as it interferes with sensitive electronic equipment leading to malfunctions and costly repairs. Schools with fluorescent lights and electronic equipment in the form of computers; those near high voltage transmission lines and near antennas for wireless communication are prime candidates for poor power quality (Havas 2006b; Vignati and Giuliani 1997).

Another, less well understood, consequence of dirty electricity is ill health for those who have become electrically hypersensitive (EHS). Diabetics with EHS have higher plasma glucose levels and require more medication when exposed to this energy, and people with multiple sclerosis have a worsening of their symptoms (Havas 2006b). The most common complaints among self-proclaimed EHS include chronic fatigue, chronic pain, difficulty sleeping, mood disorders such as anxiety or depression, concentration and memory problems, dizziness, skin irritation, visual disturbances and ringing in the ears (Firstenberg 2001; Havas and Stetzer 2004; Schooneveld and Kuiper 2007).

A study of dirty electricity, in a Toronto school, documented improved health among teachers and improved behavior among students when the dirty electricity was reduced with Graham/Stetzer filters (GS filters) plugged into outlets throughout the school (Havas et al., 2004). These filters short out high frequency transients and harmonics that contribute to poor power quality.

We repeated the study at three schools in Minnesota: an elementary and middle school, in the same building, and a nearby high school.

2. Materials and method

This research was approved by Trent University Ethics Committee and complies with local, state, and national regulations. Teacher participation was voluntary and those who participated could opt out during the study. Teachers provided written consent for us to use the information they provided with the understanding that their identify would not be revealed.

Three schools in Minnesota, an elementary, middle and high school, agreed to participate in a study that monitored and improved power quality and assessed teacher health and student behavior. The middle and elementary schools were in the same building. We did spot measurements of magnetic fields in randomly selected classrooms (using a trifield meter) and found the values to be low (less than 2 mG). Two power quality exposures were tested in each school. One test was with dummy filters that have no effect on power quality and the other was with GS filters that improve power quality. These filters are identical except the dummy filters are internally disconnected. A total of 541 GS filters or 285 dummy filters were installed in the three schools during testing. The protocol was as follows: first two weeks (Jan 31 to Feb 11 2005) with dummy filters, four weeks with GS filters (Feb 14 to Mar 11), and two weeks (Mar 14–25) with dummy filters to minimize seasonal effects on health and behavior. This was a single blind study as teachers were unaware of which filters were installed at any time during the study. While we did not use exactly the same number of real and placebo filters during this study, whether teachers counted the number of filters in their classrooms, along the hallway, in the library, etc. is questionable. We are confident this was a blinded study.

Power quality was monitored with a Microsurge meter that measures high frequency transients and harmonics between 4 to 100 kHz. This meter provides a digital reading from 1 to 1999 of |dv/dt| expressed as GS units with +/–5% accuracy (Graham, 2003). The power quality was measured during the weekend when the dummy and real filters were first installed. Lights were turned on in each room and some computers may have been on but were not in use. Readings obtained are likely to be lower than readings during regular school hours. While this is less than ideal we did not want teachers to know when the filters were exchanged.

Teachers answered a questionnaire related to their health and the behavior of their students at the end of each school day for an 8-week period between January 31 and March 25 2005. For ethical reasons information on the health and behavior of individual students was unavailable and we confined our questionnaire to classroom behavior. Internal checks were used to determine reliability of the responses to the questionnaire with similar questions asked in different ways.

A total of 44 teachers responded frequently enough to the questionnaire to enable statistical analysis providing 685 teacher-days of data. Two-tailed t-tests (dummy vs. GS filters or poor vs. improved power quality) were used for each teacher and for each symptom at the 5% probability level for significant effects and at the 10% level for slight effects. Classroom behavior was assessed the same way. Middle and elementary schools were in the same building and data were combined for analysis. We analyzed data for 14 classes in the middle and elementary school and 17 classes in the high school.

3. Results and discussion

GS filters improved power quality in all three Minnesota schools by more than 90% in the frequency range of 4 to 100 kHz (Table 1). Dirty electricity for all three schools averaged 574 GS units and ranged from 90 to greater than 2000 with dummy filters installed. With GS filters the values ranged from 16 to 150 with an average of 37 GS units. Based on previous studies, values below 50 and ideally below 40 GS units are associated with health benefits for those who are electrically sensitive (Havas, 2006a).

3.1. Teacher wellbeing

Teacher health and sense of well being improved with enhanced power quality (Fig. 1). Of the 38 symptoms 79% were better, 13% were worse, and 8% were the same while the GS filters were installed. Headaches, general weakness, dry eye/mouth, facial flushing, depression, mood, dizziness, asthma, pain, skin irritations, clarity of thought, and energy were among the net improvements documented by teachers. Elementary and middle school teachers reported greater improvement (68% of net symptoms) than high school teachers (24% of net symptoms).

A similar study to the one in Minnesota was conducted in a Toronto school for students with learning disabilities from grade 1 to 12 (Havas et al., 2004). Net improvements in teacher wellness were documented for 14 of the 16 symptoms (88%). In the present study asthma, among teachers, was one of the symptoms that improved as did other respiratory ailments such as runny noise and sinus congestion. Installation of GS filters in a Wisconsin school, experiencing sick-building syndrome, resulted in students with asthma no longer requiring daily use of their inhalers as documented by the school nurse (Havas, 2006a).

Table 1 – Power quality with real and dummy filters installed in three Minnesota schools

School	Power quality	#rooms	#filters	Dirty electricity (GS units)			Power
				Minimum	Mean	Maximum	% improvement
Elementary	Poor	35	62 (dummy)	147	722	>2000	
	Improved	35	131 (real)	29	41	60	94%
Middle	Poor	30	87 (dummy)	200	563	>2000	
	Improved	28	139 (real)	28	46	150*	92%
High	Poor	36	136 (dummy)	90	438	>2000	
	Improved	37	271 (real)	16	23	40	95%
All	Poor	101	285 (dummy)	90	574	>2000	
	Improved	100	541 (real)	16	37	150*	94%

*Boiler room, large copy machine.

Many of the teachers' symptoms that improved are common among people who have developed electrohypersensitivity (EHS) (Firstenberg, 2001; Schooneveld and Kuiper, 2007). The symptoms of electrohypersensitivity resemble radiowave sickness, first described among radar workers following World War 2 (Firstenberg, 2001). Electrosensitivity may be severely affecting 3% of the population, who would be unable to work in a school environment with computers and fluorescent lighting and with wireless technology associated with phones and computers (Johansson, 2006). Another 35% of the populations have some of the symptoms of EHS (Philips and Philips, 2006), such as headaches, body aches and pains, fatigue and poor sleep and simply associate these symptoms with either aging or living a stressful lifestyle.

Teachers in this study were ranked based on the amount their symptoms improved (Fig. 1).During the period of enhanced power quality, 64% of the teachers were better, 30% were worse, and 7% were the same resulting in a net improvement among 34% of the teachers overall. This corresponds to the 35% with moderate symptoms of EHS according to Philips and Philips (2006) and is just below the 40% in the Toronto School study (Havas et al., 2004).

Several teachers showed marked improvements ranging from 10% of their symptoms tomore than 70%. We believe this relates to the degree of electrosensitivity of the individuals involved.

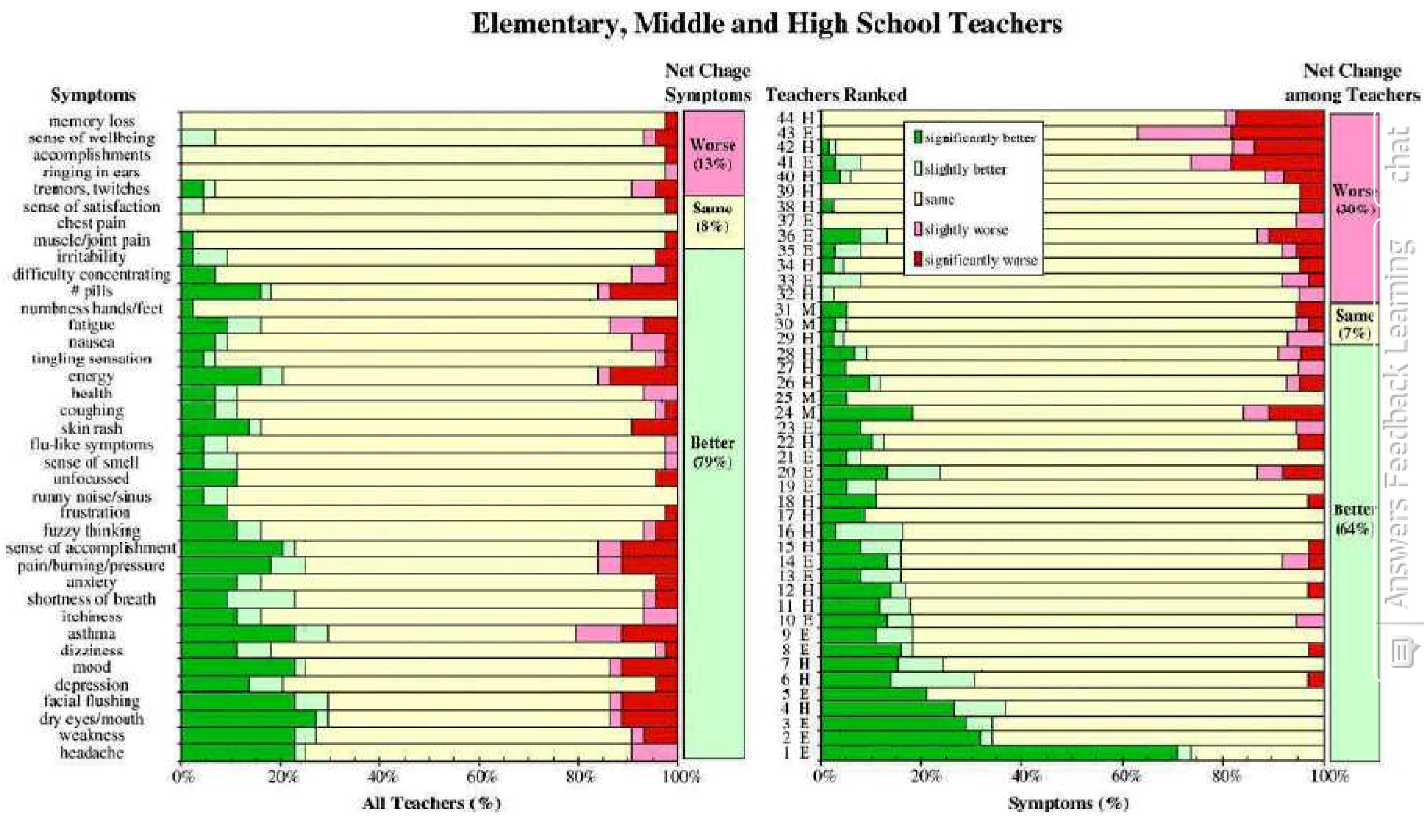

Fig. 1 - Changes in health and wellness symptoms, associated with improved power quality, among teachers in three Minnesota Schools. Note: letter after teacher ranking is for elementary (E), middle (M), and high school (H).

The teacher who benefited the most is an elementary school teacher. Levels of dirty electricity in her classroom were reduced from 406 to 40GS units and 27 (71%) of her symptoms improved. She noted that her psoriasis, which had been bothering her for years, completely cleared-up during the study and she did not change any of her medication or skin lotions. Skin irritations following exposure to computer screens, commonly referred to as screen dermatitis, have been extensively studied in Sweden (Johansson, 2006). Production of mast cells and histamine may be the underlying mechanism for the skin irritations and this seems to differ among people with EHS.

We were unable to lower the dirty electricity in each classroom below the recommended 40 GS units and found that teacher response related to both the original levels of dirty electricity and the values after cleanup. The greater the improvement in power quality the greater was the improvement among teachers (Fig. 2).

The dummy filters, in Fig. 2, represent the ambient levels of dirty electricity and the real filters indicate how much the dirty electricity was reduced in any one classroom. Since we know which teachers taught in which classrooms, we were able to compare their “recovery” with the before and after filter values for power quality.

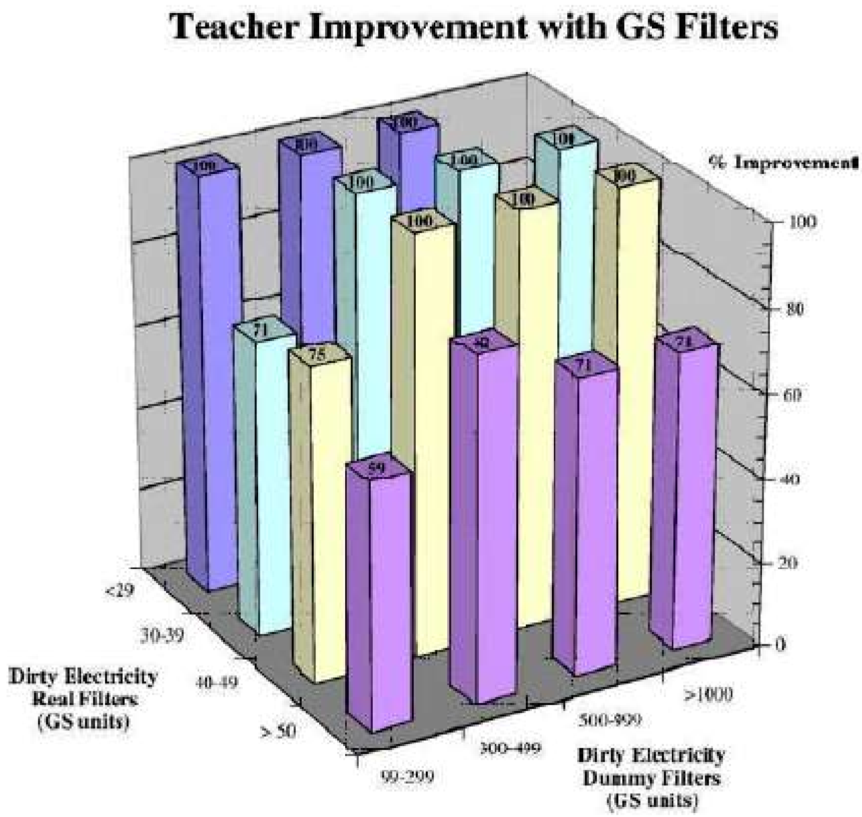

Fig. 2 – Net improvement in the health and wellness of teachers in three Minnesota Schools associated with power quality. The real GS filters improved power quality, while the “dummy” filters represented ambient levels.

In classrooms that had values of dirty electricity above 300 GS units and that were reduced to less than 50 GS units with the filters, all the teachers improved. In classrooms where the filters reduced the dirty electricity to above 50 GS units fewer teachers improved (59–82%). In classrooms with the lowest levels of dirty electricity (less than 300), the levels needed to be reduced to less than 30 GS units before all the teachers improved. This demonstrates that the teacher's response was influenced by the original levels of dirty electricity and the values after cleanup.

Other studies have examined the relationship between poor power quality and cancers. Milham and Morgan (submitted for publication) reported a cancer cluster among teachers at La Quinta Middle School in California. Of the 137 teachers, 18 cancers were observed and 6.5 were expected. This 3-fold increase in cancer cases has a 1 in 10,000 possibility of being due to chance. Monitoring of the rooms showed that 13 rooms had high levels of dirty electricity (>2000 GS units) and the teachers who taught in those rooms had a greater risk of developing cancer. Cancer risk for teachers was 1.8 fold if they never taught in those rooms; 5.1 fold if they ever taught in those rooms; and 7.1 fold if they taught in those rooms and had been at the school for more than 10 years. Cancers included melanoma, thyroid, uterine, breast, colon, pancreas, ovary, larynx, lymphoma, and multiple myeloma. In the present study we did not inquire about cancers among staff, but if the conclusions of Milham and Morgan are correct then levels in at least three rooms, with values above 2000 GS units, should be reduced.

Interestingly, cancers (Eger et al., 2004; Kundi et al., 2004; Wolf and Wolf, 2004) and symptoms of EHS (Zwamborn et al., 2003; Oberfeld et al., 2004) are the two most common associations with RF exposure from wireless technology including their base stations and antennas.

3.2. Student behavior

During this study, the behavior of high schools students did not improve whereas elementary and middle school students did.

3.3. High school

Thirty-eight percent of the behavioral traits and 18% of the high school classes were worse overall during the period of enhanced power quality (Fig. 3). One exception was the computer room where student behavior improved for more than 60% of the behavioral traits tested. Interestingly, the results for the Toronto school showed that improvements among high schools students were marginal compared with middle and elementary school students (Havas et al., 2004). This may be due to cell phone use, which is another form of radio frequency exposure that was not controlled in this study, or to the fact that high school students change rooms for their classes and hence a 60-minute exposure in any one class may not be sufficiently long to assess changes in behavior. According to the Principal, 50% of the high school students carry cell phones to class, although they are allowed to use them only in between classes.

In a study of 250 self-proclaimed EHS sufferers, 26% claimed to be bothered by cell phones (Schooneveld and Kuiper, 2007). According to the Stewart Report (2000), children may be more vulnerable to cell phone radiation and should be discouraged from using them for non-essential calls. Here the concern was for developing brain tumors rather than for other less severe but chronic symptoms of EHS.

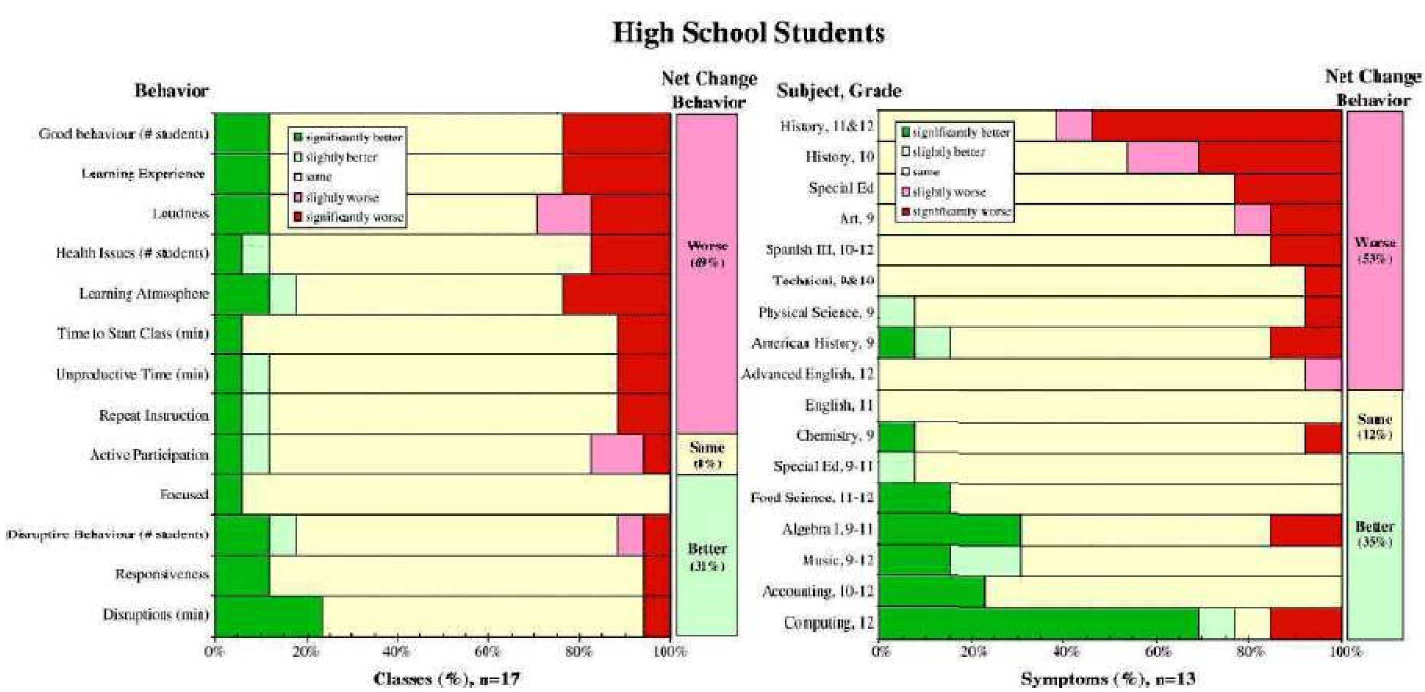

Fig. 3 – Behavioral changes in high school students in Minnesota associated with improved power quality.

3.4. Elementary and middle school

Behavioral traits among elementary and middle school students were better for 70% of the traits and for 42% of the classrooms overall (Fig. 4). The improvements were not nearly as dramatic as for the Toronto school for learning-disabled students (Havas et al., 2004). Perhaps students with Attention Deficit Disorder (ADD) or Attention Deficit Hyperactivity Disorder (ADHD) are inherently more sensitive to electromagnetic energies.

Teachers reported that students were more actively involved and more responsive during classes. The amount of time it took to start the class and to deal with disruptions was reduced. Students were more focused and required fewer repetitions of instructions and had fewer health complaints. Overall this resulted in an improved learning environment and a better learning experience.

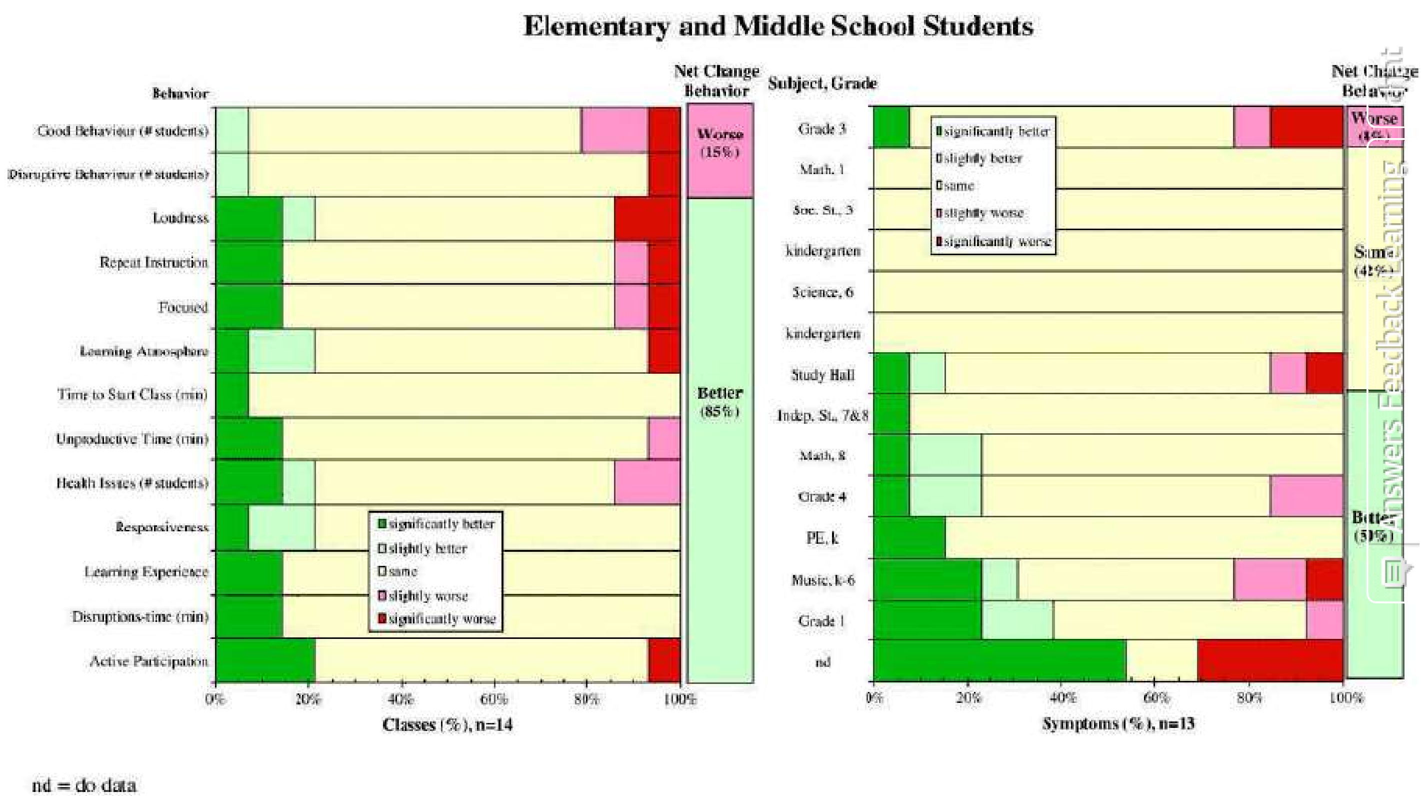

Fig. 4 – Behavioral changes in elementary and middle school students in Minnesota associated with improved power quality. nd=no data.

3.5. High school vs. elementary/middle school

This different response among the teachers and students in the high school and those in the elementary/middle school may be due to natural variability or, possibly, to other sources of radio frequencies radiation that were not monitored such as wireless computing, within the school, or telecommunication antennas, outside the school. Neither building had wireless computing at the time of this study. However, within a radius of 400 m, the Elementary/Middle school had 1 antenna and the high school had 4 (www.antennasearch.com). Monitoring of RF radiation at these schools is advised to confirm or rule out this exposure to RF radiation.

Studies showing increased symptoms of EHS and/or cancers near cell phone antennas cite a critical distance of 300 to 400m and exposure values far below the existing Federal Communication Commission (FCC) and international guidelines (Oberfeld et al., 2004; Wolf and Wolf, 2004; Zwamborn et al., 2003).

4. Conclusions

Poor power quality or dirty electricity has been implicated with poor health in schools in Ontario, Wisconsin, California, and now Minnesota. Fluorescent lighting and computers are the primary sources of poor power quality but external sources cannot be ruled out. Improving power quality with GS filters is accompanied with enhanced teacher wellbeing and improved student behavior in middle and elementary school resulting in a better overall learning experience. The effect of poor power quality on health is a relatively new area of research but one that needs attention, especially in schools, where the health and wellbeing of teachers and students are at stake. Work on electric and magnetic field metrics with and without Stetzer filters urgently needs to be carried out to determine just what characteristics of the dirty electricity may be interacting with the people.

Boards of Education have long considered the health effects of air quality, mold, and asbestos and have reduced these in school buildings. Many schools restrict wearing of perfume to protect those with chemical sensitivities, and have nut-free environments for those with peanut allergies. School Superintendents and School Boards need to recognize that some people are sensitive to electromagnetic energy and that schools need to be monitored for power quality and for other forms of radio frequency radiation. If levels are high they need to be reduced to ensure a safe environment for both students and staff. More research is required into the health effects of dirty electricity but in the meantime, based on the evidence to date, steps should be taken to reduce dirty electricity exposure in schools.

Appendix A.

Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.scitotenv.2008.04.046.

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