CURRICULUM FUNDING PROJECT

Funding Agency:  *W. M. Keck Foundation: Southern California Program*

Funding Request:  $115,000 for 3 years.

Principal Investigator:  *Kevin D. McMahon (Science Teacher/Science Magnet)*

Co-Investigators:  *Karen Nicols (Art Teacher/Performing Arts Academy) & Don Moore (Literature & Drama Teacher/Performing Arts Academy)*

Project Name:  *Teaching Science in the Context of Classical Aesthetics*

Investigator Credentials:

- Kevin D. McMahon (Principal Investigator): BA Biology & Chemistry (California State University, Northridge), MS: Clinical Nutrition (University of California at Davis), MS: Science Education (California State University, Northridge)
- Karen Nicols (Co-Investigator): BA (California State University, Northridge)
- Don Moore (Co-Investigator): BA Theatre Arts (San Francisco State University).
PROBLEM STATEMENT

“You can recognize truth by its beauty and simplicity,” said Nobel Laureate, Richard Feynman (Augros & Stanciu, 1984 p. 39). It is in this relationship between truth and beauty that many scientists are beginning to recognize that aesthetics has the potential of playing a significant role in the Scientific Method. As Augros and Stanciu observed The New Story of Science, “All of the most eminent physicists of the twentieth century agree that beauty is the primary standard for scientific truth” (Augros & Stanciu, 1984 p. 39). However, it should be noted that when scientists speak of Beauty they are not informed by the Modernists subjective interpretation of aesthetics whereby “beauty is in the eye of he beholder.” Rather, as Arthur Miller observed, “So what makes [science] beautiful? For most art theorists and artists, beauty is subjective, but not for scientists. To scientists symmetry is beauty and therefore objective….” (Miller, 2006). Objective Beauty is inherent in the object perceived and is independent of the subject and hence is not subjective. Consequently, the Beautiful in science is not in the eye of the beholder, but is intrinsic to the object being beheld. Whether or not the Beauty is beheld is therefore a function of the acuity of the perception of the beholder. In this regard, aestheticians of science have more in common with Classical Aesthetics than Modern subjectivists conceptions of beauty.

This Classical view of aesthetics holds that there is an intimate relationship between the Beautiful, the True and the Good. As the philosopher/theologian, Hans Urs von Balthasar, observed, “… a being appears, it has an epiphany, in that it is beautiful and it gives itself, it delivers itself to us: it is good. And in giving itself up, it speaks itself, it unveils itself: it is true” (von Balthasar, 1993, p. 116). This epiphany of Beauty is an encounter with Mystery; as Albert Einstein observed, “The most beautiful experience we can have is the mysterious—the fundamental emotion which stands at the cradle of true art and true science” (Einstein, 1931). Mystery reminds us of the limits of our epistemologies while transfiguring our inquiry from an investigation of an object to an epiphany of the Other. This is a radical re-conceptualization of the Nature of Science.

The next generation of scientists may be more open to challenging the Baconian axiom of Science: Scientia est Potentia—Knowledge is Power; that the goal of science is the empowerment of man through the manipulation of nature. But, Beauty cannot be possessed, only safeguarded. And it is only with the utmost care and humility that we should ever consider
manipulating Her. Would we dare to complete Schubert’s Unfinished Symphony? What would happen if someone entered the National Gallery and attempted to finish Leonardo da Vinci’s uncompleted painting, “The Virgin and Child with St Anne and St John the Baptist”? Yet, scientists are pushing headlong into the manipulation of genomes—the material manifestation of Beauty’s *formal cause* as a Classical Aesthetician might characterize DNA. Do these scientists expect that genomic manipulations will produce organisms that will possess more unity, harmony, symmetry, and wholeness than they did formally? Will they be more radiant? Does any one care or think that these are questions worthy of asking? The Action Research Project I conducted, *Teaching Science in the Context of Classical Aesthetics*, suggests that a new generation of scientists may indeed be ready for a new, perhaps even radically new, approach to doing science.

During the course of a four-month study, AP Chemistry students from the Reseda High School Science Magnet received instruction in Classical Aesthetics and philosophy and its relationship to science. Although this instruction was minimal the findings of this study indicated that it had a significant effect on the students’ perception of science. One student stated, “It opened up science in a new way for me to incorporate philosophy and freedom of thought into the scientific field which I had previously considered really strict.” Here, we begin to see an openness to re-conceptualizing science; one willing to consider the value of incorporating aesthetically and philosophical ideas into what was formally believed to be “really strict.” And students recognized the value of learning science in the context of classical aesthetics and what a science informed by this perspective might look like, “I think students would have greater appreciation for science if they understood the beauty of it. Then, I think that would make them more motivated to learn science and do well in class.” They also began to perceive that a new, more modest, science might emerge from being informed by Beauty, “You get to appreciate the beauty within science and science is not all about trying to find an answer.”

What is science then, if it is not all about trying to find an answer? Perhaps it is more than taking Francis Bacon’s inquisitional stance to force nature to reveal her secrets:

“The secret workings of nature do not reveal themselves to one who simply contemplates the natural flow of events. It is when nature is tormented by art, when man interferes with nature, vexes nature, tries to make her do what he wants, not what she wants, that he begins to understand how she works and my hope to learn how to control her…. It is my intention to bind, and place at your command, nature....” (Francis Bacon as quoted by Comstock, 2000, p. 139)
Perhaps science, newly configured by Classical Aesthetics, will not approach Nature as an object to be vexed, tormented, and bound, but as the Other who simply asks of us to be open; as one student stated, “By giving Beauty a chance, I hope to be more open-minded.” And in this openness we may encounter Beauty’s mystery which may promote an even greater stimulus to learn, as observed by the student who said, “Mystery is beauty waiting to be unraveled. The secretive component to mystery is what influences us to gain to knowledge to that truth within mystery.” But as another student reflected, mystery is the antinomy of the knowable, Bacon postulated source of power, and as such mystery is its necessary balance: “Mystery is what keeps men honest. Mystery is a safeguard, the watcher of power, it is knowledge’s balance.” This is a science that I believe that the next generation is ready, even eager, to embrace.

A review of the literature demonstrates that there currently does not exist a curricular program that addresses the need of incorporating aesthetics in science instruction. During the course of my Action Research Program I had the opportunity to develop such a program, but I was only able to implement a fraction of this curriculum given the constraints of incorporating it in the context of an AP Chemistry class. This grant, which I believe is consistent with the vision of the W.M. Keck’s foundation’s vision of supporting programs “that push the edge of the field, present unconventional approaches to intransient problems, or challenge the prevailing paradigm,” would allow for the expansion and integration of this curriculum into the Reseda Science Magnet’s already successful cross-curricular instructional program.
ACTIVITIES

In spite of the fact that numerous scientists have endorsed the idea that beauty is an essential part of the Nature of Science, there has been virtually no attempt to incorporate aesthetics into the secondary science curriculum. There are, however, a couple of notable exceptions: the work of Mitchell Resnick and Mark Girod suggests that the benefits of aesthetics in the science classroom can be significant. In *Beyond Black Boxes: Bringing Transparency and Aesthetics Back to Scientific Investigation*, Resnick argues that the “instrument-building and aesthetic tradition of science have arguably been attenuated in recent years… (Resnick; Berg & Eisenberg, 2000, p. 8). Resnick developed a curriculum in which students (mostly 4th and 5th grade inner city children) built their own scientific instruments. The students were instructed to make their instruments beautiful, not just with decorations, but to incorporate aesthetics into their overall design and functionality. Resnick reported that students demonstrated pride in their creations, greater motivation to learn science, and better understanding of the methods of science including its limitations. Mark Girod from the Department of Education at Western Oregon University conducted a study in which an aesthetical pedagogy was introduced to fourth grade students in their science instruction. He and his colleagues reported that interviews of students indicated a favorable response to the introduction of ideas of beauty in science. They discuss one of the students as follows:

“Bright and bubbly, Brieana’s learning typifies aesthetic understanding. “Most people think rocks are... just junk. Most people think rocks are all the same and not interesting. Most people don’t think about their stories” (Girod, 2002, p. 10).

Brieana’s choice of words “their stories” is evidence of an encounter not with an object but of the other—Beauty. If this can be experienced in rocks which according to our young aesthetician is viewed by many as “just junk” how much more so in a galaxy or a flagellum? What stories can they potentially tell our young people?

I received similar positive responses by my AP Chemistry students while conducting my Action Research Project, *Teaching Science in the Context of Classical Aesthetics* ([http://www.kevindmcmahon.com/scienceaesthetics/thesis/thesis.html](http://www.kevindmcmahon.com/scienceaesthetics/thesis/thesis.html)). This project began to introduce students to the philosophy of aesthetics, but because of time restraints we were only able to complete one-third of the curriculum. Nevertheless, 88% of the students who participated in the study said they
believe the instruction was beneficial and a similar percentage of students stated they gained knowledge that was useful to their understanding of science and nature (http://www.kevindmcmahon.com/scienceaesthetics/scienceaesthetics.html). I am proposing an expansion of this curriculum to support an entire year long science course, Science and Aesthetics, which I believe will demonstrate that the paradigm shift discussed in the Introduction is possible, perhaps even inevitable, when students are allowed to do science in the context of aesthetics.

The Grant will support a three-year study. The first year will be dedicated to the expansion of the curriculum that I developed for use in my Action Research Project. The curriculum is introduced with a discussion of the Nature of Science. There is considerable misunderstanding among students and teachers regarding the nature of science both in its strengths and limitations (McComas, 1998). Misconceptions such as the reduction of science to scientism is due in part to a lack of instruction in both the nature of science and philosophy (McComas, 1998; St. Pierre, 2006). Furthermore, there are myths regarding the nature of science that scientists and science teacher willingly or unwillingly perpetuate. These myths include: (1) that science is identifiable with method, (2) that method is the criteria of truth, (3) that good science can only be practiced when it functions autonomously, that is, independent of other epistemologies and authoritative social institutions, (4) that science is right, (5) that science is the best and consequently the only way that Nature should be discussed within the Public Square, and (6) that the methodological assumption of material causes necessitates ontological materialism (http://www.kevindmcmahon.com/scienceaesthetics/philosophyscience/documents/positionpaper.html). Those who have incorporated these myths into their understanding of the nature of science will likely be resistant to the idea that there is anything that science can learn from such esoteric endeavors as philosophy and metaphysics. The lack of philosophical knowledge, and misconceptions and myths regarding the nature of science makes it difficult for both science educators and students of science to perceive the appropriate nexus of classical aesthetics and philosophy to science.

“Why Study Classical Aesthetics and Philosophy in Science?” (http://www.kevindmcmahon.com/scienceaesthetics/philosophyscience/documents/whyaesthetics/whyaesthetics.ppt.html) is a brief instructional unit that will follow the discussion of the Nature of Science. It will attempt to address some of the aforementioned obstacles in order to establish the legitimacy of teaching science in the context of classical aesthetics. The instruction will not be didactic, but will rather present students alternative points of views (often those of noted scientists) regarding the nature
of science. Students are expected to understand and reflect on the alternative perspectives of science presented.

Several years ago I had the opportunity to teach a Philosophy class for the Reseda High School Science Magnet. Although the class covered a broad spectrum of topics ranging from the philosophy of the Pre-Socratics to the Post-Modern Deconstructionists it was only natural that there was an emphasis on the history and philosophy of science both because of the context of being a Science Magnet class, but also because I am a science teacher. What I quickly discovered was that while students enter secondary school classes with previous knowledge in social studies, science, math, and language arts they have virtually no experience with either the vocabulary or the ideas of philosophy. To facilitate their acquisition and understanding of philosophical terms and ideas I began working on a concept map which I called, *A Model of the Human Atom*.

*A Model of the Human Atom* ([http://www.kevindmcmahon.com/scienceaesthetics/Human%20Atom/humanatom.html](http://www.kevindmcmahon.com/scienceaesthetics/Human%20Atom/humanatom.html)) has undergone a major revision for the purposes of the Action Research Project. The concept map was constructed so that the human nucleus is surrounded by three hexagonal orbitals: the Beautiful (Ontology), the True (Epistemology), and the Good (Ethics). The orbitals are
interconnected suggesting, as with classical philosophy, the interrelationship of the Transcendental. Each of the hexagonal orbitals has six suborbitals that contain a pair of antinomies (analogous to the fourth quantum number, \( m_s \), the spin quantum number which states that electrons that occupy the same orbital must spin in opposite directions).

Antinomies are ubiquitous in human experience: in philosophy they are evident as in the *coincedentia oppositorum* of Nicholas of Cusa, a philosopher of the Late Middle Ages, and the *binaries* of the post-modern deconstructionist, Jacques Derrida; in religion there is the *ying-yang* and *god-man*, and in science there is the *wave-particle duality of matter*. Philosophers, theologians, and an increasing number of scientists recognize that antinomies cannot not be resolved through reason alone; rather resolution may be achieved in a moment of *noetic apprehension*. Antinomies can provide students with opportunities to reflect *tacitly* so as to experience *noetic* moments with the True, the Good, and the Beautiful. Note that the *Nucleus* remains undefined in this model because it is highly personalistic in that it is shaped by the individual’s philosophy, faith, culture, and life-experiences.

It is anticipated that each instructional unit (antinomy) will require two weeks of instruction. In each case the principle investigator will provide the theoretical content and, in about a third of the units, will oversee the implementation of Group and Individual Activities that are associated with the unit. The Co-Investigators will use their expertise (art/literature & poetry/drama) to help implement the activities that correspond to the other units. The first year of the Program will be spent completing the curriculum, and developing the Group and Independent Activities associated with each Antinomy, as well as the various assessment tools to be used throughout the course of the study.

The Project will employ student surveys as the primary assessment tool. An Initial Survey will be completed by each student to assess his or hers knowledge and attitude regarding the nature of being—Beauty (ontology), how we know and criteria of truth (epistemology), and how we are to behave (ethics). At the conclusion of the course each student will complete the same survey again so that a comparison can be made regarding the development of the students’ attitude and knowledge before and after instruction.

At the beginning of each instructional unit (antinomy) the students will be presented with a prompt which may include a poem, quote, an excerpt from literature, a video and/or sound file. Students will then be given an antinomy specific survey. The survey will ask them to reflect on
the prompt and to respond to several questions related to topics that will be addressed by the antinomy. Over the course of the two-week instructional period we will examine the particular antinomy through explicit instruction, and Group and Independent Activities. At the end of instruction the students will complete the same antinomy specific survey.

At the end of each semester the student will compose a Free Response survey in which they will respond to the query: “Was learning science in the context of classical aesthetics a valuable experience? Why?” Over the course of the year each student will complete two Pre/Post Instructional Surveys, 18 Pre/Post Antinomy Surveys, and two Free-Response Surveys. This course will be offered during the second year of the Program. The class will be an elective course and students will be drawn from two of the five small learning communities at Reseda High School: the Reseda Science Magnet, and the Fine and Performing Arts Academy. The principle investigator, Kevin McMahon, teaches science for the Science Magnet, while Karen Nichols and Don Moore teach art and literature and drama, respectively for the Fine and Performing Arts Academy. It is anticipated that the blending of both instructors and students will facilitate the contextualization of science and aesthetics.

It is during the third year of the study that all the assessment tools (surveys) will be analyzed. It is expected that a paper will be generated and submitted for publication during this time. In addition to journal publication, it is anticipated that the results will be published on the web and submitted to the NSTA for presentation at the National and/or Regional Conference(s). If the findings indicate that the students have demonstrated a positive response to this instruction will growing in knowledge of the relationship between science and aesthetics then the curriculum will be aligned to the State Standards and then submitted to the Office of Curriculum Development at the Los Angeles Unified School District for course approval. If the course is approved as an elective course then the course will be perpetuated without the need for outside funding.
## Timeline & Budget

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity</th>
<th>Expenses</th>
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<tbody>
<tr>
<td>1</td>
<td>Curriculum planning &amp; design</td>
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<td></td>
<td>• weekly meetings of the principle &amp; co-investigators</td>
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<tr>
<td></td>
<td>• preparation/purchase of instructional materials</td>
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<td></td>
<td>• establishment &amp; maintenance of website</td>
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<tr>
<td>2</td>
<td>Instruction</td>
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<td></td>
<td>• Principle Investigator</td>
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<td></td>
<td>• Co-Investigators</td>
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<td>• collaboration time</td>
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<td></td>
<td>• field trips</td>
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<td></td>
<td>• guest speakers (stipend)</td>
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<td>3</td>
<td>Assessment, Distribution &amp; Continuation</td>
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<tr>
<td></td>
<td>• collaboration time (assessment)</td>
<td>$10,000</td>
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<tr>
<td></td>
<td>• preparation of materials for distribution (web/journal)</td>
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<td></td>
<td>• presentation of results (NSTA)</td>
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<td></td>
<td>• preparation and submission of grants for continuation</td>
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<td></td>
<td>• LAUSD: Michael Butler (independent assessor and auditor)</td>
<td>$7,500</td>
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<td>• LAUSD:</td>
<td>$10,500</td>
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<td></td>
<td><strong>Total =</strong></td>
<td><strong>$115,000</strong></td>
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### Explanations:

1. Based on 1 hour/wk (36 weeks) meeting between the three investigators (hourly salary $75).

2. Cover the cost of time and materials for the Group/Independent activities and assessments to be used throughout the course. Some of the materials will be hands on such for the making of scientific instruments, or stage props for play productions (ex: Galileo Inquisition Trial), and art supplies.

3. The website will support both student instruction as well as distribution of the investigation’s results. Budget includes purchase of web hosting, and compensation for investigator(s) responsible for website maintenance.

4. The amount allocated in the budget compensates the principle investigator for the instruction of one class period five days a week for the entire school year. It also compensates for the other duties that he will perform that do not fall under the categories listed in the budget such as time conferencing with parents, setting up field trips, and coordinating the program with the co-investigators.

5. The amount allocated in the budget compensates the co-investigators for the instruction of one class period two days a week for the entire school year.
6. The amount budgeted for this item is calculated according to the formula discussed in #1. The purpose of this collaboration is to allow time for interdisciplinary networking, discussion of coordination of activities, and to discuss student progress.

7. The amount allocated will cover the cost of transportation to and from various venues including museums, science centers, performing arts centers and other miscellaneous expenses incurred as a result of field trips. It is anticipated that there will be three field trips per semester.

8. The amount allocated will cover the cost of a small stipend provided to members of both the scientific and artistic community of Los Angeles to speak to student and to give their insights into the relationship of science and aesthetics.

9. The amount budgeted for this item is calculated according to the formula discussed in #1. The purpose of this collaboration time is to assess the data that had been collected during the course of the year and prepare the report for the Grantor and to the LAUSD.

10. The amount budgeted for preparation is to cover the cost of the materials need to produce the “hard copy” report as well as the web report.

11. It is anticipated that the results of this investigation will be presented at NSTA and the NSEAD (National Society for Education in Art and Design). The amount allocated in the budget is to cover the expenses of transportation, housing, and meals.

12. The amount allocated in the budget is to compensate the principle investigator for the time and money spent preparing grants for the continuance of the program and the possible expansion to other school sites.

13. An independent auditor assesses and evaluates the use of all grant money distributed to employees of LAUSD. The amount budget compensates the auditor for this assessment.
RESUME

Kevin D. McMahon (Principal Investigator):

Kevin McMahon received his Bachelors degree in Biology and Chemistry from California State University, Northridge in 1977. He graduated from the University of California at Davis in 1979 with a Masters degree in Clinical Nutrition. After five years working as a private sector nutritionist he changed his profession and became a science teacher for the Los Angeles Unified School District. He has been a science teacher for 23 year and has taught both middle and senior high school and virtually every type of science offered. He currently teaches AP Biology and AP Chemistry, Honors Chemistry, and Chemistry at the Reseda Science Magnet in Reseda, California. He has also been the Varsity girls and boys Tennis Coach and has taught Philosophy as an elective course for Reseda High School. He received in Masters in Science Education from California State University, Northridge. His thesis, *Teaching Science in the Context of Classical Aesthetics*, serves as the basis of this grant proposal.

He is married to Jan McMahon, a Registered Nurse and Doctor of Naturopathy. She works as a post-partum nurse and has a private practice for the holistic treatment of women’s health issues. His daughter, Megan, is an English teacher who also is his colleague at the Reseda Science Magnet. She graduated *summa cum laude* from Cal State University, Northridge. His younger daughter, Breanna, is a student at Reseda Science Magnet and plans to major in business. Mr. McMahon attends Saint Nicholas Greek Orthodox Church in Northridge. He is the author of two books, *Garments of Skin*, and *Daughter of Abraham*. 
REFERENCES


