ETHICAL CHALLENGES OF TECHNOLOGICAL SOCIETIES:
CREATIVE AVENUES FOR STUDENT RESPONSE
Toward a Model "Science is Creative" Fair in Sonoma County

by

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Interdisciplinary Studies:
Intersections of Art and Science

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5/18/12
Date
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Purpose:

Contained under the umbrella ‘Project 2061,’ the central framework for the modernization of science education, “science literacy for all Americans,” was introduced by the American Academy for the Advancement of Science in 1989. More than twenty years later these recommendations remain widely cited yet, with federal accountability efforts focused almost singularly on high stakes testing, little has been accomplished on a national level. In response, local entities have become hotbeds of innovation, their successes resonating up to create the definable and thus fundable fields of Informal Science Education (ISE) and Science Technology Engineering Art and Mathematics (STEAM).

The Bay Area is one such hotbed, home to the Maker Fair, the Exploratorium, innovative charter schools, and more. However, few of these options provide opportunities for techno-ethical explorations grounded in student creativity, and even fewer are directly available within the day-to-day curriculum of public schools. Alongside, community-supported efforts have been used to restore arts education to several local school districts. The stage is set to meld these approaches into a model project in Sonoma County.

Procedure:

Through a pilot curriculum project, community presentations, and coalition building within both the public and private sectors, this project has sought to assemble the necessary support to envision a first ever “Science is Creative Fair” in Sonoma County. An innovation able to fit within current nationwide standards, a successful future grant application would allow the program to develop into a workable national model.
Findings:

Interest exists amongst current Sonoma County public high school teachers in community supported pathways to enrich their science classrooms, especially options which involve clear lines of support and which seek to not add significantly to their current workload.

Teenagers are fully capable of following art/science/design projects to logical conclusions and are eager to investigate ways in which they can help shape their own identities, neighborhoods, and world—conservations which they feel are all too often left out of their current education.

Communities are especially receptive to supporting student efforts, including volunteers to help create, display, and celebrate student work. For many adults, the lack of time to reflect and explore in their own schooling (and their resultant disinterest in science) was cited as the key factor in their desire to support the founding of a “Science is Creative Fair” today.

Conclusions:

In the coming years, all three essential elements of the “Creative Avenues for Student Response” umbrella appear feasible. 1) Teachers have been identified from at least four local area public high schools who wish to participate in a pilot program. 2) Local businesses have offered to host, award, and display student projects. 3) Volunteer mentors exist in the form of an ongoing mailing list and a potential service learning course at Sonoma State University.

Financially, partnerships with the traditional science fair, the Children’s Museum of Sonoma County, and the Share Exchange could help defray some costs. A micro scale grant may be enough to begin, however, with a recent funding emphasis on Informal Science Education at the NSF, the potential exists for a larger, more development scale grant as well.

Chair: ____________________________ Date: 5/18/12

MA Program: Interdisciplinary Studies, Intersections of Art and Science Sonoma State University
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Science Education Reform: Community Based Arts Integration

A Review of the Literature

Section 1. The Need for Science Education Reform

During the 2008 presidential election, 85 percent of Americans believed the top issues affecting the health and competitiveness of the nation were science related (Science Debate, 2008). Yet, where once technological innovations were seen as universally positive (better living through chemistry a not so distant mantra), modern dialogues have grown more complicated. Worldwide, citizens have come to question whether, in all cases, the benefits of technological development outweigh the risks (OST, 2005). With growing concern in areas such as genetic engineering, nuclear science, and climate change, Americans have come to ask themselves if, in the modern age, they are prepared to make crucial socio-scientific decisions.

![Bar Chart]

Figure 1: Science Preparedness in American Adults (Macdonald, 2008; Greene J.P., 2003)

In the literature this idea of "preparedness" is often broken down into the following three categories: students, textbooks, and teachers. Highlights of each are presented below.
Students:

According to WestEd (2004), high school drop-out rates in California are at an all time high of 30 percent (rising to 50 percent among African-American and Hispanic communities). Additionally, when students who do choose to stay in school are offered a choice, they actively avoid science courses at both the high school level and beyond (Mallow, 1988; Osborne, 2003).

Textbooks:

Throughout the literature, textbooks have been described as overstuffed and undernourished, emphasizing the learning of answers more than the exploration of questions, promoting memory at the expense of critical thought, and of focusing on reading in lieu of doing (Abell, 1994; AAAS, 2000). In addition, it has been noted that each of the above aspects further fail to promote teamwork among students, thereby promoting an individualistic (famous inventor centric!) view of science and thus inhibiting an appreciation for the importance of democratic participation in guiding socio-scientific progress (Knain, 2001).

Teachers:

Shortcomings in the previous two factors, students and textbooks, are often extended by teachers who lack even a rudimentary education in science and mathematics. In 1989, a majority of junior and senior high school science teachers did not meet reasonable standards of preparation in those fields (Rutherford, 1989). Today, little has changed. When polled by Teacher Magazine, only 50 percent of teachers believe the coursework for their education degree prepared them to be effective teachers in their field (Teacher Magazine, 2007-2008). While many undertake professional development to reduce these deficiencies, studies in the UK show that worldwide teachers are already the top profession when it comes to unpaid work hours (BBC, 2005). Overworked and faced with concerns over their own efficacy, one third of all teachers leave the profession in the first three years, one half in the first five (EdGov, 2008).
In the face of these challenges, educators, policymakers, and local communities have sought a variety of solutions. The first section of this review traces the interplay between the two large scale players (academic and federal) as they strive, sometimes together and sometimes in opposition, to realign standards for teachers, students, and curriculum. The second section outlines community-based responses to both the federal mandates of No Child Left Behind and the general challenge of providing meaningful education to young adults. A final conclusion delves critically into what makes community responses so effective, presents remaining challenges to implementation, and proposes a potential model project for Sonoma County and beyond.

**Project 2061: The Vision**

In 1989, the American Association for the Advancement of Science (the largest non-profit in the world dealing with science issues and the publisher of *Science Magazine*) formalized *Project 2061*, a nationwide call for science education reform. Distillable into four relatively self explanatory goals (Figure 2), the recommendations of this project continue to resonate throughout the literature with a noted emphasis on life-long scientific involvement for all.

1. Prepare a scientifically literate workforce capable of competing in a technologically driven global economy.
2. Promote a deeper understanding of the nature of science for both teachers and students.
3. Enable educators to become leaders in scientific policy making.
4. Provide access to quality science instruction in all students.

*Figure 2: Four Philosophical Goals of Project 2061 (Rutherford, 1989).*
Curriculum Reform

In 1993, under the Clinton Administration, the objectives of Project 2061 were refined by prominent educators into the publication, *Benchmarks for Science Literacy* (Benchmarks, 1993), a document that established set learning goals for what students should know and be able to do in science, mathematics, and technology by the time they graduated from high school. Many of today’s state and national standards draw their proposed content from these benchmarks, though notably not their testing methodology, which tends to emphasize multiple-choice questions over proposed opened styles more closely linked to critical thinking.

In 1998 *Benchmarks* also presented evaluations of the ten most commonly used textbooks in middle and high school science courses. Scored by panels of teachers, criteria included: provided a sense of purpose, took account of student ideas, engaged students with relevant phenomena, and developed and used scientific ideas.

Exactly zero of the commonly used middle school textbooks received a ‘satisfactory’ rating in any of these categories. For the high school textbooks, the only marks above “poor” came solely for standards relating to “laying out the purpose of chapters.” On the whole, textbooks were found to be inaccurate, packed with facts while lacking concepts, and “uninteresting”—observations made even more disheartening (according to Chambliss, 1989) when we realize how often teachers who lack sufficient training are thus relying on the textbook as the sole subject matter authority and pedagogical guide.

More than a decade later, with such clear survey results, many have wondered why no new science textbooks? It appears that while there exists a burgeoning market for college
curriculum that takes an interdisciplinary approach to science, bioethics for example (Greenberg, 1998), demand for inquiry-based high school textbooks that would fulfill the goals of Project 2061 have lagged behind due to fear these texts would not currently conform to the tests administered under NCLB. Additionally, in public schools, books are often used as long as possible, replacements more often than not merely upgrades of old versions.

**Teacher Development**

In 1996 the National Research Council further built upon the existing framework of Project 2061 and introduced a set of National Science Education Standards stressing the importance of instruction that “engages students as active participants in their own learning and emphasizes the development of complex cognitive skills and processes” (NAP, 1996). Of the following seven key suggestions to improving teacher training programs, only the first three have been widely implemented.

- Generation of a personalized portfolio during teacher accreditation
- Mentor programs for young teachers
- Technology integration
- Fewer topics with more depth, a focus on learning by doing
- Learning to see science as an evolving process
- A wider range of learning styles including hands on and problem solving
- Constructivist approaches that root instruction in student’s prior experience

All of these suggestions align well with modern theories on brain development and effective interactions between curriculum, pedagogy, and assessment. For fine reviews of these topics see The Role of Assessment in a Learning Culture (Shepard, 2000) and What Makes Professional Development Effective? Results from a National Sample of Teachers (Garet, 2001).
Roughly, both studies conclude that effective professional development focuses on A) deep knowledge, B) opportunities for active learning, and C) coherence with other learning activities.

Additionally, these reviews and the literature as a whole demonstrate that whenever any of these elements are used in teacher training, a positive effect is seen on the number of teachers who then enter and remain in the teaching force. According to Czerniak, "highly efficacious teachers were more likely to use open-ended, inquiry, and student directed teaching strategies, while teachers with a low sense of efficacy were more likely to use teacher directed strategies such as pure lectures and reading from the text" (Czerniak, 1998).

The two most implemented reforms have been the incorporation of portfolios into teacher accreditation and the rapid growth of teacher mentor programs. Up from 40 percent in 1991, by 2006 more than 80 percent of new teachers in the U.S. participate in some form of mentoring (AAASCU, 2006), with a greatly reduced rate of attrition for those who do. However, currently only 16 states both require and finance mentoring programs leaving the burden to the schools themselves. Of these 16 states, only 5 provide funding beyond the first year.

Also often tried, though with more controversial results, have been attempts at technology integration. Across the country many high schools have attempted to implement extensive (and expensive) laptop programs. The main criticisms have been, due to lack of teacher expertise, the ways in which students use these resources in the classroom—in the words of Mike Resnick (2008) at MIT, “more like T.V.’s than paintbrushes.”

The remaining four teacher training suggestions have not been integrated at the federal level and have thus remained almost entirely recommendations with a few trial exceptions outlined below. Political barriers reside in conservative objections to: linking science and public policy, funding public education in general, and concerns over the power of critical
thinking to subvert dominate paradigms and foster new identities (Thomas, 1996). Modern
documentation of these political positions began during the Reagan administration and are
summarized in many reviews, including *The Manufactured Crisis: Myths, Fraud, and the Attack
on America's Public Schools* by David C. Berliner (1995) and *Revitalizing Arts Education through
Community-Wide Coordination* by Susan Bodilly (2008).

However, despite omission from federal plans, elements of these last four National
Research Council proposals have been utilized in private sector academic initiatives. One
example is *Teachers for a New Era* (TNE) a program launched in the summer of 2001 by the
Carnegie Foundation for the Advancement of Teaching (Carnegie, 2006). Run over five years,
the program worked in conjunction with eleven regional teacher training programs, including
Cal State Northridge and a workshop at Bradley University entitled *Science 101: An Integrated
Inquiry-Oriented Science Course for Education Majors*. Like many of its kind, however, the
course was not a required element of a certified teacher training program and, with dwindling
requirements for teacher development in general (forced by dwindling availability of funds
previously provided to teachers for these purposes), the course has a hard time maintaining
enrollment. This reflects a general feeling amongst teachers regarding the lack of useful
professional development. See Figure 3 (Edgecomb, 2008).

![Figure 3: Availability of Adequate Professional Development](Teacher Magazine, 2007-2008)
Follow-up studies to the TNE program performed by RAND Corporation and the NSF (Mosaic and Mosaic II) demonstrated mixed results depending predominantly on the measure used (RAND, 1998; RAND, 2006). In districts not closely aligned with reform-oriented approaches, common practice was to use existing state and district standardized tests to assess the efficacy of programs. Many of these tests were designed under NCLB and consisted solely of multiple choice and memorization-based items and only minor improvements were seen in student test scores from these TNE trial classrooms. This finding caused organizations such as the Heritage Foundation to question whether the initial monetary investments needed for science education reform would be worthwhile (Greene, 2005). However, in districts where achievement measurements were more closely aligned with the goals of science education reform (involving open-ended items emphasizing problem solving skills), student test scores were found highly sensitive to these new styles of instruction and showed wholesale gains.

In a parallel finding, a majority of teachers cited the demands of NCLB as the primary factor leading them to shy away from reform-oriented practices (Spencer, 2008). Overall, the consensus of the literature is in strong agreement; what we test for is what we receive.

**NCLB, an American Roadblock?**

Internationally, efforts similar in scope to Project 2061 have been proposed in countries including Australia, Canada, New Zealand, the UK, and Denmark (Hand, 2003). The most successful of these programs have been Relevance of Science Education (ROSE, 2008), an international comparative research project based in Oslo; Beyond 2000: Science Education for the Future in the UK, (Millar 1989); and in Denmark, the national implementation of an inquiry-based core science class labeled Public Understanding of Science (De Vos & Reiding, 1999).
Perhaps the single largest difference between these international efforts and those in the U.S. has been the lack of a balanced approach to all four philosophical goals of Project 2061 in America. While No Child Left Behind purports to promote “competitive workforce preparation,” it’s possible this narrow focus solely on test scores may have had the effect not of improved education, but of limiting school options (Freire, 2000; Bodilly, 2008).

That is, by perpetuating a confrontational teaching style these approaches have led to increased drop-out rates and a failure to promote in both teachers and students a true understanding of the fundamental nature of science (McComas, 2000). In addition, due to zero sum cuts in arts funding, student access to a well rounded education has steadily eroded (Bodilly, 2008).

![Figure 4: Teacher Reactions to No Child Left Behind (Teacher Magazine, 2007-2008)](image-url)

While the Heritage Foundation and other conservative think tanks have published reports attempting to refute the notion that high-stakes policies force teaching styles, follow-up articles and persistent polls of actual teachers demonstrate otherwise (Greene, 2005). In a February, 2012 National Science Teachers Association (NSTA) article, more than 93% of surveyed teachers indicated NCLB forced them to “teach to the test.”

According to Diane Ravitch, one of the initial proponents of NCLB under the Bush administration, as currently implemented NCLB is “a corruption of the standards movement,
one failing to account for individual experience, expression, and capability, which turns assessments into “heavy handed systems without the capacity building and professional development components originally proposed as part of the vision (Shepard, 2000; Ravitch, 2010).

Assessment’s Integral Role

While “standards” have recently become synonymous with NCLB, as with the RAND investigations outlined above, no matter what material is covered the importance of assessments in line with desired outcomes cannot be overstated. According to Sharon Lynch (2000), who helped write the initial Project 2061 documents and who was hired specifically to study equity, the science education reform movement with standards linked directly to “promising practices for teaching and learning” has great potential for underserved populations exactly because it “includes students, is systematic, and provides accountability through measures of success.” Lynch believes that the standards in Project 2061 are both more flexible and more ambitious than those of NCLB and that true reform must care as much for its inputs (teachers, students, and curriculum) as it does for its outputs.

Summary of Barriers to Reform Implementation

The literature suggests three primary reasons why reforms at the academic and federal levels have been largely regarded as ineffective in America. First, with more than 80,000 high schools nationwide, all under highly localized school boards, education reform in the U.S. may necessarily involve a slower transition relative to other countries (Rutherford, 1989). Second, unlike some international reforms, federal priority in the U.S. has not been placed on developing enhanced curriculum at both the elementary and secondary level, rather it has
focused on adding additional requirements to already inflexible loads required of teachers (Knain, 2001). Third, no matter what the reform, solutions will remain ineffective without pedagogical support from science teachers themselves (Spencer-Chapman, 2008).

In recent years, top-down efforts at progress have slowed with a deeply divided congress unable to agree on possible reforms and President Obama essentially continuing the main curricular thrusts of NCLB with minor adjustments on approaches towards “failing schools.” Locally, this national stagnation has only enhanced the urgency felt in smaller communities. The remainder of this review will focus on the efforts of these local laboratories for change to re-energize science education toward the original goals of Project 2061.

**Section 2. Community Based Education Reform: Grand Ideas, Local Innovations**

Unwilling to wait for federal and academic bodies to reach consensus, individuals in the private sector, teachers, and community leaders have taken the lead in exploring new pathways in education. While the full breadth of these efforts cannot be contained within one review, references to seminal reviews in each area are presented in the wheel below.
In general each of these individual (and in truth often overlapping) modalities of innovation exhibit key characteristics associated with what Urban Options, an S.F. bay area organization which provides experiential curriculum to middle school teachers, calls sustainable education—that is, an educational culture that values human potential and honors the interconnectedness of social, economic, and ecological well-being based on the following guidelines:

- All children are assumed to be innately curious and to have an inherent capacity to learn.
- True education honors its Latin root, educare, meaning “to nourish.” (Kamp, ODE, 2008)
- True education generates fluent knowledge, imbuing students with both the ability and desire to create. (Resnick, 2008).

Figure 6: Elements of Sustainable Education

According to the cited literature reviews (see figure 5), the outcomes of these approaches match up well with the goals of Project 2061, especially the three most often neglected at the federal level: access, citizenry, and understandings of the true nature of science. Mentorships, project based learning, interdisciplinary approaches, and arts integration all engage a wider variety of students, improve graduation rates, and encourage students and communities to take a more active role in each other’s futures. Teachers who begin integrating their curriculum enjoy an enhanced experience that more closely fits with the vision they had when they became teachers, one which keeps them wanting to further innovate and improve year after year.
Community supported art integration holds significant promise as it: A) requires the least funding, B) is the most accessible for all types of students, teachers, and schools, and C) is the most readily implementable in a short time span (Bodilly, 2008).

**Community-Based Arts Integration**

In recent decades, political and economic forces have left two thirds of public high schools without a licensed art or music teacher. To fill the void, community driven efforts to integrate art into other disciplines have surged throughout the United States. A concise history of these trends along with outlines of five such projects can be found in a recent review by Susan Bodilly (2008): “Revitalizing Arts Education through Community-Wide Coordination.” One of the highlighted projects, The Alliance for Arts Learning Leadership, is located in Alameda County. Led by administrators, teachers, and community members, the alliance is a grassroots organization which, without federal aid, assembled the necessary funding, human resources, and social will to restore arts to a majority of Alameda County public school districts.

Benefits detailed for teachers of all disciplines that effectively integrate art into their curriculum include increased student motivation, cognition, and social skills (Catterall, 2002; Finn, 2007, Rogers, 2008; Swift, 1999). Schools and school districts who embrace arts integration see higher academic achievement, reduced drop-out rates, and increased teacher involvement in professional development (Gullatt, 2007). Evidence suggests that these improvements are due to the ability of arts education to enable students to actively participate in the creation of knowledge, a critical factor according to Project 2061 with regards to students achieving science literacy. In essence, when students are encouraged to be more than merely receivers of information they learn to gather and assimilate and construct meaning and
thus have a prolonged retention of knowledge, attributes fundamental to enabling citizens to take active, long-term roles in their communities. (Brinton, 1996; Gullatt, 2008)

Benefits Specific to Science Classrooms

Observing the state of current environmental problems, some educational leaders have called for a more socio-political approach to teaching science. Curriculum involving active and ethical neighborhood involvement has been suggested with the intention of producing future citizens who will work to restructure society along more socially-just lines (Hodson, 2003).

At times these tactics have also proven controversial, some educators noting that developing psyches are fragile and that changing one’s mind is often more of a social than a logical process that can come with consequences both in school and at home. In essence, teachers must be wary of seeing education as a practice in behavior modification (Lemke, 2001).

In response to this criticism, others have argued that some values (peace, equity, human rights, environment, and true representation) are universal and that it is impossible to separate the challenges facing a society from the mission of education (Schreiner, 2005). Indeed, that society has a duty to both itself and young people to give them as many tools as possible for critical introspection.

*Imagining what it is like to be someone other than oneself is at the core of our humanity. It is the essence of compassion, and it is the beginning of morality.*

—Ian McEwan

Arts integration may actually go one step further, perhaps even managing to reconcile the two previous views. According to Jensen (2006), the ability to connect with people from multiple angles is exactly the flexibility that an arts-integrated program can provide—indeed,
that horizons may be broadened even more effectively by a shared sense of active creation among peers than by active challenges to core beliefs. It is not so much important what students create or that they agree, but that they experience the passions and perspectives of their peers.

Similarly, it’s been commented that what art integration can provide is an increased ability to deal with ambiguity (Girod, 2007; Parker, 2008). From skeptically reading scientific reports and forming one’s own opinion, to designing sustainable policies, to helping students overcome their own fears that too many problems have been left for them to solve, it’s been observed that art integration can be a powerful tool toward teaching students to think critically, see implications, and ask the right questions. Further, in an increasingly technological age, some educators have also wondered what happens when we do not take such approaches, when we attempt to teach science as purely rational and lifeless. What kind of identities do we then recruit into scientific professions? (Lemke, 2001)

**Art Integration, Turning STEM into STEAM**

The overlap between science and art is not new. Indeed, art and inspiration have always been observable in the work of many of our greatest scientific thinkers (Lightman, 2005). Twin regulators of human understanding, the two disciplines share many mutual characteristics: inquiry, invocation, and insight (Wilson, 2002), and examples can be found all around from community gardens and murals, cutting edge use of science to create art, and online archives of activities students can do at home (Candy, 2002; Bijvoet, 1997; Malloy, 2003; ASCI, 2008).

As a knowledge-into-action approach, arts integration has been seen to increase both access and desire to pursue science education, deepen student inquiry, and offer students the
ability to explore the relationships between science, technology, and society, both in and out of the classroom—an expansion of the learning environment seen by some as critical in the digital age (Jensen, 2006; Resnick, 2008). In all of these aspects, art integration in science classes is in direct support of the goals of *Project 2061*, a fact acknowledged in just the last few years with the evolution of several new fields in science funding including a new emphasis on Informal Science Education (ISE) by the National Science Foundation (see figure 7). Under this umbrella is support for projects which have begun to re-envision STEM (Science Technology Engineering and Mathematics) as STEAM, (Science Technology Engineering Art and Mathematics).

![Figure 7: Number of NSF awards by year for Informal Science Education](image)

Awarded in 2002, the first large scale ISE grant funded the “**Center for Informal Learning and Schools**” at the Exploratorium in San Francisco. Steadily increasing every year, the NSF estimates that more than $28 million will be assigned across approximately sixty grants in 2012. For a list of recent grants relating to community-based arts integration and technoethical activism see Appendix 1.
Reform Barriers Specific to Science Classrooms

Teachers:

The vast majority of science teachers have minimal experience with artistic, interdisciplinary, and dialogue-based teaching styles. The tendency instead is to teach one subject as a tool of the other rather than truly exhibit the abilities of art and science to co-create new pathways of inquiry (Girod, 2007; Trumper, 2006). This approach fits philosophically with the finding that, as of 1998, 80 percent of science teachers did not believe in the efficacy of a constructivist approach to teaching science (Czerniak, 1998). These are significant barriers, though evidence suggests that even the most skeptical science teacher after undertaking even the most minor attempts at art inclusion, observes immediate positive results and becomes more likely to work toward future integration (Spencer, 2008).

Access:

In past generations access to scientific education was limited to a privileged few. Big or small, local or global, a fundamental aspect of Project 2061 is the understanding that the wider the range of people, viewpoints, and approaches involved in steering human ingenuity, the more informed, creative, and just those decisions will be.

In recent years, science education reforms appear to have been nurtured primarily in charter and private schools. Potentially related, government data reveals the continued abandonment of public schools (see figure 8), though this evacuation has come across the political spectrum.
Thus, while alternative schools help push the envelope, lack of access to innovative educational techniques continue for those most in need. In fact, in public schools, the bulk of innovative opportunities exist solely in restricted access programs. For example, ART QUEST at Santa Rosa High School is not open to all students (nor is it truly interdisciplinary, with students taking one extra art elective but still placed in main stream math and science courses). Across the country, only 9% of students in “gifted and talented” programs were from the bottom quartile of family income (NCES, 2008).

Reduced class sizes have also been proven to be an important ingredient for innovative teaching. However, public school resources are scarce and there is a growing body of evidence that suggests teacher quality is a more important factor for student outcomes. Reducing class sizes would be an improvement, but the number of qualified science teachers willing to work at current teacher salaries might not then be available (RAND, 2002).

Funding:

While seemingly in perpetual crisis, the California state budget has now been declared in a state of emergency (Rau, 2008). Proposed cuts in K-12 education amount to $7.2 billion or $1,200 per child in a state that already ranks 46th in the nation in per student funding (CTA, 2008). In addition, in the last decade, funding reductions have greatly reduced the state’s...
ability to include innovative programs. One example of this is the drastically diminished scope
of the Northbay Science Project which specialized in training middle school science teachers
who lacked an understanding of their subject (L. Cominsky, personal communication, November 28th, 2008).

Conclusion

"There is a major categorical flaw in the way we commonly think about scientific and
technological research as being outside the major cultural flow, as something only for
specialists. We must learn to appreciate and produce science and technology just as we
do literature, music, and the arts. They are part of the cultural core of our era and must
become part of general discourse in a profound way." -- Stephen Wilson (2002) from
Information Arts: Intersections of Art, Science, and Technology.

Twenty years after the establishment of Project 2061, philosophical recommendations
have been made, but little has been done at the national level to effectively reform public
institutions. Student drop-out rates have steadily increased. Teachers have less freedom to
teach students in innovative ways. Public schools have less funding to provide complimentary
activities for students. In a rapidly developing technological world, students continue to leave
high school disenfranchised and disheartened about the roles they can play in their
communities (Bodilly, 2008). While in recent years these failures (especially with NCLB as
currently construed) have begun to be recognized, with over 80,000 high schools each under
highly localized administrations, it has also become increasingly apparent that real change must
begin in communities and classrooms and with teachers themselves (AAAS, 2008).
In the future, modified standards as well as improved and diversified training methods for teachers are expected to be important steps toward reforming science education. However, while many see hope for these changes in the near future, training new teachers from the top down will take years and require a substantial input of funds. Until fundamental changes take hold at the national level, instituting entirely new curricula in public schools may not be feasible.

In the mean time, community-supported arts-integrated approaches to science education reform have been shown to be effective at:

- Engaging “multiple intelligences,” even in large public classrooms
- Being action oriented—allowing students input into their own education
- Involving local communities
- Functioning with comparatively low cost
- Having a lower impact on teacher schedules than other reforms
- Fitting with current standards while leaving the door open to pedagogical shifts in assessment
- Being resilient and contagious
In conclusion, this literature review finds community supported integrative arts approaches to science education to have strong potential toward reaching the four goals of "science literacy for all" by providing: A) reduced dropout rates and increased interest in science; B) deeper exploration of the importance of "inquiry" and "creation" in the nature of science; C) inspiration of a wider range of students, teachers, and mentors to take more active roles in their communities and explore issues through their own unique lenses; and D) access to innovative teaching (currently found predominately in alternative schools) to public school students as well.
ETHICAL CHALLENGES OF TECHNOLOGICAL SOCIETIES:

CREATIVE AVENUES FOR STUDENT RESPONSE

Toward a model “Science is Creative Fair” in Sonoma County

Methodology

This project has primarily been one of community outreach. Actions have included: solicitation of students and educators to participate in pilot art/science curriculum projects; performance of integrated learning exercises with homeschool students, display of created works in public forums; follow up community presentations to expand the vision and gauge support; application for a micro-scale “community improvement” grant; and finally establishment of a coalition of project partners and volunteers along with identification of a target NSF grant for future funding.

Definition of Terms

Alternative Research Projects.

Interdisciplinary projects performed in place of traditional research papers. Previous student alternative projects have consisted of everything from graphic novels and movies, to invention proposals, movies, short stories and more. Because of the potential for a wide range of interdisciplinary interest, successful projects most often occur when science teacher and student are supported by a mentoring artist.

Purpose

Philosophical understandings of the need for science education reform in America have been in place for decades, advocates recognizing that in order to have a truly engaged and prepared public, “science” needs to be a more universal activity, one in which we can all participate.
The long term goal of this project is to explore the feasibility of implementing a three-pronged "Science is Creative" program in the North Bay aimed at providing mentor-supported opportunities for science students to create alternative research projects (ARP's). Benefits would extend to current science classrooms, teachers in training, and the community at large, with potential for the project to become a national model.

Figure 10: A three prong project proposal

At present a full scale pilot remains on the horizon. Project efforts have focused primarily on laying groundwork, identifying allies and creating opportunities for interdisciplinary interactions in both subject matter and participants within Sonoma County.

Scope

Figure 11: Feasibility study timeline. Design Days, Community Outreach, Grant Proposal
Beginnings

The seeds for this project were first planted during my years teaching high school science in Maine. An approachable teacher with experience in a wide range of educational styles, I had a knack for reaching students previously discouraged in their science education, my biggest success coming with the help of several art teachers. After a series of experiential assignments during the year, I offered students the option of performing what I came to call “alternative research projects” (ARP’s) instead of traditional research papers. The only requirement was that their project had to explore some area of science in the future and attempt to address for themselves an instance where they had found themselves asking the all too common modern science class question, “but what can we do?” Many previously struggling students began to participate and do research they never would have otherwise done.

Fast forward to 2011 and the Sonoma County science fair. As a volunteer judge I had the opportunity to closely examine all the Earth and Natural Science projects. From follow-up interviews, it became apparent that: A) a vast majority of the students were participating solely because it was a requirement, B) few students had done much background research or chosen a subject they cared deeply about—most of the projects overly formulaic in layout, design, and overall topic, and therefore C) few projects included any element of reflection into what their investigation might mean to the world the student lives in.

In the following weeks I contacted participating Science Fair teachers and offered to personally support any student they’d allow to perform an alternative research project in the future. The projects would be a part of a pilot version of a “Science is Creative Fair” which would be either an add-on event to the traditional science fair (a possibility suggested by Mike Roa of the Sonoma County Office of Education) or as a separate community-supported activity.
At this point several small scale art-science activities were also offered to prepare students for what their larger projects might look like. (For a list of these proposed smaller scale activities see Appendix 2).

Already near the end of the school year, few science teachers were able to immediately integrate these new elements. Overall reception, however, was positive with secular charter schools almost unanimously onboard and pledges of interest from multiple public high school teachers including: David Casey and Casey Shea at Analy, Len Greenwood and Melissa Neufer at Montgomery, and Paul Jolly and Sean Vezino at Windsor. In addition, several middle schools also received word, the REACH charter school in Sebastopol offering me the opportunity to do several of the smaller activities as afterschool mini-courses the following year. Of these proposed activities, the recycled materials mini-golf project, designed as part of an internship with River Of Words in Berkeley, received almost universal enthusiasm.

The long term goal remains to work with public school students as the group most in need of innovative teaching methods. However, in need of a more immediate forum with young investigators I also decided to contact the local homeschooler associations, SCHN (Sonoma County Homeschool Network), and SRCH, (Santa Rosa Community Homeschoolers). Without a traditional end to their school year, the homeschool families were open to beginning immediately and a series of project-based meetings was arranged for the summer. Follow up activities have occurred with several public schools, but it was these homeschool “Design Days” which quickly became this project’s core exploration.
**Design Days**

During the summer of 2011, more than twenty afternoons of art/science/design activities were hosted in my backyard. Taking inspiration from the Putting Lot in Brooklyn, NY, the initial goal was to design a recycled materials mini-golf course in order to “reclaim an urban space.”

![Image 1](image1.png)  ![Image 2](image2.png)

**Figure 12: The Putting Lot in Brooklyn, NY. A reclaimed urban landscape.**

At the request of the SRCH crew (a group of tight knit Santa Rosa teens) participant days were segregated into two age ranges: 12 to 16 year olds hailing primarily from Santa Rosa, and 5 to 11 year olds travelling from all over Sonoma County. Joshua Murphy, one of the older teens, was enlisted by me to help with the initial planning and attend the younger days as my assistant.

Each meeting generally consisted of between 8 and 16 participants and lasted 2 to 4 hours. The different age groups were given almost identical challenges. These similar expectations made setup easier and also provided insight into how student approaches tend to differ at different stages of cognitive development.
The older group took more time to examine sample creations and listened at greater length to explanations, in the end enabling them to create more complicated constructions. The younger crew, more eager to begin, tended to grab and play with items before instructions could be fully given. However, while this eagerness tended to make longer term tasks more difficult, the younger participants also came up with some strikingly inventive ways to do things and were less likely to simply imitate what I'd already done.

For both age groups, parents were given the option to stay and watch or participate. In general, parents of younger children remained throughout the afternoon, at times helping but more often resting in the shade while I led the flow. Parents of older kids almost always left
immediately, asserting their desire to give their teenagers space to “do their thing.” However, upon return, many of these adults found themselves unable to resist jumping in.

Primarily due to scheduling difficulties (younger kids coming from all over Sonoma county, limited morning hours available for myself, and highly variable summer weather complicating both storage and setup), the younger crew met only four times, their series ending soon after the mid-summer fieldtrip.

*Getting the “ball” rolling*

![Image of kids building a marble run](image1.jpg)

![Image of kids building a marble run](image2.jpg)

*Figure 15: Marble run madness.*

The first meetings involved crafting giant Rube Goldberg machines out of bamboo, PVC pipe, marbles, pipe insulation, plastic bottles, and anything else we could dig out of our recycle piles. During the construction, concepts in math, physics, and economics involving: geometry, measurement, trial and error, materials pricing, slope, momentum, inertia, friction, and gravity were explored. Although each Design Day was allowed to be its own isolated adventure, the goal of this initial day was to learn about “things that roll.” Overall it was hoped we’d later use this collected knowledge to design a truly innovative mini-golf creation.
It's time for Design Day 1
Marble Madness!

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Achievement Items earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get 'er Done</td>
<td>Basic supplies bucket</td>
</tr>
<tr>
<td>Everybody say, jump, jump!</td>
<td>Trellis and dowels</td>
</tr>
<tr>
<td>Spin Doctors</td>
<td>Large ball bearing</td>
</tr>
<tr>
<td>More the merrier marble exchange</td>
<td>Bonus Bucket</td>
</tr>
<tr>
<td>Circle the wagons (horiz or vert)</td>
<td>Beam</td>
</tr>
<tr>
<td>Represent! (water, pulleys, springs, dominoes, balloons, bounces; use &gt; 2)</td>
<td>Sound blaring when all groups finish</td>
</tr>
<tr>
<td>Final Challenges: GrillAus, Co-Op, Bouncing to the Beat!</td>
<td>Marble Mastery!</td>
</tr>
</tbody>
</table>

Figure 16: Broken into "achievements," each completed activity led to access to more materials.

**Thar be Designers**

The second challenge involved making "larger-than-life" paper mache structures: fun in their own right, these would also potentially make great obstacles for mini-golf holes! To begin we made small monsters before constructing large scale armatures out of scrap wood and PVC. In addition to being inexpensive, paper mache has the added benefits of being A) relatively easy to modify even after dry (including the drilling of holes), while also being B) weather resistant with proper coating.

Figure 17: Paper mache monsters.

An additional factor in the decision to go with paper mache was that it is lighter weight than other potential materials. Without a permanent home (my backyard could only host us for
so long), one possibility was to make modular constructions that could be stored in a trailer and then taken to schools, street fairs, and other community “guerilla education” opportunities.

The first annual Share Fair, to be held downtown on July 10th, was one such forum on our radar.

![Figure 18: Framing a dragon.](image)

After a long day and some progress made on several dragons and a castle, we called it quits. The following week, fieldtrip!

**Golfin in Guernville**

On June 17th I arranged for the homeschool students to have exclusive access to the “Pee Wee Golf” amusement park in Guerneville. Younger kids arrived in the morning; the teens followed up in the afternoon. Turnout was low among the younger crew, indicative of dwindling interest and an inability to find workable times with such a widespread group.

The field trip provided a useful intermission to the rush of early summer activities, a chance to take stock and ask the Design Day participants what they wanted to accomplish in the weeks ahead. My initial schedule had greatly underestimated the time needed to exhaust
the potentials of each activity and yet, in what would be perhaps our only real form of assessment, we needed to decide how best to create something tangible.

I'd also recently discovered the existence of a “community improvement grant” through the community advisory board (CAB) of Santa Rosa and been encouraged to apply by city administrator Ed Buonaccorsi. Applying for the grant could be a great experience for the teens, empowering them to take visible action in their community, and potentially provide funding for a more large scale creation be it the modular and portable direction we were now headed in or perhaps even aid in securing a more permanent site similar to the Putting Lot reclaimed alleyway in Brooklyn. However, less than a month remained before both the CAB grant deadline and the Share Fair.

![Figure 19: Kangaroo pouch and GMO stew.](image_url)

During the field trip I asked each foursome to fill out a worksheet describing their favorite holes. What did they like about them? What might they have done to make them better? If they were to design their own, what theme would it have? What obstacles would go
along with that theme? I told them to initially think big with no limitations on their proposals; we’d figure out the details later.

Primarily raised in a “free school” model, many of the homeschoolers were unaccustomed to filling out written worksheets. It quickly became clear, this mode of feedback was going to be lacking. In the end I conducted oral interviews with each group. They spoke and I drew pictures. Different than I’d envisioned, but effective in its own way and soon I’d convinced them that they didn’t have to be Da Vinci to get their point across.

![Figure 20: Hand drawn notes from fieldtrip interviews](image)

Consensus held that the most enjoyable elements were the most interactive. Putting through a dinosaur’s legs? Ho hum. Not nearly as fun as trying to avoid a moving spider, launching a ball into a kangaroo’s pouch, or being forced to choose one of multiple pathways to the final green! The teens also enjoyed several styles of play they’d made up on their own,
most involving ways to impede each other’s shots instead of sitting idly by. Golf, unlike most
sports, is traditionally an individual enterprise in which one only indirectly competes against
other players. By placing objects (backpacks, other clubs, hats) they’d brought with them on
the course or rolling other balls on collision courses, they’d invented for themselves a more
compelling experience. By the end of our conversations, the teens expressed a confidence that
they’d now be able to design and build their own innovative and interactive course.

Some of their new ideas for holes included: a labyrinth with potentially rearrangeable
barriers (obstacles perhaps representative in some way of the “life of a teenager”); a pinball
machine where the club handle acts as the launcher with the head of the club then inserted
into the “hole” to become a flipper; a chicken that changes the player’s ball into a tough-to-
putt egg on the final green; a cooperative hole where players work together or go out on their
own; a croquet style hole; and a puppet theater where the ball triggers actors to move across
the stage.

Following the field trip, the next weeks were filled with intermittent rain. The CAB
grant was due on July 1st, and the Share Fair would happen on July 10th. Concern grew about
whether we would be able to complete any of our collection of ideas in time.

I cleaned out our carport and, as a group, we decided once and for all to shift away
from large-scale permanent creations to making “smaller” pegboard prototypes. For arcade
fans we made pinball machines with rubber band bumpers, cardboard tube spinners, and
working clothespin flippers. Several of the more artistically inclined students took up the
challenge to make vertical “storyboard” fall down machines in which they attempted to have
two differently weighted and size balls tell a story they’d written of two people coming and
going from each other’s lives.
And lastly, our best creation, and the one we eventually took to the Share Fair, was a giant cooperative marble maze.

Many connections flowed from the Share Fair: A) an extensive mailing list of volunteers (including green builders, lawyers, and artists) interested in the "recycled mini-golf urban space renewal project;" B) a deepening of my relationship with Kelley Rajala and the people at the Share Exchange, further opening it as a venue for later community outreach; and C) several
passersby mentioning our creation to Collete Michaud and Theresa Giacomino at the Children’s Museum of Sonoma County opening their doors for a later meeting.

Visuals from these prototype projects also aided in completion of the final CAB grant application. We now had concrete ideas if not a “concrete” final location. Several dead ends had already been pursued in the West End, one in conjunction with the Santa Rosa Tool Library and The Artistic Wonders Society that had looked promising but was slowed and finally canceled when Artistic Wonders was unable to complete an offer from the water district to refurbish a property near Dutton and West 4th.

Despite this lack of an immediate location, the CAB committee’s initial response was favorable. An invitation to present before the full committee extended for mid-August. However, this date would be pushed back multiple times, eventually occurring late in September. While waiting for that process to move forward, the main thrust of my project shifted to following up on connections with the Share Exchange and the Children’s Museum and exploring my own self as artist, activist, and community network builder. Though large group activities with the teens went on hiatus, I did still do some project-based math tutoring with Joshua Murphy, my Design Days assistant.

Figure 24: Deriving Pi from sidewalk circles.
Community Outreach and Nature Art

On September 8th I was invited to give the opening talk in the “Great Communities” movie series at the Share Exchange to discuss the benefits of recycled art projects. Among those in attendance were Theresa Giacomino of the Children’s Museum, multiple homeschool families, supporters from the Share Fair, and people who had seen flyers around town.

During the event, I presented the Design Day’s work from the summer and discussed other examples of recycled art from around the world and its potential to promote social reflection among viewers. At the end of the talk a brainstorm session sought to devise other potential “urban reclamation” projects in Santa Rosa. Theresa Giacomino was an active and eager participant. It was clear that if I could secure enough initial funding, the Children’s Museum, in need of installations before their grand opening in 2013, would be a great fit for the recycled materials mini-golf course.
A Recipe for Reclaiming an Urban Space

Figure 25: A recipe for reclaiming urban spaces and an example of the social commentary potential of recycled art.

At the final presentation before the CAB committee I presented this connection with the Children's Museum and suggested the museum as a probable location. From the ensuing discussion, it became clear the grant would be denied. Per CAB's mission, the project could not be supported as it was not located in a neighborhood, but instead on a business premise.

Avenues to pursue the recycled mini-golf project remain, be they through the SSU Excel for Youth program (where I will teach a condensed version this summer), as an afterschool program, or as a competition at the Children's Museum as part of a potential "Science is Creative Fair" where physics and math classes compete for the opportunity to build their winning designs.

Rivers and Tides and You

As an educator I've spent a good deal of time asking students to embrace their own creativity, to not just think, but do. In order to continue networking with an even larger cross-section of the community, as well as push my own "intersections of art and science" self, on December 6th I accepted Kelley Rajala's offer to lead an evening of interactive nature art at the Share Exchange. Kelley had witnessed my earlier Great Communities presentation and was moved by the interactive and environmental potentials of our brainstorm session.
I believe in the 3/4 baked philosophy. People chase perfection—trying to ‘fully bake’ their ideas before sharing them with the world. Too many people end up never sharing their songs, dreams, novels, and inventions. The 3/4 baked philosophy is about finding that right time to share your work—letting the community fully bake it. The more you do this, the more you put yourself out there, the more success you have.” -- Jason F. McLennan, The Living Building: Biomimicry in Architecture, Integrating Technology with Nature

Participants arrived for a screening of the movie, Rivers and Tides, depicting the nature art creations of Andrew Goldsworthy. What they found was a room filled with nature art supplies including: bowls of water to decorate with wildflowers, varied grains of sand and stone and seeds to create patterns, dried leaves to potentially shape into animals for release in the fountains around town, precut sticks to create a 3’ by 4’ fractal tree, ivy leaves to make a leaf snake, and a collection of egg-shaped slices of tree branch tessellated and hand-drilled to be assembled into a mobile—a bird bursting into flight! (See pictures below for visuals of some projects, Appendix 3 for handouts from the evening). Participants ranged from Santa Rosa Junior College students, homeschool teens, local artists, friends, and people I had not previously met.

Figure 26: Leaf animals.
Some attendees moved from station to station while others became attached to the one just right for them from the start. Three elderly ladies sat in front and "knitted" together a long "snake" of leaves using dried stems for pins. Later in the week the leaf chain was released to twist and flow down the Santa Rosa creek.

At the end of the evening people left with bright smiles, thankful and a little awed at the opportunity to see themselves as doers of art and science as they worked right alongside Mr. Goldsworthy up on the big screen.
Earth Hour

During a follow-up conversation with the Share Exchange in which they volunteered to be the physical hub of any future "Science is Creative Fair" activities, Rebecca Valentine asked if I would also be interested in helping her plan an Earth Hour event at the Share Exchange on March 31st, 2012. Earth Hour is an international climate awareness movement in which cities, landmarks, and individual citizens turn off their lights for at least an hour in solidarity with the planet.

The event was well publicized, among other outlets making the Press Democrat's top ten things to do in Sonoma County for that weekend. The initial grand vision was to co-create with attendees a giant indoor campfire in the shape of the continents of the world.

Leading up to the event Sean Vezino, a Windsor High School teacher, and I projected and traced the outlines of the continents onto a giant 20' x 16' blue tarp. Over the room's entry way we erected a 18' tall bamboo teepee. In the days leading up to the event I collected carloads of sand, rock, bark, leaves, flowers, sticks, seeds, and more.

Figure 29: Earth Hour behind the scenes.
On the night of the event, the doors opened at 7:00PM. Throughout the evening more than 40 people of all ages participated. Upon entering, people were given several mappings of the Earth as guides to help them “raise the continents” from out of the blue tarp sea. These handouts included elevation and vegetation mappings with instructions for people to try to assimilate both maps. For example, a brown mountain region like the Sierras might be made out of bark chips, while an elevated icy region like Antarctica might be made out of white stone or sand with white flower petals on top.

Figure 30: Earth Hour raising the continents.

Additionally, around the room bowls of water, flowers, and floating candles were available to those who preferred not to work on the floor. On a corner table was a collection of nature poems and Native American stories for people to peruse. While some people had brought their own favorite campfire stories to share, the availability of these resources allowed a wider variety of voices to contribute when the lights went out.

At 8:15PM we began to light the candles and at 8:30PM turned off the lights. After a brief introduction to the purpose of Earth Hour and some moments to enjoy the work we’d created, I told the opening story, a native myth from the book *Keepers of the Earth: Native American Stories and Environmental Activities for Children*. It was a tale of how stories themselves came to be given to humans (by a wise old stone outcropping)—and provided
much needed warmth given against the long dark night. Something we now do quite well with technology, but in so doing have perhaps forgotten how to live in rhythm with the planet.

"For nothing is fixed, forever and forever and forever, it is not fixed; the earth is always shifting, the light is always changing, the sea does not cease to grind down rock. Generations do not cease to be born, and we are responsible to them because we are the only witnesses they have." -- James Baldwin

The story to me was also an illustration of one of the truly wonderful things about being human: no answers have been given. In an immensely vast universe we are alone, curious, and easily moved to inspiration—imbued with the ability to appreciate both the scientific beauty of discovery as well as the deep cultural knowledge of our native world.

Another attendee, Miguel Elliot, founder of Living Earth Structures and organizer of natural building workshops around the world, told an old Buddhist story, “The Stonecutter,” about a man who wants to be everything else other than what he is until he finally learns to see the value in the skills he already has.

The evening lasted until around 10:30PM when the tea lights finally began to burn low. The last hour was entirely campfire songs led by anyone inspired to share and taken up by all the voices in the room as we learned the words. Late into the night, it was just me during the final clean-up, but it was all of us who left a little in awe at what we’d created.
Significance

When it comes to the field of chemistry, I am accustomed to the role of expert. In my years as a teacher I’ve experienced considerable success at sharing the “already known” in ways students of all backgrounds can relate to. But science, like life, is not about walking previously lain paths. In both science and life we are most successful when we learn “foundations” so we may build upon them.

From the open-ended challenges of the initial Design Days, to working with current classroom teachers, to instigating mixed age “intersections of art and science” activities within the community, this project has sought to provide citizens young and old with ways to participate in science education. While I brought to each event some expertise and a general plan, in the end it was the participants themselves who were given the opportunity to experience concepts in science through their own artistry—in effect learning the process of “science” far better than if I had merely told them what to expect and then set up a lab to demonstrate exactly that. A future Science is Creative Fair will be imbued with these same qualities.
Limitations

Due to school year limitations, aside from a few advisory visits to afterschool programs, the primary high school age curriculum component was done with homeschoolers and not the educational institutions perhaps most in need of innovative support, traditional public school students.

Initially troublesome as well was the discovery of just how many science students manage to go their entire four years of public school without being asked to complete a research paper or science project of any kind. Thus, some public schools may lack a natural method for integrating alternative research projects into their current curriculum. However, at least one teacher saw this as less of an obstacle than an opportunity for the project to help reignite active and supported research components into their school’s curricula. Similar views were expressed by teachers in Alameda County just before they began working with their surrounding communities to revive arts education in their district.

Ethical Challenges of Technological Societies: Creative Avenues for Student Response

Figure 33: Three pronged project proposal.
Finally, in order to be sustainable beyond an initial pilot, the third long term prong of the proposed "Science is Creative Fair" project plan calls for a college level service learning course geared toward potential teachers. Talks with the Hutchins and Extended Education departments at SSU have been positive with potential for the course to be offered during either the winter intersession or as a full semester course. Resources have been gathered and work has begun on a syllabus. The time needed to complete this task may become part of a future grant application.

**Results and Conclusions**

![Diagram](image)

**Figure 34: Benefits of mentor-supported creative research projects.**

The literature and the journey that has been this exploratory project suggest a variety of aspects in which a full-pledged Science is Creative Fair would be an effective route to
promote science education reform in Sonoma County. For a distillation of these qualities related to mentor-supported alternative research projects, see figure 33 above.

**Pilot Activities and Community Outreach**

Teachers who attended the interactive evenings were immediately struck by the degree of student involvement and began to wonder in what ways they could further innovate their own curriculum. Though only a small sampling of the initially proposed projects have been put into action, these have already become model programs for future work. “Recycled Materials Mini-Golf Design” will be offered during SSU’s Excel for Youth program in the summer of 2012 and “rearrangable labyrinth building” will be taught at the Children’s Museum next spring after their official opening. Both of these remain potential Science is Creative Fair theme contests for current math and physics classes in which the winning designs could be built on site at the Children’s Museum.

During the Design Days, students were engaged as unique individuals, each with something to contribute from previously existing skills and each able to develop new ones. Projects also involved a massive amount of cooperation (science is not an individual pursuit!) and was observed to be an effective way to teach physics and math to student creators and the general public at the first annual Share Fair in downtown Santa Rosa. These are activities that can be integrated directly into current curricular units, with an established network of community support available to help ease the time and skill set requirements of teachers. This includes volunteers interested in assisting all facets (construction, permits, design) of potential “reclaim an urban space” projects as well as artists/mentors willing to work with students and teachers during a pilot Science is Creative Fair.
Through the Design Days experiments young adults were given opportunities to grow. Encouraged to consider new questions and new solutions while also thinking deeper about how their creations might be beneficial to their communities. Materials expenses were small, able to be defrayed solely by small drop-in fees during the Design Days and small donations at the door for the movie/interactive art evenings. The Share Exchange graciously allowed us to use their space for free.

As a whole, a Science is Creative Fair would also fit the truism that community-based projects are high bang for their buck, having the potential to connect otherwise disenfranchised students across the county to potential mentors without the need for a large amount of physical infrastructure or curriculum development, though initially a project coordinator and several lead artist/mentors would need to be compensated.

**Future Funding**

When approaching a new project, the Center for Ecoliteracy in Berkeley has a general tenet: One can help others prepare for change, share models and means and visions, but no program will be effective and sustainable long term unless there is a local understanding and desire for implementation.

The Bay Area is indeed a hotbed for innovative science education, home to the Maker and BAEER Fairs, the Exploratorium and the California Academy of Science, summer and after school programs throughout the community, and numerous charter schools in the Reggio Emilia, Waldorf, and Montessori traditions.

Many of these options invite students to explore technological innovations. Some offer ways for young people to learn about and consider the ways humankind interacts with the natural world. A few provide opportunities for teenagers to respond from their own creative
Community-based efforts have helped restore arts education to public schools in Alameda County. From these efforts, we learn that the potential exists for a project designed from the bottom up to both engage already present resources as well as to gather a new collection of community supporters in ways no one has yet tried on a significant scale: community-supported alternative research projects.

Organizationally, partnerships now exist locally with the Share Exchange, the Children’s Museum, the CHOPS teen club, SCOE, and local teachers providing A) known public entities through which to advertise future events, B) locations through which to host and award interdisciplinary projects, and C) partner applicants for large scale grant applications.

The remaining logistical barrier is the funding needed to coordinate these efforts. With some pieces of the support network already in place, a micro-scale grant might be enough to get an ad-hoc program going. However, in order to truly ensure long term sustainability and co-create all three proposed prongs (classroom ARP’s, supporting Science is Creative Fair, and service learning course to provide college student mentors), a development level grant would be needed. Judging from current shifts in science education reform funding (see Figure 7, page 16), this may actually be possible.

The current leading funder of Informal Science Education, the NSF, estimates it will award more than $28 million to similar projects in 2012. Preliminary proposals for the coming year begin in August. I’ll be working with the Children’s Museum, the Share Exchange, the Sonoma County Science Fair, local area high schools, the Center for Ecoliteracy, and the SSU Center for Community Engagement as potential advisers/partners. Soliciting budgets and
making a multi-year plan is now a logical and attainable extension. A rough outline for the three main phases is shown below.

- **Phase 1**
  - Pilot 20-30 ARP's with four public high schools
  - Support projects with help of artist-mentors
  - Present pilot projects at local businesses
  - Design college level service learning course

- **Phase 2**
  - Initiate Sonoma wide Science is Creative Fair
  - Teach "Intersections of Art and Science" service learning course
  - Move toward sustainability with college student mentors as facilitators

- **Phase 3**
  - Expand local Science is Creative Fair
  - Use pilot to design a model for other local programs around the country
  - Create a national "Science is Creative Fair" contest on-line

*Figure 35: Three phase grant proposal outline*
Reflections: How the Project Illuminates the Three Hutchins' Program Themes

Social Justice

A common challenge to social justice in any culture is the tendency for those in power to seek to limit the number of people involved in making decisions. Science and science policy suffer from this same tendency to exclusion. From a young age many of us become convinced we either are or are not science capable. Compassion and equity depend on a wide variety of citizens interacting and taking active and informed roles in community decisions.

From the beginning it was clear the homeschool teens had a wide variety of self perceived ability to “do science.” Most of the young men were self-identified geeks, building electronic circuits in their bedrooms and catapults in their backyards. Interestingly, and similar to the stereotypes of traditional school, most of the young women didn’t believe they were as ready to participate. A similar division of initial “perceived ability to participate” occurred during the Share Exchange evenings though not quite as gender segregated.

Figure 36: Fractal trees and Fibonacci sunflowers.

By providing a wide range of modalities through which to access participation (integrating the story board idea into the pegboard projects or the making nature art while teaching about fractals and Fibonacci numbers), those present learned to either adapt old skills
to new variations (like knitting into the making of giant leaf chains) or were emboldened by the experiential nature of the activities to try something new (power tools, mechanical construction, calculations). From my experience as a teacher, it is often this “courage to try” that can be lost quite young as we learn to be scared of showing signs that we are uncertain.

Figure 37: The joy of the teenagers (especially the young women) in being allowed to use power tools and have equal footing when it came to making decisions was apparent. The same was true for the younger kids when it came to having an equal share in the “continent creating” process during Earth Hour.

Another simple example of community building occurred during the Share Fair. On first attempts, many groups had difficulty navigating the labyrinth. Each quadrant was designed to be partially hidden, one “theater” area was even curtained so only one participant could see inside. Initially most groups communicated with directions such as “my right” or “my left”—unhelpful to four people all at 90 degree angles from each other!

The result was often one person taking over, tilting the board forcefully up and down in an attempt to overpower the other players (and unsettling a few of our more delicate features which had not experienced such roughness during play testing). The issue was alleviated almost universally when we encouraged groups to introduce themselves. Directions quickly became “toward Mark” and “toward Ann,” groups began to work together and the challenges became significantly easier.
With this discovery, some of the teens became even more ambitious in their role as designers, wondering in what other ways they could use structure to cause subtle shifts in player awareness. The idea to construct a “prisoner’s dilemma” style hole was suggested, where players could choose to work together (going a shorter route but requiring trust) or take a longer path on their own.

Similar to the experience of other teachers who have implemented arts-integration techniques, by learning to embrace the role of “designer,” creative types who previously felt shut out in science classes began to see themselves as not only capable, but worthy of societal participation.

Weeks after the Earth Hour event I ran into several SRJC students who had been in attendance, Hannah Bartee and Prahlad Papper. We had not met before that evening but quickly said a big hello. When I asked them in retrospect what the event meant to them, they both replied that while the creation process itself was interesting and cool, what stood out to them was the, “sense of instant community.” Entering a room transformed with buckets and tarps and a giant Earth on the floor, all these intergenerational people that had not known each other beforehand were “building together and laughing as if they were family.”
In the end, one could argue that all of these events were participant self selecting; people who come to Earth Hour events are likely predisposed toward community. It’s a good reminder for the potentially more diverse audiences of future endeavors, though after each Share Exchange event more than one person approached me afterward and stated that they weren’t usually the type to “get their hands dirty.” Change and social justice and connection to environment often begin with a reimagining. And sometimes, these are really just reawakenings of connections long held, innate to the human experience but lost track of in a world where we can push back night with the flip of a switch. Perhaps it is even more meaningful that all these “predisposed” people (myself included) were moved beyond what we thought we would be.
**Ecological issues**

Ecological awareness was present throughout the activities in several ways. First, the use of natural and recycled materials triggered people to think about how much we tend to discard items rather than find new uses. As Buckminster Fuller once said, “Pollution is nothing but resources we’re not harvesting. We allow them to disperse because we’ve been ignorant of their value.”

In the modern world we are constantly bombarded by symbols asking for our allegiance. There is a spiritual grounding, a remembering perhaps, that comes in working with the Earth. In the process of examining topographical maps many questions arose. Some I could answer: “Why doesn’t the north pole show up as a continent?” And others I couldn’t: “My ancestors came from around here. What mountains are those? What kinds of trees are these?” Questions like these are more often followed up on by the asker when they are self-generated. When students begin to go beyond the book for answers, what they are really doing is research, dipping into the pool of shared knowledge instead of looking only at the symbols directly before them.

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**ADBUSTERS, Feb. 2011**

Name these brands

![Brand Logos]

Name these plants

- Maple
- Ash
- Spruce
- Oak
- Aspen
- Russ's shirt

"A democratic civilization will save itself only if it makes the language of the image into a stimulus for critical reflection — not an invitation for hypnosis." Umberto Eco

Figure 40: Symbols. How many can you identify?
By creating art with the intention of leaving it around town (leaf animals and giant chains, wooden mobiles and tree branch fractals) the framework of the Rivers and Tides event involved a sort of anonymous visibility, a sense of invited curiosity in both maker and viewer. What will someone think when they come across this? Will a kid be excited to see a duck made of leaves floating by in the water? Who put this bird mobile here? How many walnuts can I roll down the bamboo ramp at one time?

American children today live in a world made of imported plastic, items often made by other children living in impoverished countries. The Share Exchange events became ways to not just celebrate the beauty of natural forms, but also to reconnect with the power of human ingenuity to imagine and invent with local and ubiquitous materials rather than the mass-produced imports of another.

"When I work with a leaf, rock, stick, it is not just that material in itself, it is an opening into the processes of life within and around it. When I leave, these processes continue."

-- Andrew Goldsworthy.

By reaffirming our connections to the planet during the evenings of nature art and helping us demonstrate what we’re capable of creating, we began to remember that we are an amazingly creative and adaptive species... when we let ourselves be.

*Change*

It can be pretty daunting being a young person in today’s world. Possessing the ability to modify sky and land and body, we continue to discover techno-ethical considerations our ancestors could not have imagined. “But what happens if I?” and “Should I just because I can?” both becoming very important questions. Or, as the great designer Charles Eames once put it, "Beyond the age of information, there is the age of choices."
During the initial Design Day the homeschool teens showed they were already well on their way. After a few easy challenges I began to place large obstacles in their paths forcing them to design ways to either exchange marbles or have a marble jump across a gap. In a traditional classroom, anything that did not conform to the parameters of the particular experiment would have been at best discouraged. (After all how would it be scored?) Using elements of my backyard I hadn’t expected, one group of homeschoolers attached ropes to the trees above and completely abandoned their earlier structure. A new zip had completely circumvented my best laid plans. They’d not only thought outside the box, they’d physically and metaphorically made the world itself into their classroom!

“If success or failure of this planet and of human beings depended on how I am and what I do...

HOW WOULD I BE? WHAT WOULD I DO?” -- R.Buckminster Fuller

Similarly, at the community nature art events many people found themselves moved not only by the illustrated connections between mathematics and natural phenomenon, but also by the opportunity to go beyond being observers or solely followers of another’s already well laid out plan.

An element of change discussed often in my cohort (especially in examining how the first world tends to give “aid” without first asking what is needed), and later echoed in my case study of the Center for Ecoliteracy, is the notion that in order for change to be effective and sustainable, the central driving force cannot come from outside a community. In the end, I believe this is why the pegboard prototypes were the most successful Design Days creations. The ideas were ones the teens and I came up with together. Paper mache and to some extent the final building of a mini-golf course petered out partially due to time, and partially because “building the structures as travelling educational tools” to be taken to traditional schools and
used to inspire math and physics classes to design their own, was much more my vision than that of the teens.

Many of our world’s most crucial challenges are predicated on how we practice, pursue, and share our science.

![The (Integrated Arts) Scientific Method](image)

**Figure 41: The non-linear integrated arts scientific method.**

In a rapidly changing time, art enables us to try on and create new value systems. As current resources (oil, fresh water, arable land) continue to diminish, these potential shifts in how we perceive wealth and community can help us understand what things we truly value, how to conserve and/or transition away from them, how to most equitably distribute what we have, and how best to use our current resources to provide for the future. At a young age we are more open to seeing the world in new ways. As we grow older we naturally, scientifically, begin to develop expectations. Change comes when we are able to see with fresh eyes: insight; shared knowledge; the desire to explore, prod, and kneed the uncertain; each of these is essential to shifting perspective and each is intimately wrapped up in the intersection between art and science.
On a personal level, preparing for the events was deeply meditative. In recent years I have not been good at slowing down and knowing a place. Gathering nuts and leaves and stones, those moments of collecting, of studying trees and getting to know the vegetative details of the city I live in was deeply rooting.

A few days after the Rivers and Tides event I set free on the Santa Rosa creek the leaf snake, extra leaves, and sawdust I'd collected from pre-cutting branches with my father near his home.

Figure 42: Leaf snake on the river and leaves thrown from the bridge.

"The real work is the change. The sea has taken the work and made more of it than I ever could have hoped." —Andrew Goldsworthy

The primary goal of this project has been to enable those involved to more readily see themselves as designers, to provide participants with avenues for empowered self expression, to model ways that they not only should, but also can be a part of the conversation of how best to steer our human ingenuity. And in so doing, become the “socio-scientific decision makers” of Project 2061.
Sustainable change involves bringing together a diverse collection of forces. It has to make sense fiscally, ethically, and socially. It has to work within the private sector, the educational framework, and the neighboring community. Finding this balance has been one of the main challenges of the project. Pursuit of this balance is also what has given it strength. The successes of each pathway have fed off the other: curricular explorations leading to community presentations, community presentations leading to more awareness, awareness leading to the support network needed to bring the full vision to life.

“We don’t accomplish anything in this world alone ... and whatever happens is the result of the whole tapestry of one’s life and all the weavings of individual threads from one to another that creates something.” -- Sandra Day O’Connor, former U.S. Supreme Court Justice
References


