

Fractal images – a new way to reduce stress and to improve educational workspaces

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Abstract

Stress is one of the most common side-effects of the educational process, especially in learning, teaching and evaluation. Without proper coping strategies, all those involved in education (pupils, teachers, parents, leaders) might experience burn-out syndrome, anxiety and avoiding behavior.

This article reflects on the significant positive effects of introducing fractals images in workspaces. The purpose of this paper is to explore whether fractals can reduce stress, increase openness to experience and raise tolerance to frustration and angst.

Fractals are computer generated shapes with the help of a mathematical formula that describes the complex look of geometrical natural things like clouds, trees, ferns, blood vessels, muscle tissues. Even the human brain has a fractal dimension. These shapes can be broken into an infinite number of pieces and still be self-similar with the whole, no matter what scale. Actually, fractals are the mathematics behind nature and behind all dynamic non-linear systems (human behavior, learning, weather and economics)

Scientist and human know that being exposed to natural environments can have an effect in reducing psychological and physiological stress. This raises the question if fractals are responsible for this and if they can offer the same benefits.

It is important to focus on the possible positive effects of fractals because they can be a useful, cheap and easy way to improve the educational workspaces in such a manner that can reduce stress and increase wellbeing without any effort.

Keywords: fractals, psychological stress, healthy education, education workspace, environmental stressors.

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1. Background

The educational system - no matter which - implies a series of stressful factors that may have negative or positive effects on all those involved in teaching, learning and evaluation processes.

Therefore, the article focuses on how fractal images, when present, can reduce stress and improve educational workspaces. The present study was undertaken because School stress can easily be compared to workplace stress. Both involve psychological and environmental stressors. (Hoy, 1990). However, in children, in some situations, stress can have more adverse effects than in adults.

Both active (children, teachers) and passive (parents, relatives) participants in education might experience, at a certain moment, a high level of stress directly related to demands of school activities or environment (Kyriacou, 2010; Crnic et Low, 2002).

Requirements that exceed one's ability to resolve them are considered especially stressful. People respond to this kind of situation in an adaptive or non-adaptive manner, depending on their personality traits and coping strategies (Washington, 2009).

Throughout life, coping strategies develop in different contexts. While adults may have some adaptive response to daily tasks, children and youngsters try developing their ways to cope (Skinner& Zimmer, 2007).

This statement leads to the idea that those who provide education should focus more on how to provide school settings with fewer stressors, which may even assist children to cope better. It is important to help children develop healthy adaptive behavior to stressful situations because daily tasks, deadlines, evaluation and requirements rarely stop.

Because they are still developing their coping strategies the risk for psychosomatic symptoms like headaches, stomach pain, backache and dizziness to emerge is bigger than in adults. Manifestations can range from no symptoms to very powerful reactions because children report and evaluate a stressful situation in different ways (Torsheim et World., 2001). So is not easy to know when a child experience stress. He might not show it, or he might not have the ability to express it in a proper way. School should be a source of relaxing, not of additional stress. However, in some situations, a little pressure can be motivational.

Nowadays, educational institutions are struggling to provide alongside knowledge, proper environments for healthy education. Aspects like illumination, noise level, personal space, furniture, wall decorations, are now taken into consideration. Without these at a proper level, pupils can have difficulties in learning and feeling well during school time. A noisy workspace without light, with only white walls and bad furniture, can increase cortisol levels (stress hormone) and blood pressure that might lead to serious health problems (Cohen, 1986).

Besides school settings, psychological stressor factors are also common in pupils due to school demands but also due to socialization with peers itself. Bullying and other forms of aggression are also known to cause a lot of stress in its victims. When pressure is high the risk for school failure, anxiety, depression, avoiding behavior is also high (Frumkin et all, 2006).

Stressors, whether environmental or psychological, are usually the primary cause of physical pain and psychological complaints in children. The source of most of them relates to school. It is well known that children spend almost all of their time in classrooms. A proper school setting increases chances of turning pupils into well-adjusted adults that can work and contribute to a evolved society (Hjern et all, 2008).

The purpose of this study is to highlight the possible use of fractal images in classrooms, school corridors, laboratories and other workspaces designed for learning in such a manner that can reduce stress, improve educational environment and provide healthy education.

Fractals are geometrical figures that can be broken (fractured) into an infinite number of pieces, no matter the size and still be similar with the whole figure. This kind of shapes and figures are inside and outside the human body. Fractals represent the mathematics and geometry behind natural elements (Mandelbrot, 1982). Also, nature is produced by iterating (repeating) itself from the smallest scale to the largest scale. The best example of a fractal is the tree that can easily be compared to lungs or heart blood vessels. A small branch is actually a miniature of the tree.

2. Purpose of the study

Fractals are nature and exactly like nature, they can reduce stress. This was the starting point of this theoretical framework. A series of studies have already proven that nature can decrease perceived stress and improve health (Weinstein. et al., 2009, Ward-Thompson C. et al., 2012). Some even argue that people feel an unconscious need to be in contact with nature, like a basic need (Willson, 1984; Fromm, 1964).

Based on these findings, other researchers are focusing on whether fractals can have the same effect as natural environments. The results confirmed their hypothesis. (Taylor, 2011; Salingarosa, 2012). Dr. Joye even states that probably the mathematics behind handle nature's positive effects (Joye, 2008).

The present article aims to raise awareness on a new method that can be used in educational workspaces to reduce stress in an easy and efficient way with little resources. Fractal images can be found anywhere on the internet and generated with programs like Ultra Fractal, Mandelbulber or Incendia. This means that everyone can have access to a tool to help well-being. Some programs are totally free. However, some mathematical skills are required to produce something that can be seen as art or as a tool to reduce stress.

How these shapes can be used in social sciences or even in architecture is a little explored and studied subject because fractals were invented (or discovered) only 40 years ago in 1975. This paper aims to reunite all the findings available on this subject. Most of the research in the domain was more focused on mathematics than on the effects of fractals. For those in the social sciences field, fractals can sometimes be an entirely new matter. Bringing a mathematical object into social sciences can be hard and needs a consistent amount of documentation and research.

The article was undertaken to do a literature review of present studies and to correlate it with personal research results conducted in another study, where fractals were used in Unification Experiential Psychotherapy as an instrument to explore and reduce anxiety and raise tolerance to daily stressors (Simion, 2015). Anxiety and stress are common during school time. Some stressing events from school persist even in adulthood. Providing health education can be a turning point in someone's evolution. Controlling daily stress is difficult for teachers and school principals, but controlling environmental stress can be simple.

The main purpose of this paper is to trigger awareness on a new method to reduce stress and on the need for more research on this new subject.

Also, another objective is to underline some ways in which these images can be used in classrooms and how they can improve space and contribute to a healthy education. Fractals are more popular these days, and a lot of designers use it for clothes and architecture. Some even make art from it. Actually, with the help of nature's mathematical formula and a computer, some self-similar artificial colorful shapes and images are created. Adapting these pictures for school ambient is important. This might be a way in which students, teachers, and parents can be exposed, without any sophisticated instruction or technology, to some sources of stress relief

like fractals. It seems that geometrical shapes that have a fractal dimension can have a positive effect on someone only by their presence, without it being necessary for you to contemplate it.

Highlighting some methods of how school psychologists and counselors can use fractals in some interventions as therapy is another purpose of this article. Fractals can be a pretext for exploring other problems due to their projecting power and their resemblance to Jung's mandalas (a circular representation of the self). Also, contemplating them can be a pretext for entering a meditation state, which can be a relaxation method, and also a method to explore the inner self.

3. Sources of evidence

To understand how fractals can be a useful tool to reduce stress and to improve educational workspaces, it is necessary to underline the connection between nature, stress, fractals and human perception. Unfortunately, at present, the amount of available research that focuses on how artificial geometrical shapes can be used in classrooms is scarce.

However, some studies have proven that stress is influenced in a positive way by nature. These findings were the foundations of this article. When talking about nature, fractals should also be included.

Mandelbrot was the father of nature's geometry because he was the first one who found out its dimension. A tree is not 1D – because it doesn't fit in a point, neither 2D because it is not plane, but also neither 3D because it can't fill the whole space in a box. Also, for a shape to be fractal, it has to be statistically self-similar to the whole no matter the scale.

Allot of things are considered to be fractal or have a fractal genesis. Some enthusiasts even argued that everything is fractal, from trees, clouds, to muscle tissue, DNA, and the brain.(Mandelbrot, 1998). Of course, some studies are arguing that shapes like retinal neurons, blood vessels, molecular clouds are not 100% fractals (Panico & Starling, 1995; Blitz & Williams, 1997).

So throughout these articles, the term fractal refers only to those computer generated shapes with mathematical formulas that can also be used to measure the dimension of some natural forms.

The fact that not all natural things are fractals suggests that some natural elements might have no effect on stress and also that the positive impacts of nature on stress may be stronger because of their mathematical formula. Either way, the connection between well-being, feelings of relief and time spent in or being exposed to nature is well documented by architects, psychologists, doctors, and mathematicians.

A study from 2008 shows that breaks taken in nature can stimulate attention and productivity of working memory. Some participants were asked to relax during work time for ten minutes in a room with pictures of nature, and in the other part, in a room with city photographs. The results showed that working memory, attention, and relaxation were 20% better for those who were exposed to nature (Berman, 2008). Nature seems to reduce stress and improve memory and attention even when it is present just in pictures.

Another study conducted in 2009 at Rochester University in the USA showed that nature has a positive influence not only on stress but also on life expectations and personality. 370 people, divided into two groups, were asked to watch sets of 4 images with nature or with urban landscapes for 2 minutes. The results recorded by a questionnaire showed that those who were exposed to nature were more likely to respect friendship and to aim for community acceptance. Instead, those exposed to urban landscapes expected fame and wealth in life. In the second part of the study, each participant received 5 dollars and was told that he might double his money if

he offers it to another person. If that person offers the money to someone else, then he will receive ten dollars. Those exposed to nature were more likely to take the risk and give the money away and lose it (Weinstein et al, 2009).

A study conducted in 2012 found that those who live in environments with a lot of nature nearby have a lower level of perceived stress and cortisol (stress hormone) in their blood than those who live in more urban places without trees, lakes, parks (Ward-Thompson et al, 2012).

It is remarkable that in the quoted studies, nature managed to induce relaxation and positive effects, even though subjects weren't physically in natural environments. They only watched it or were near it. This raises an inevitable question: How and why do simple photos of trees, plants, rivers and mountains change affective disposition, reduce stress and even influence life principles?

This article believes that the fractals behind nature and its mathematical formula are responsible for these effects, more than the aesthetics of nature. This is why fractal images might be better in classrooms than some simple, random pictures of natural elements.

A study conducted at NASA (National Aeronautics and Space Administration) on working stations showed that not all natural landscapes can help in stress relief, but only those with a mid-range fractal dimension. As said before in the article, fractals have a dimension between 1 and 3. If the dimension is closer to 1, the generated shape is smooth and sparse. On the other hand, if the dimension is closer to 2 then the fractal is intricate and detailed. Throughout the research, a scientist used four images: one of a savannah, one of a big forest, one of random squares (not fractal) and for checking purposes, a white image. The results showed that the savannah was perceived as being more beautiful than the rest. Participants were asked to perform stressful tasks like arithmetic, logical problem solving and creative thinking while electrical skin conductivity was monitored to see the psychological response to the stress of mental work. The savannah seemed to have the most restructuring and damping effects on stress. An important note of this study was that exposure to different images affected only the variation of stress, but not the performance (Wise & Taylor, 2002). This leads to the idea that fractals might not be a reason for attention distraction when present in classrooms and school settings. Also, the study confirms that some fractal images can have more significant effects on stress damping than other similar images.

Throughout their research, scientists suggested that the preferences of savannah might be connected with the fact that early humans were mostly exposed to this kind of environment and also because they offer a larger perspective of any dangers that might be out there. The forest, on the other hand, was too dense to see anything, and dangerous (Orians, 1980).

More research showed that there is more than that. Goldberger argues that the mind and brain have an intrinsic fractal structure that makes people recognize and pick fractal shapes from a multitude of forms (Goldberger et al, 1990).

So this proves that fractals are inside the human body as well. The case of Jason Padgett, a non-educated person, with no connection to mathematics stands as another proof. Following a head injury, he started seeing fractals everywhere. Moreover, he was able to draw them precisely (Dossey, 2012).

The fractal artwork of painters such as Escher and Pollock before fractals were even named can also be considered a proof of fractals presence fractals in our unconscious psyche.

C. G. Jung stated that there is an unconscious psyche that connects all of the human beings. He argued that the presence of the same fantasies and motives in different cultures that had no contact with one another are due to this unconscious psyche (Jung, 2003). Fractals can also be considered this type of motive because they are present in worldwide architecture before even

being coined. Fractals can be found in Hindu temples, Gothic cathedrals from Europe as well as in African villages (Sala, 2002).

Also, normal humans can see fractals when they ingest psychotropic substances or due to entopic phenomena, anesthesia or dreaming because of brain architecture (Bressloff et al., 2002).

Humans, no matter what age, have a particular connection with fractals. The human body is also a fractal just like some exterior elements. This explains why some people feel the need to take a walk in the park or just to be in nature. They actually feel the need to connect their inside with their outside representation and thus stress may be diminished. Children spend almost all of their waking time in classrooms and just a little time outside, in nature. If they can't be taken outside, it is important to bring the outside closer to them, so they benefit from the positive effects of fractals behind nature.

4. Main argument

Fractals should be present in every workspace, especially in school environments. Children are learning their ways to cope with life. It is important to offer them a proper setting for developing those strategies. Also, school demands can be very stressful. Competition, deadlines, evaluation, and comparison, are known to cause a lot of negative stress. Stressed children feel sick, empty, complain a lot, have low grades and avoiding behavior when it comes to school (Torsheim & World, 2001; Crnic & Low, 2002; Brooks, 2005).

Even though there are a limited number of studies on the subject, this paper comes to support the fact that fractals do reduce stress only by their presence and can even do more if used as a therapeutic instrument in psychologist offices.

Taylor R.P. dedicated a part of his work to studying fractals and human reactions to it. One of his studies showed that stress dropped by 60% in all of the 350 participants only by being exposed to fractals. The results were obtained by measuring changes in skin conductivity when exposed to stressful stimuli. Also, his studies showed that only some fractal images have a significant effect on psychological stress relief (Wise & Taylor, 2002; Taylor et al, 2005).

Another study, in which EEG was used to measure brain response to fractal stimuli, results suggest that only fractals with dimensions from D 1.3 to D 1.5 are likely to achieve some transformations in the viewer's psychological state. The study used only skyline silhouettes, and this suggests that there might be more fractals that can have a restorative effect on well-being, but not yet studied (Hagerhall et al, 2008).

Other researchers suggest that this dimension is higher, 1.6-1.9 (Forsythe et al. 2010). More studies on larger experimental groups are needed for a clear view on the kinds of fractals that are most helpful.

In 2011, Taylor and colleagues suggested that eye motion, when scanning a fractal, draws a 1.5 D fractal dimension, no matter the size of the image scanned. What can happen when the eyes meet a 1.5 D fractal? This question needs to be studied more because it seems that the eye has a fixed fractal, and maybe the restorative effect is greater when the eyes meet an exterior representation of its tracking motion (Taylor R.P et al, 2011).

In the study where EEG measurements were made, the fractals with D 1.3 had the highest activation of alpha frequencies in the brain. Alpha activation is high when the viewer is relaxed, as in a meditation state and when the attention is focused more inward (Hagerhall et al, 2008). Some may say that fractals can be a source of distraction for students. Further research on the matter should be made. Inward attention is more similar to fascination than to concentration. Fascination is part of human nature and effortless. Natural objects like clouds, sunsets, snow

patterns hold the attention easily by allowing space to think about other things as well (Kaplan, 1995). So fractals in classrooms will probably fascinate children and maybe, because of their stress reduction, the concentration will be easier to maintain.

This means that it is recommended to use only fractals with mid-range dimensions (1.2-1.5) for the best improvement of the educational workspace. This kind of computer-generated fractal images aren't very complicated and consist of repeating sparse shapes that can be easily observed and identified. Most of them are similar to trees, clouds and waves, are not very complex, and the repetitive pattern can be found easily.

Fractals can be used in classrooms like decorative paintings. Children don't have to look at them or find them very attractive. Stress will be lower only because of their presence in the educational workspace where children perform stressful tasks like creative thinking, logical problem solving and others. In his studies, Taylor used a 19-inch screen for showing the images. This means that some standard A4 or A3-sized fractal drawings are sufficient. Because in some studies participants were asked to look directly at fractals or fractals were sideways, the best option is to put some in front of the class and some on the other walls. Four images should be enough because in the cited studies just a small number of fractals were used.

Joye argues in his work that fractals can decrease stress while Euclidean simple shapes like cubes, triangles, spheres can increase reactions to stressors. One of his papers is a statement for fractals to be used in architecture like buildings plans or facade decoration because these shapes were traditionally present in humanity's culture (Joye, 2007). Modern architecture seems to have reduced the number of fractal shapes and the presence of natural elements. The people are not in contact with nature as they used to be before modernization. Some scholars think that these discrepancies may be the reason for high levels of stress and psychopathology. (Parson, 1991; Gullone, 2000).

Changing a school facade can be expensive and time-consuming, but putting fractal images in classrooms and workspaces is also a way to provide healthy settings.

Salingaros suggests in his work that fractal environments may be healing and could help the viewer to feel less stressed by tasks, deadlines, and other stimuli. He also admits that fractals with the right dimension (those who are not too complex and intricate) have positive effects no matter if abstract or representational. So as long as the size is right, the schools can use any kind of fractal images, no matter what color or how big (Salingaros, 2012).

These findings are also sustained by personal research on Fractal Techniques, a creative meditation technique specific to Unifying Experiential Therapy (UEP) that used fractals as a pretext and as a provocative tool for insight. The study was taken on 24 participants with medium or high levels of anxiety and stress divided into two groups. First 12 subjects attended UPD (a unifying personal development within an experiential group) program for 3h per week while the other one didn't benefit from any psychological intervention.

Manifest and hidden anxiety levels were measured in all participants by using Cattell Anxiety Scale Questionnaire-C, before and after the experiment period. For measuring stress during last six months, Perceived Stress Questionnaire (PSQ) - known as Levenstein was used. Also, Perceived Stress Scale (PSS) was applied to gather information about the level of stress in the last six months.

Results showed significant statistical differences between testing and retesting periods between the groups. While the control group had no significant change in the evolution of stress, the experimental group showed a decrease in anxiety and stress levels in all 12 participants. The sign test was also applied to see if all the participants benefitted from the effects of fractals. The control group showed random increasing and decreasing of stress in all participants. These suggest that stress levels were more influenced by circumstantial stressors and daily events (Simion, 2015).

It was interesting that all 12 members on whom Fractal Technique was applied for 30 hours showed a significant decrease in levels of stress and anxiety, except one person. This person was emotionally blocked; she had a high degree of stress but a low level of anxiety. All of her experiences during meditation showed difficulties in self-expression. The Sign test showed an increase with one class in her level of anxiety and decrease in stress. One interpretation of these results can be that she let her feelings and emotions emerge.

Feedback from participants confirmed that all of them went through a personal growth process due to self-knowledge and the opportunity to discuss stressful situations and to access and transform inner traumas. These showed that fractals not only did reduce stress, but they also worked as a therapeutic instrument for self-exploration and restructuring when used as creative meditation support.

Reuniting all of the findings above confirms the use of fractal images in classrooms and also in psychologists' and counselor's offices. Specialists that work with children can make non-invasive exploration starting from fractals that can also improve well-being and provide useful information about their personality to the viewers. Children set in groups of 10 or 12 can be asked to pick the fractal they like or dislike (to explore his self and non-self). Also, they can pick a fractal for everyone (to explore how he sees others) or to pick one that can stand as a picture for his family (to explore how he relates to his family). The possibilities are limitless when fractals are used in UEP or UDP. UEP is a humanistic-experiential holistic method that is centered on symbol analysis of personal growth and evolution through improvisation, provocative exercises, and creative meditation. The emphasis is on the diagnostic power of metaphor when translated from the person's language into person's reality through questions that help insight (Mitrofan, 2004).

5. Conclusion

The above-cited study shows that fractals are the mathematics behind nature and almost exactly like nature they can improve well-being, relaxation and concentration. In some of the above-cited studies, nature was used only in pictures and those who were exposed to it experienced increased memory, attention and a low level of stress and cortisol (Weinstein et al, 2009; Ward-Thompson et al, 2012). Therefore, the positive effects of nature seem to be due to the mathematical formula behind it.

Researchers wanted to know what images are probable to cause the most positive effects. Findings suggested that the observer perceives fractal images that range from D 1.2 to D 1.9 dimensions as being the most appealing. Skin conductivity and EEG responses indicated the same (Wise & Taylor, 2002; challenging all 2005; Hagerhall et al 2008).

This means that fractals do reduce stress and leads to the conclusion that these kinds of images can be a real source of relaxation in classrooms and schools in general.

School can be stressful due to its demands but also due to its environment. In some studies, it was suggested that Euclidean shapes like circles, triangles, squares, cubes, increase stress (Joye, 2007; Salingaros, 2012).

The present findings and personal research results suggest that more complex figures like fractals are needed to improve workspaces. Not all fractals have the same effect. From the current studies, a conclusion can be drawn concerning what images are best suitable for school environments.

Fractals that range from D 1.2 to D 1.9 are usually smooth sparse shapes. There is a variety of fractals programs that any mathematician can use that can generate fractals for specified

dimension. Of course, fractal with dimensions between 1 and 2 can be easily recognized by some indicators like space between shapes, smooth shapes, mid-range complexity and similarity to a coastline, wooden plants and trees, waves, clouds, sea anemone, bacterial growth pattern or electrical discharge. Fractal images can be found for free or even for money as art pieces or personalized fractals. A simple search on Google leads to a multitude of these kinds of sites.

It is recommended, from the present studies, until further information about the effects of other fractals dimensions, to use in classrooms only fractals that respect the dimensions between 1.2 and 1.9 which are well documented.

In the reviewed papers, most of the fractals were just present in the workspace, without asking the participant to look at or contemplate them. A simple conclusion can be drawn for this. Fractals can be introduced in classrooms or workspaces and have subtle positive effects like stress relief. Of course, some might think that fractals might be a distraction. More studies should be made concerning these aspects. Kaplan affirms in his study that fascination is specific to natural elements and involves no effort while concentration is specific to artificial tasks and demands. Because fascination is effortless, the author believes that this kind of attention allows the viewer to think of other things as well (Kaplan, 1995).

Another conclusion that can be drawn from the present literature review is that fractals are present in our life from the beginning of humanity on earth. Some say that this is the reason participants were attracted to savannah because early people lived in this kind of environments (Orion, 1980). Cases like Padget, the shapes that appear when eyes are shut or brain is intoxicated suggest that human brain is also fractal (Goldberger et al 1990, Doseey. 2012). Fractals can also be used in psychotherapy as a pretext for exploration due to their projection power (like the tree test).

Throughout my personal research, I used fractal images as support for creative meditation in a Unifying Experiential Therapy manner. All those involved in the personal development group had lower levels of stress and anxiety after the ten group meetings. Most of them confirmed that during the provocative exercises they had valuable insights about their personality, traumas and some of the things that kept them blocked and stressed (Simion, 2015).

This suggests that fractal can also be used by psychologist and school counsellors in groups of children or even with just one person at a time. Everything depends on specialist's openness and creativity to use a mathematical instrument in his practice.

In conclusion, fractals that range from D1.2 to D.1.9 can be a good, cheap way to improve educational workspaces and to contribute to a healthy education because of their ability to subtly reduce stress. Of course, more research should be made on the matter, on a larger population, and on school-aged children, to make sure that fractals do have the expected effects on school settings and their pupils and teachers.

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