Project-based Inquiry Science

A Model for Teaching, Learning, and Assessing Science in Grades 7-11 Classrooms

Regina Toolin and
Beth White
University of Vermont

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PBIS Workshop Agenda

- Introduce PBIS with a hook from Vermont Public Radio (3 min)
- Debrief Radio Clip: *How can we use this as an entry point for integrating PBIS into our Sound Curriculum?* (6-8 min)
- Introduce PBIS through Sound Curriculum then spend time developing your own unit using the PBIS Project Planner and Share (30-35 min)
- Introduction to Compass School's *Science of the Mind Curriculum* (5-7 min)
- Questions, comments, resources, and time for completing evaluations (3-5 min)

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PBIS Learning Goals

We hope that participants will leave this workshop with:

- an understanding of the main tenants of PBIS,
- several clear examples of how to incorporate PBIS concepts into various types of science curricula and beyond,
- a start on your own science lesson plan that incorporates PBIS, and
- lots of resources to take home to further support your professional development!

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Prior Experience with PBIS

Please take a few moments to answer the first question on the Workshop Evaluation Tool to give us an idea of your prior experience with PBIS.

- Thumbs up—I've had lots of experience with PBIS and use it in my curriculum
- Thumbs side—Some experience, I've heard about it!
- Thumbs down—PBIS is brand new to me!

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IMAGINE…

You are on your your way to school and you're thinking about the sound curriculum that you planning for an upcoming 9th grade physical science unit. Since you've heard about an approach called *Project Based Inquiry Science* (PBIS) you have been trying to figure out how you can integrate your upcoming unit with a real-world, community-based issue. You switch on your radio and you hear the following clip:

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Sound Article Debrief

So, what were some thoughts and ideas that came up for you?

Share ideas about integrating:

- Social justice
- Student choice
- A captivating hook
- Real-world, local issue
- A differentiated approach
- An interdisciplinary approach

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Sound Article Debrief

So, what were some thoughts and ideas that came up for you?

- how they came up with average for decibel rating (compared to I-phone listening)
- Impacts on health would this impact if folks wanted to stay in the area
- Social justice issue – Can the gov't. force people out? How can it be related to the different scientific disciplines?
- Demographics – Who lives here?
- Looking at what changes have occurred? Increased traffic, for example.
- Tools or measurement – Authentic Data collection.

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Memes: Ideas that Govern Themselves

"A *meme* (Blackmore, 2000; Brodie, 1996; Dawkins, 1976) is an idea that has a life of its own. It refers to a unit of cultural information transferable from one mind to another. It thus acts as an underlying belief that drives how people interpret what is going on around them and organizes what they do" (p. 26).

-Caine and Caine, *Natural learning for a connected world: Education, technology, and the human brain*

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PBIS is curriculum that…

- is ***learner-centered*** and honors ***teacher as facilitator***
- contains ***authentic content and purpose*** and is based on a *rich, complex,* ***driving question that is relevant*** *to student lives*
- is grounded in ***challenging projects*** that *integrate technology* and *culminate in a* ***presentation, model and/or performance*** (**artifacts**) over an *extended time frame*
- **is** ***collaborative, cooperative***, **and** ***interdisciplinary***
- is ***incremental*** *and* leaves room for ***continual improvement***
- incorporates ***problem-solving, peer persuasion*** **and/or** ***presentation*** (authentic, community-based accountability)
- contains *explicit educational goals* based on ***standards*** **(NGSS, CCS)**

Source: Krajcik, Czerniak and Berger (2003)

The PBIS Project Planner

Let's take a moment to familiarize ourselves with the various sections of the PBIS project planner.

Using the PBIS Project Planner, brainstorm a possible project idea for your own science unit.

PBIS PROJECT PLANNER*

*Modeled after and adapted from Vermont secondary PROJECT Science Partnership and Buck Institute for Education (www.bie.org/)

VISION: What are the big ideas?

Teacher(s): Project Title: Grade Level(s)	Subject(s): ▪ How can you incorporate **interdisciplinary subjects** into this project design? Timeframe:
Big Ideas/Enduring Understandings: What big ideas or real-world dilemma will drive this project?	**Essential Questions:** What essential questions will drive the project?
	▪ Consider the themes that will focus the unit and ones that integrate social justice issues (preferably local ones/issues that are meaningful to student audience). ▪ This is a great activity to do with your students but it is usually helpful to already have some ideas in the hopper.

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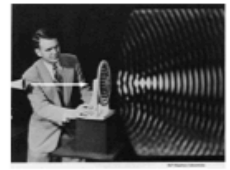
The PBIS Project Planner

Let's see how we can integrate a fairly traditional, yet student-centered, learner-directed, hands-on Sound Lab into the Project Planner

Name: ______________________ Date: ______________ 1



Exploring Sound

A series of self-guided labs

What do you KNOW about sound? What do you WONDER about it? And after exploring sound, what have you LEARNED?

KNOW	WONDER	LEARNED

Please be sure to read the directions carefully at each station and complete the tasks as well as the reflection questions with each task. If you have any questions, do not hesitate to ask for help.

This is how you will be graded on this activity:

Score	Requirements to earn that score
3	Students must answer all questions on their observation sheets accurately and thoroughly; diagrams must accurately demonstrate how sound traveled in each activity and be labeled according to directions.
2	Students must attempt to answer all questions with minor misunderstandings; diagrams are complete with minor errors.
1	Students did not attempt to answer all questions, and some answers show major misunderstandings or are not complete; students did not follow directions to label diagrams; and students have made no attempt to show how sound travels or one which demonstrates little understanding of how sound travels

NOTE: IF you finish your station early, please flip to the back and study the vocabulary and answer the extension questions. Make sure you leave your stations cleaner than you found them.

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The PBIS Project Planner

Think ★ Pair ★ Share

PBIS PROJECT PLANNER*
*Modeled after and adapted from Vermont secondary PROJECT Science Partnership and Buck Institute for Education (www.bie.org/)

VISION: What are the big ideas?

Teacher(s): Project Title: Grade Level(s)	Subject(s): ▪ How can you incorporate **interdisciplinary subjects** into this project design? Timeframe:
Big Ideas/Enduring Understandings: What big ideas or real-world dilemma will drive this project?	**Essential Questions:** What essential questions will drive the project? ▪ Consider the themes that will focus the unit and ones that integrate social justice issues (preferably local ones/issues that are meaningful to student audience). ▪ This is a great activity to do with your students but it is usually helpful to already have some ideas in the hopper.

Quick walk-thru of planner with Sound Curriculum as example.

Silently read and jot down notes.

Share ideas with partner then switch (give yourselves about 5 minutes each).

Report out to the whole group.

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Source: Krajcik, Czerniak and Berger (2003)

More Food for Thought
Examples of Curricula that integrating PBIS Across Disciplines

In your packets on the right side, there are a few examples to prime the imagination.

- Physics & Humanities: *Sound Curriculum*
- Biology & Humanities: *Science of the Mind*
- Environmental Science/Physics & Humanities: *Students for Sustainable Energy*
- Chemistry & Humanities: *Research & Service Class*

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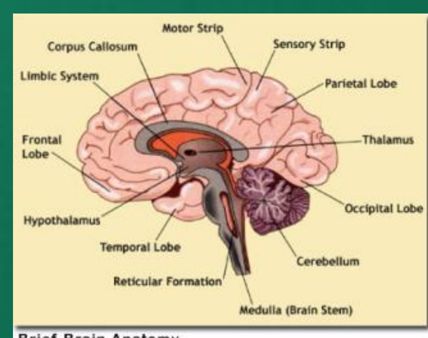
Integrating PBIS Across Disciplines

Biology & Humanities: Science of the Mind

- Teachers and students from Biology & Humanities Classes co-designed the class
- Students *democratically decided* they wanted to study the brain
- Students picked their *own topics* which had to *relate to subjective experience of mind and the physical brain* to go deeper into
- *Writing* articles were *modeled* after *New York Times* science section
- Each had to submit *an original piece of artwork*
- The drafting process was significant and effective.



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Integrating PBIS Across Disciplines and throughout the Sciences

Biology & Humanities: Science of the Mind

- Classes incorporated time for **reflection**
- We provided time for students to "**mess about**"
- **We utilized a project board**
- **Students explain** their thinking and projects to each other and **make recommendations/consult**
- **Students sent their work** to professionals at Harvard
- **Students both collaborated with each other** and **REAL scientists**
- **Students did better work as evidenced by the journals**

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We Connected with the Community

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Harvard Brain Bank, Harvard MRI Research Lab, UMASS Psychology Department, Brattleboro Meditation Center, Harvard Graduate School of Education Mind Brain and Education Program, Landmark College, Harvard University Mind Brain and Behavior Initiative, Harvard University Moral Cognition Lab, Social Cognitive and Affective Neuroscience Lab at Harvard Center for Brain Science, Harvard University Department of Psychology, Project ZERO at Harvard Graduate School of Education, Harvard-Smithsonian Center for Astrophysics Lab for Visual Learning, and others!

One Example of a SOTM Project: *My Brain Likes Exercise, How About Yours?*

Whole class got invited to participate in real-world science study: "*The Effects of Physical Activity on Cognitive Abilities across Development: Acute Study*" (University of Massachusetts)

Compass student, Max, went deep into this topic to explore: *How physical exercise affects brain plasticity*

Max extended learning to school community by studying the EQ: *Should we have physical education at Compass?*

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The New York Times

April 1, 2008 1168 words.

BASICS

Blind to Change, Even as It Stares Us in the Face

By NATALIE ANGIER

Leave it to a vision researcher to make you feel like Mr. Magoo.

Hook Intriguing story. Personal.

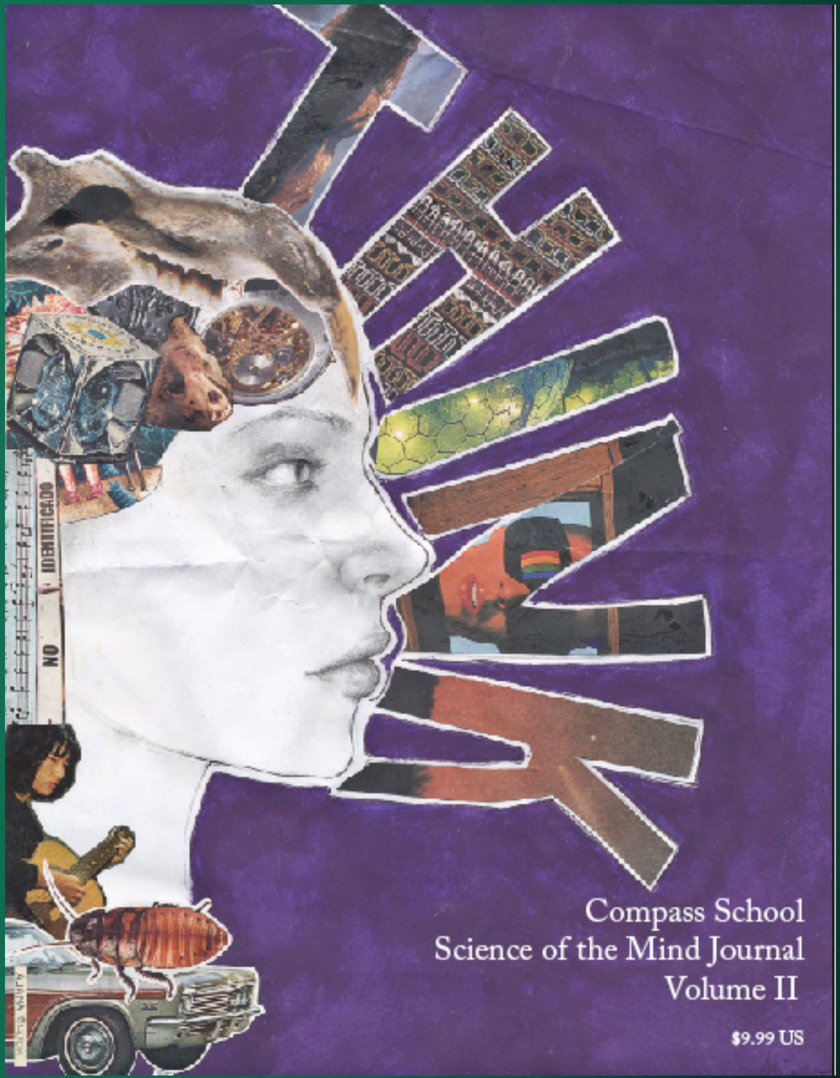
When Jeremy Wolfe of Harvard Medical School, speaking last week at a symposium devoted to the crossover theme of Art and Neuroscience, wanted to illustrate how the brain sees the world and how often it fumbles the job, he naturally turned to a great work of art. He flashed a slide of Ellsworth Kelly's "Study for Colors for a Large Wall" on the screen, and the audience couldn't help but perk to attention. The checkerboard painting of 64 black, white and colored squares was so whimsically subtle, so poised and propulsive. We drank it in greedily, we scanned every part of it, we loved it, we owned it, and, whoops, time for a test.

Dr. Wolfe flashed another slide of the image, this time with one of the squares highlighted. Was the highlighted square the same color as the original, he asked the audience, or had he altered it? Um, different. No, wait, the same, definitely the same. That square could not now be nor ever have been anything but swimming-pool blue ... could it? The slides flashed by. How about this mustard square here, or that denim one there, or this pink, or that black? We in the audience were at sea and flailed for a strategy. By the end of the series only one thing was clear: We had gazed on Ellsworth Kelly's masterpiece, but we hadn't really seen it at all.

Scientific explanation of hook with concrete examples

The phenomenon that Dr. Wolfe's Pop Art quiz exemplified is known a of our visual system to detect alterations to something staring us straig modest as a switching of paint chips. At the same meeting, held at the America at Columbia University, the audience failed to notice entire st fact that one poor chicken in a field of dancing cartoon hens had sudde also recalled a series of experiments in which pedestrians giving direct tourist didn't notice when, midway through the exchange, the sham to altogether.

We modeled our journal writing after the New York Times Science Section



Link to FREE DOWNLOAD of Journal from year #1: http://www.compass-school.org/news/2008/09/19/science-mind-journal

Link to FREE DOWNLOAD of Journal from year #2: http://www.compass-school.org/news/2010/06/17/2010-science-mind-journal-now-here

Student Response to Science of the Mind Class

"In much the same way we learned to use a scalpel to dissect a brain, this class also gave me the knowledge and skills necessary to dissect my mind, to really look inside and start to understand what is going on.

We were not only taught the physiological ways in which a brain functions; we were taught the emotional and spiritual ways in which those biochemical reactions play out in our lives."

-Kelty

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Time to Process:
Q&A, Evaluation, & Additional Resources

Resources around the room include:

- Science of the Mind Journal from both years
- Feeding the Community with Hope Journal, a product of a 2-week service learning project at Compass School
- PBIS books
- Buck Institute for Education at: www.bie.org/project_planner/create_new/

Articles/resources in the right side of your green folders under the clip:

- The curriculum mentioned at the end of this PowerPoint (Students for Sustainable Energy and Vermont Commons School Research & Service Program)
- Project Based Inquiry Science Overview
- Chapter 5: "Where's the Joy? Justice and Caring in Science Education" by Maria Rivera Maulucci and Angela Calabrese Barton

"[T]he more an empowered school becomes a model of success, the more nonempowerered schools criticize it" (p. 72).

"People have to understand that these programs work not because they are so meticulously crafted and engineered but because the faculty will not let them fail. They developed these programs, and they are determined to make them work" (p. 74).

-Carl D. Glickman, *Holding Sacred Ground*

We very much appreciate your feedback.

Please contact us to share ideas and stories!

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Additional Resources to Review at Home

Students *for* Sustainable Energy

Inspiring students to tackle energy projects in their school and community

Regina Toolin and Anne Watson

Sustainable energy is one of the most critical issues facing our planet today. As the world struggles with fluctuating oil prices and rising green energy initiatives, students need to know that they have the power to effect change. At Montpelier High School (MHS) in Vermont, students are accustomed to making such changes in their school and community. Over the last six years, MHS students have participated in the Annual Winooski River Cleanup Project, the construction of a solar-powered greenhouse that provides produce for the school's cafeteria, and a thriving composting program used to fertilize the produce and plants grown inside the greenhouse.

This article describes the sustainable energy projects that MHS physics students designed during the spring semester of 2008. An overview of the project is followed by a description of the planning and implementation processes, examples of specific student energy projects, and a discussion of outcomes and lessons learned. We hope that our experiences will inspire other teachers and students to undertake similar projects and create positive changes in their own communities.

Project planning and implementation

After completing units on motion, force, and momentum, the Classical Physics course at MHS culminates with a unit on energy. During the spring semester, energy systems and energy transformation are the big underlying ideas (Wiggins and McTighe 2003), with a focus on applying energy concepts, equations, and theories to local sustainability initiatives. Students quickly learn that the ability to calculate the theoretical energy produced by a small wind turbine is just as important as the ability to build one. They come to appreciate the importance of calculating energy equations and applying this new knowledge in meaningful and relevant contexts.

Preparation, planning, and problem-posing

Student-driven sustainable energy projects were first introduced in the Classical Physics course in 2004. Given the projects' history and reputation, students, teachers, and administrators have become accustomed to the excitement it generates each spring. In fact, the projects are often the reason students enroll in the course in the first place.

Research & Service

The mission of the Research & Service Program is to go beyond the traditional disciplines, to go beyond the classroom walls, and to connect learning to community engagement and environmental stewardship in a fun, hands-on, and rewarding way. Ultimately, the Research & Service experience teaches students that with knowledge comes responsibility, and that they can and should have an active role in improving their communities. The Vermont Commons School's mission statement is very clear about ...r need to contribute positively to our community and our ...ironment as we foster our sense of citizenship, both ...y and globally.

...ng people to learn and grow, they first need to be engaged. Students become most engaged when their work is ...d to community service. The Research & Service program at Vermont Commons School nurtures in students: 1) ...d ability to apply theoretical knowledge to current problems 2) motivation to work harder 3) improved ...kills 4) a reduction in negative stereotypes and an enhanced appreciation of diversity 5) a deeper ... of the complexity of social issues 6) an increased sense of connection to the community and 7) greater ...

...ervice Program is a concrete manifestation of Vermont Commons School's deep commitment to ...ion, service learning, and ecological stewardship, and provides a multi-aged setting that encourages ...tes group collaboration skills.

...ses use rubric-based assessments to help the students reflect on their experiences and grow as ...uated, and assess themselves, on their active participation, preparedness, attitude, mastery of ...d leadership, and teachers send written comments home each quarter. In order to do a ...d follow it up with research & reflection, R&S courses run the duration of a semester and are ..., and 12th grade) and spring (7th, 9th, and 11th grade). Read the Community Engagement ... to find out what students have been doing recently.

...rvice courses for 2011-2012 include:

...d refugee community. As a U.S. Refugee Resettlement city, Burlington is home to ...ton, more than 50 languages are spoken! Working through local organizations ...gram and the Association of Africans Living In VT, students help some of ...English. Students also work with English Language Learners at the ...rth End. The goals are to learn from and get to know the people, gain a ...xt of refugee resettlement, and learn what it takes to successfully integrate ...ogether.

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Literature on Project Based Learning

- Teachers are generally enthusiastic, motivated, and successful in their quest to implement project-based learning in their science classrooms (Rosenfield and Ben-Hur, 2001).
- Standards-based, inquiry science curriculum can lead to standardized achievement test gains in historically underserved urban students, when the curriculum is highly specified, developed, and aligned with professional development and administrative support (Geier, et al. 2008).
- School culture and mission and teacher prior knowledge and experience of PBI played a significant role in teachers successfully implementing PBI in secondary science classrooms (Toolin, 2004).
- Driving Question Board (DQB) in project-based science (PBS) units: . How to organize, focus, and link students questions to content learning goals. Examples in physics and chemistry provided (Weizman, et al. 2008).
- A planning team from a new urban public high school featuring project-based science, technology, engineering, and mathematics (STEM) education, with a population of African-American, low-income, and special needs students, creates a positive school culture with a clear vision and core values that engender relational trust, a strong sense of community, and principal and teacher co-leadership (Rhodes, 2011).

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Literature on Project Based Learning

- PBL maximizes the use of technological tools for analyzing, presenting, and communicating results (Grant, 2002; Morrison & Lowther, 2005).
- How can science instruction help students and teachers engage in relevant genetics content that stimulates learning and heightens curiosity? (Alozie, 2010).
- Underrepresented HS students' interest in science and science teaching increased as a result of engaging in a PBL summer program (Toolin, 2003).
- At the start of an integrated Algebra I and Environmental Science class, students were presented with the following challenge: "How much carbon is stored in the Normanskill Preserve?" They were told they had one month to investigate and present their results, and asked, "What do you need to begin?" (Penniman, 2011).
- The frequency of teachers' use of specific inquiry-based activities correlates with improvements in students' science attitudes and plans; the extent of the success of a PBS curriculum with students from groups underrepresented in science careers appears to be dependent on elements of both teacher knowledge and teachers' frequency of use of inquiry-based activities that are consistent with culturally relevant pedagogical practices (Kanter, 2010).

Integrating PBIS Across Disciplines and throughout the Sciences

Environmental Science/Physics & Humanities:
Students for Sustainable Energy

- Winooski River Cleanup Project
- Solar Powered Greenhouse—*applying energy concepts, equations, and theories to sustainability initiatives*
- Composting System

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Integrating PBIS Across Disciplines and throughout the Sciences

Environmental Science/Physics & Humanities:
Students for Sustainable Energy

1. Assessing/teaching fundamental concepts of energy
2. Students brainstorm project options and formed teams based on following essential question: *How can we reduce the need for energy or switch to alternative forms of energy consumption in the Northeast?*

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Integrating PBIS Across Disciplines and throughout the Sciences

Environmental Science/Physics & Humanities:
Students for Sustainable Energy

3. Students and teacher identified and created protocol to prevent potential risks and began work on projects based on flexible project criteria.

4. Community members/experts were contacted via email or phone

E.g. Restoration of Lane Shops Hydro Dam in Montpelier, VT

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Integrating PBIS Across Disciplines and throughout the Sciences

Chemistry & Humanities: *Research & Service Class*

Students in the Environmental Engineering Research & Service class at Vermont Commons School (vermontcommons.org) conducted a survey to *assess potential sources of contamination to the Bartlett Brook watershed*, a natural and recreational resource for the City of South Burlington, Vermont, and a drinking water source for 70,000 people.

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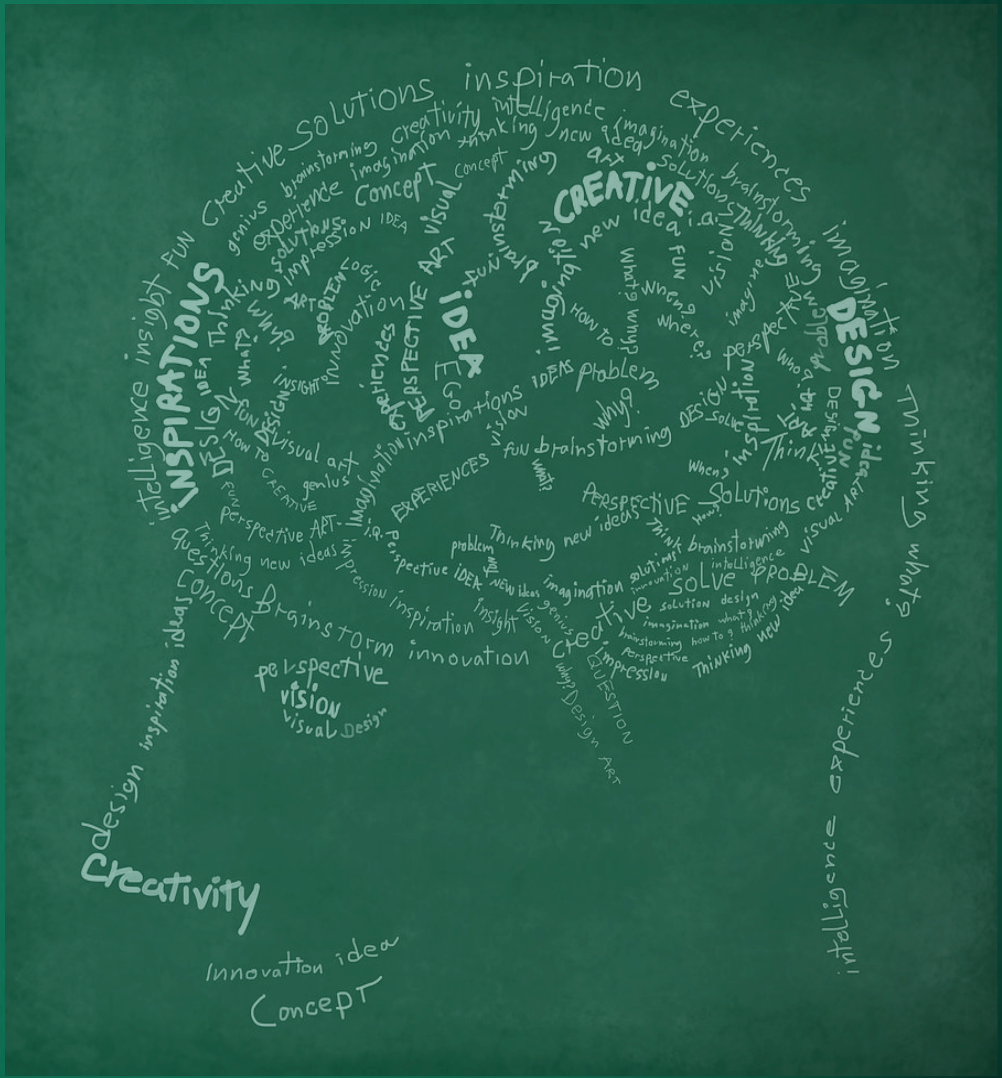
WPTZ Channel 5 feature story: www.wptz.com/news/vermont-new-york/burlington/Students-testing-water-off-Shelburne-Road/-/8869880/13008690/-/15o88cc/-/index.html).

Thanks again, and please consider contacting us!



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