Professional Society Support for Scientists in the K-12 Classroom

The Geneticist-Educator Network of Alliances (GENA) Project

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Background

Content Issues: The National Assessment of Educational Progress (NAEP) reveals a disturbingly large percentage of 12th-grade students who are deficient in their understanding of many biological concepts, including genetics (O'Sullivan *et al.*, 2003; Table 1). Moreover, a two-year study by The American Society of Human Genetics (ASHG) identified widespread student misconceptions about genetics as revealed in essays submitted to ASHG's annual National DNA Day Essay Contest (*Genetics* **178**: 1157, 2008; Figure 1). The National Science Foundation and others believe that a broader learning community, including outreach by university scientists, could improve learning.

TABLE 1

NAEP test results in 2000 for science reveal a deficit in student understanding of core genetics concepts (O'Sullivan *et al.* 2003)

Theme	Grade	Students with complete/essential answers (%)	Students with partial answer (%)	Students with unsatisfactory answer (%)
Classification	8	23	16	58
Theory of evolution	8	53	NA	45
Reproduction	12	61	NA	39
Evolutionary relationships	12	25	NA	70
Darwin's theory of evolution	12	53	NA	47
Genes*	12	21	45	30
Mutation*	12	2	33	58
Interpreting genetic material*	12	1	1	83
Genetic disease*	12	5	31	56
Recombinant DNA usage*	12	8	27	59

Percentages may not total to 100 due to rounding and student omission (i.e., no answer was given).
*These questions are in the molecular and human genetics category.

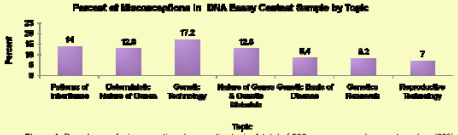


Figure 1. Prevalence of misconceptions by genetics topic. A total of 500 essays were chosen at random (20% of total submitted) and were systematically reviewed for misconceptions. Frequently observed topics of misconceptions were identified and essays were catalogued on the basis of the type(s) of misconception(s) they revealed.

Incentives: Colleges and universities tend not to value faculty participation in activities that do not yield published papers and grants. A three-year study by the University of Maryland, Change and Sustainability in Higher Education (CASHE), examined the effect of Math Science Partnership (MSP) programs on institutions of higher education (IHEs) with regard to curriculum, faculty engagement, and sustainable change. Among their findings:

➢ Promotion systems at IHEs do not reward faculty participation in K-12 education.

➢ Dean-level involvement is crucial to the success and sustainability of STEM faculty participation in schools.

In response, the ASHG and the National Science Resources Center (NSRC) are using genetics education to build a national framework of long-term collaborations between high school educators and scientists at IHEs and to support participating faculty in their efforts to achieve tenure and promotion. This project, the **Geneticist-Educator Network of Alliances** (**GENA**, grant #0634296), was established with support from the Math Science Partnership program at the NSF.

Overview and Description of GENA

Since the project began in late 2006, the GENA project has supported the development of 70 alliance partnerships (a geneticist paired with a high school biology teacher) throughout the United States and Canada. There were 13 alliances who participated in the first cohort (2007), 37 in the second cohort (2008), and 20 in the third cohort (2009).

Table 2. Timeline for each cohort

Spring	Geneticist Application: Geneticists are selected based on pedagogical and content knowledge as well as commitment to outreach. Educator Application: Teachers are selected based on pedagogical and content knowledge as well as proximity to partner geneticist.
Summer	Geneticist and their teacher partner attend a three-day summer workshop that concentrates on inquiry, misconceptions in genetics, and curriculum development. Partners begin to work in an area of genetics that they would like to alter in their curriculum. Each alliance submits a planning worksheet at the end of the workshop.
Fall	Alliances continue to work together to develop draft lesson plans for submission to ASHG. ASHG staff review and critique the lesson plans and share their comments on MSPnet; alliances revise their plans before implementation.
Spring of next year	Alliances implement their lesson plans in the classroom and assess effectiveness. A revised lesson plan and a one-page summary of the experience are submitted to ASHG as a final report. The final reports are posted on MSPnet and are linked to the ASHG Web site.

Goals of the GENA Project

1.Build partnerships between faculty in IHEs and high schools to develop and implement lesson plans to improve genetics education in high school biology;

2.Provide an infrastructure that supports geneticists' educational work in school classrooms as a worthwhile professional activity;

3.Demonstrate that ASHG can leverage its members and leaders to become more committed to K-12 STEM education; and

4.Explore whether and how ASHG, as a scientific professional society, can influence higher education's view of faculty engagement with K-12 education.

The Successes of the GENA Project

External evaluators from The Study Group Inc. assessed the impact of the three-year GENA project on GENA participants and on ASHG using documentary, survey, and interview data techniques. Programmatic success was defined where a majority effect was observed.

All 13 Cohort I alliances completed their assignments to develop, implement, and evaluate a learning plan, and 28 of 37 alliances (76%) received GENA certification by the end of the 2008-2009 school year. More than three-fourths of the Cohorts I and II participants described their partnerships as highly or moderately effective.

A.Impact of the GENA experience on teachers

Type of Impact	Number (%) of Cohort I teachers who applied impact to themselves	Number (%) of Cohort II teachers who applied impact to themselves
Strengthened level of confidence in teaching patterns of inheritance	9 (82%)	18 (53%)
Became more skillful in identifying and providing appropriate instruction to counter students' misconceptions	9 (82%)	26 (77%)
Targeted student misconceptions more explicitly when developing lesson plans	11 (100%)	26 (74%)
Used inquiry-based instruction more effectively	9 (82%)	18 (51%)
Used inquiry-based instruction more often	4 (36%)	22 (63%)
Used scientists and their expertise more frequently	7 (64%)	17 (49%)

B. Impact of the GENA experience on geneticists

Impact on Teaching Practice

Most GENA geneticists reported being able to apply what they have learned from the experience of teaching high school students to their own teaching and are more confident in making presentations to non-scientific audiences.

Impact on Teaching Practice	Number (%) of Cohort I geneticists who applied impact to themselves	Number (%) of Cohort II geneticists who applied impact to themselves
Became more skillful in identifying and providing appropriate instruction to counter students' misconceptions	10 (77%)	24 (92%)
Broadened repertoire of pedagogical approaches	10 (77%)	19 (73%)
Changed teaching style to be more inquiry-based	6 (46%)	14 (58%)

Impact on Commitment to Education Outreach

GENA was the first outreach experience for 10 of the 13 (77%) Cohort I geneticists. Most of the geneticists reported interest in participating in another education outreach program and believe that scientists have a role and responsibility in improving K-12 STEM education. Here are a few examples of the geneticists' comments:

• The value of education outreach is extremely high. As research increases, the gap for what makes one science literate grows. There should be pressure on the scientific community to do outreach…
• Education outreach should be part of an academic portfolio. It should not only be allowed but encouraged… It should just be the way that business is done in academia.

Impact on Commitment to Education Outreach	Number (%) of Cohort I geneticists who applied impact to themselves	Number (%) of Cohort II geneticists who applied impact to themselves
Broadened understanding of the rewards and challenges of teaching genetics at the high school level	11 (85%)	28 (93%)
Strengthened level of confidence in participating in education outreach	10 (77%)	17 (57%)
Will definitely (or probably) participate in another education outreach program in the near future	13 (100%)	30 (91%)
Encourage colleagues to participate in education outreach	9 (69%)	24 (77%)
Promote the use of education outreach as a qualification for granting tenure	8 (62%)	15 (48%)
Use of GENA participation when documenting performance for tenure	9 (69%)	24 (77%)

Impact on Recognition for Education Outreach Efforts

Some geneticists have taken steps to promote the value of education outreach in their own departments. Although most departments do not view education outreach as a valid criterion for tenure or promotion, there was some public recognition for those outreach efforts.

Impact on Recognition for Education Outreach Efforts	Number (%) of Cohort I geneticists who applied impact to themselves
More public recognition for those participating in education outreach	6 (46%)
More colleagues participating in education outreach	4 (31%)
More mention of education outreach at faculty or staff meeting	6 (46%)
Greater acceptance of education outreach being a valid criterion for tenure or promotion	4 (31%)
Building education outreach into proposals for external funding	4 (31%)

C. Impact of GENA on ASHG and other scientific societies

(a) The ASHG Board adopted a *Statement on the Importance of Participation of Scientists in K-12 Science Education*, which has influenced other scientific societies to adopt similar statements (e.g., American Society of Plant Biologists) or to consider them (e.g., The American Physiological Society, Society for Neuroscience, American Society of Microbiologists);

Statement on the Importance of Participation of Scientists in K-12 Science Education

The American Society of Human Genetics (ASHG) encourages administrators and leaders in institutions of higher education, including medical schools, to give appropriate credit to faculty who participate in formal outreach activities involving K-12 students and teachers. For example, during the appointment, tenure, and promotion process, participation in sustainable teaching activities and curriculum and materials development should be highly valued. Continued public support for genetics research and informed participation in an increasingly genetics-based healthcare system demand that consumers understand genetics and its importance in health and disease. ASHG will continue to leverage its expertise, in particular its membership, and provide leadership and organizational infrastructure to improve K-12 science education to achieve the goal of an informed public.

(b) ASHG leadership now writes letters to key administrators on behalf of geneticists to help them gain recognition for professional involvement in K-12 outreach (see Figure 2 for feedback);

Faculty #1: I received a hand written note of congratulations from the Dean of Faculty Affairs. There was an announcement by one of the education deans in the Education Committee Meeting. My division chief felt that the GENA participation would be considered evidence of participation at a national level in education.

Faculty #2: Thanx for the letter to my boss, he read parts of it at a faculty meeting I missed and now everyone is telling me what a hero I am!!! I had to quickly point out I wasn't but it got a lot of play here so that was cool.

Faculty #3: I received a very nice hand written note from my Dean, in response to the ASHG letter. I will save my Dean's note for my P&T package.

Figure 2. Letters written by ASHG helped increase recognition by department chairs and peers.

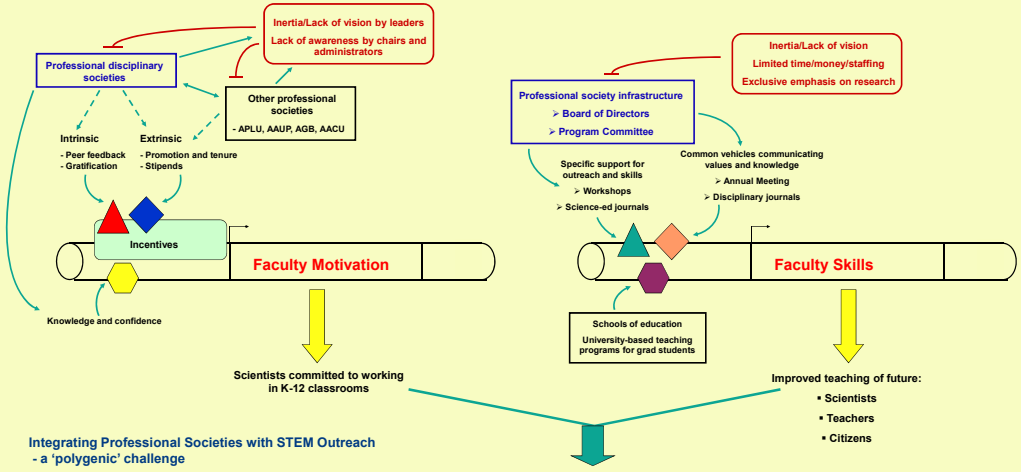
(c) A GENA-focused Invited Education Session (two-hour panel) was accepted by the ASHG Program Committee for ASHG's 2009 Annual Meeting in Hawaii;

(d) ASHG established a Genetics Education Research Grants Program, approved in April 2009 by the ASHG Board of Directors, which will distribute $10,000 annually for educational research;

(e) ASHG established a Summer Interns Program for undergraduate students interested in gaining experience in science education;

(f) Project staff organized two additional advisory meetings to explore how ASHG can help strengthen the higher education reward system to include K-12 outreach in the tenure and promotion process: the Benefits of Outreach to Higher Education (BOHE) meeting and the Workshops to Educate Regents and Trustees about Science Education (WERTSE); and

(g) GENA staff recruited 168 members of ASHG's Genetics Education Outreach Network (most of whom are academic scientists) to assist with the evaluation of K-12 state science standards.



Integrating Professional Societies with STEM Outreach - a 'polygenic' challenge

The GENA project and other MSPs have identified many factors that influence STEM learning and teaching. Professional societies can leverage their influence to positive effect in several areas, but the large number of variables and the complexity of relationships may limit success. Relationships can be visualized using a gene-interaction map, where green arrows represent activation, red 'blocking' lines represent inhibition, and colored geometric shapes represent factors that must be present for the motivation and skills 'genes' to be turned on. Dashed lines represent indirect or limited effects.

The Challenges of the GENA Project

➢ **Outreach and Tenure:** It is not clear that K-12 outreach experiences that are mediated by professional societies can significantly influence tenure/promotion decisions for scientists who participate. There is increased awareness in many departments that outreach is important and recognition for such work is slowly growing, but most Cohort I geneticists believe that GENA had no or will have no significant effect on their tenure/ promotion.

➢ **The T&P System:** In thinking about reach beyond its own members, ASHG asked whether professional societies should try to influence deans and department chairs in their interactions with the T&P system. A group of deans, scholars, and professional society representatives at GENA's BOHE meeting concluded that T&P processes are very "home-grown," and professional societies should not interfere. Instead, they should focus on providing services to their members that might indirectly benefit their careers (e.g., letters for dossiers). Such efforts will have a more limited impact but represent more achievable goals.

➢ **Systemic STEM Change:** At the WERTSE meeting, ASHG explored whether professional societies could help strengthen higher education's commitment to STEM education internally and externally (e.g., pre-service teacher prep, non-major courses, K-12 outreach). There was consensus that change might be possible if professional societies used their membership to influence academic leaders (e.g., governing boards, presidents) and business leaders, perhaps through workshops, white papers, and other resources. This type of effort is far outside the normal range of activities of most disciplinary professional societies.

The simplified diagram below models some of the interactions needed for success.

What Would We Like to Learn from Other MSPs?

➢ **Sustainability:** The involvement of scientists in professional society-mediated partnerships with high school teaching colleagues can yield many benefits. One potential barrier to wider adoption of similar, national-level programs is the fact that the workshops that initiate these relationships—by offering the professional development and building the rapport needed for partners to begin substantive collaboration—are quite expensive. *What business model can help sustain this type of partnership-building project when federal funding is exhausted?*

➢ **Dissemination:** The results of the GENA project suggest that a professional society can be fundamentally changed by its involvement in an MSP and can help support its members to become engaged in long-term outreach partnerships. However, the ASHG, as the first professional society to host an MSP, may have been atypically motivated to embrace change. Other than serving as an example of what is possible, *what can ASHG do—recognizing that there are limited resources and competing interests at all scientific membership societies—to encourage the adoption of similar programs by other societies? Indeed, is it reasonable to assume that a GENA-type model is exportable? If so, what are the strategies and tactics that are likely to be most successful?*

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