Education Strategy Roadmap

Executive Summary

The education working group is one of nine working groups in the GP-write organization. It is responsible for producing educational programs and materials that engage K-12 students and adult lifelong learners in the science behind GP-write. The group's vision is that people should have a respect for the applications of DNA science, be aware that it is embedded in almost every aspect of our daily lives, and realize that GP-write is part of this exciting area of scientific progress. To achieve this, we are proposing to develop curricula and other educational tools that can be scaled and widely disseminated, are accessible to a wide spectrum of schools, and contain both accurate science and incorporate ethical discussions around DNA technology.

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I. Education Working Group

i. Purpose

The education working group is one of nine working groups in the GP-write organization. It is responsible for producing educational programs and materials that engage K-12 students and adult lifelong learners in the science behind GP-write.

ii. Vision & Goal

We want everyone to familiar with the uses and concepts of DNA science and have access to accurate scientific information about it. Ideally, people should have a respect for the applications of DNA science, be aware that it is embedded in almost every aspect of our daily lives, and realize that GP-write is part of this exciting area of scientific progress. We also feel that the nature and scope of the GP-write project demands that it be accompanied by ethical discussions.

The overall goal of the Education team is *to engage students of all ages in the science and ethics of GP-write and encourage familiarity with the the program and its potential impact on society*.

The Education roadmap is intended to describe the methodology, action steps, resources, and metrics that will be needed to accomplished this goal. The strategy and aims of the Education working group will be closely aligned with the broader strategy of the overall GP-write project, as well as the Center of Excellence for Engineering Biology.

iii. Current Membership and Roles

Nancy Kelley - *Executive Committee Representative* - Nancy J Kelly + Associates
Amy Schwartz - Center for Excellence in Biology
Ellen Jorgensen, Ph.D. - *Education Committee Chair* - Biotech Without Borders
Jeanne Garbarino - Rockefeller University Outreach
Christine Marizzi - DNA Learning Center at Cold Spring Harbor Laboratory

II. Education Framework

i. Guiding principles

The Education working group will operate by the following principles:

- Scientific accuracy

- Access to learning for all
- Societal context and ethics embedded in all educational materials
- Engage with the aim of increasing diversity in students pursuing science
- Leverage existing educational materials to complement our efforts

ii. Key Areas

GP-write incorporates a portfolio of new and exciting technologies, and stimulates ethical discussions around genome synthesis. Key areas that educational programming would cover are:

- GP-write rests on years of development of reading and writing DNA code. Therefore our efforts should include education around the basic concepts of DNA science and genetic engineering with the goal that everyone have a basic understanding and appreciation of DNA-based science and its potential to benefit humanity and the planet.
- Educational programs should introduce GP-write and explain how it differs from previous efforts in that it is a massive undertaking - a grand challenge similar to the decoding of the human genome. Included in this is the idea of international cooperation of scientists to build a genome from scratch for the first time.
- GP-write is a wonderful way to introduce the concepts of bioethics in to the classroom and prepare future citizens to participate in the shepherding of this technology for the good of humankind.

iii. Current State of DNA Science Education

Currently, DNA science is taught at the high school level (e.g. as part of the Living Environment curriculum in NYS). Surveys show, however, that the average adult in the United States has a minimal grasp of the concepts critical to understanding of how DNA functions and therefore may not have an appreciation of why an effort such as GP-write is valuable. Our first efforts will be aimed at high school-level students, since lessons incorporating GP-write key areas can be added on to existing curricula. These lessons will also be adapted to adult student informal science learning venues such as community labs.

Several excellent programs that provide educational units in DNA science for high schools, museums and informal learning centers already exist, and we will build upon these. A partial list includes the DNA Learning Center activities (Cold Spring Harbor Laboratory), BioBuilder kits, Bio-Rad Life Science Education modules, classes and workshops at community labs (e.g. Genspace, Biotech without Borders, the Baltimore Underground Science Space), Ward's AP Biology kits, MiniPCR kits, and the How to Grow Almost Anything course from Fab Academy.

The high school teachers most likely to engage their students at this level are those who 1) are highly motivated and feel that an understanding of DNA science is critical and 2) have the school budget to buy the equipment and kits necessary to do the activities. They are most likely to be elite educators such as private school science teachers or the Math for America Master Teachers who have shown commitment to bringing cutting-edge science into their classrooms. The extent to which the vast majority of teachers engage in teaching beyond standard required science curricula depends mainly on how accessible the lessons are (price, ease of use) and

whether or not the school and environment are supportive (e.g. allowing teaching periods of sufficient length).

Learning in community labs, museums and other informal education spaces is driven by the attractiveness and timeliness of the content to the learner, and also by cost factors. Examples of these types of programs include the Boston Museum of Science's Building with Biology kit of museum activities around synthetic biology, and Genspace community lab's long-running Biotech Crash Course.

III. Methodology

The Education group will employ the following methodology to guide its activities:
1. Identification of opportunities in formal and informal education settings
2. Identification of partners
3. Proposal development, including evaluation metrics
4. Detailed budgeting
5. Securing funding
6. Implementation

i. Identification of opportunities in formal and informal educational settings

The Education group will hold regularly brainstorming meetings to consider new avenues and methods for education in DNA science and GP-write technologies. We will liaise with GP-write scientists to identify areas of the project that could potentially be the basis for education modules and/or programs. The ethics group will also be consulted as part of the process. We will also actively seek out funding opportunities in bioscience education and outreach.

ii. Proposal development

The Education group will produce age-appropriate, educationally sound and scientifically accurate content to support learning in the areas of science and bioethics underlying the GP-write project. In order to ensure widespread adoption, content should be consistent with existing learning objectives in the geographic region of proposed deployment (e.g. Next Generation Science Standards). We will work closely with GP-write scientists to ensure accuracy and generate new ideas for programming areas.

iii. Identification of partners

Within the committee we have several potential partners for creation and dissemination of educational materials, and we will seek out more within the network of science education providers. These may include schools, museums, informal learning centers,

professional associations, biotech companies, publishers of educational materials, etc. Letters of support will be requested from these partners to accompany proposals.

iv. Detailed budgeting

Budgets will be incorporated into all grants or other development efforts focused on education. Timing of projects will be determined by the success of fundraising efforts and the budgetary constraints of the funded proposals in place at that time.

v. Securing funding

The education committee will spearhead the effort to submit proposals for funding. Funding will go through the Center for Excellence and/or other institutions.

vi. Implementation

Funded programs will be managed and implemented by the staff designated in the funded proposals. Programs will be constructed to include the potential to scale widely, and will generally commence in several stages, each with successively more students or extended programming hours. Feedback from educators will be collected after each stage and used to refine the prototype curriculum activities. Evaluation metrics will be built into all proposals and used to inform decisions around further efforts.

IV. Core Activities

i. Proposal development

The working group will be responsible for facilitating proposal development around educational programs incorporating the science and bioethics of GP-write suitable for K-12 and adult learner audiences in a format usable by a broad spectrum of educators in different environments. Members with liaise with other GP-write groups to support these efforts. Proposals will identify the resources needed to carry out the specified programming. Members of the Education group may act as principal investigators, coordinators, or play other roles in the implementation of the programming.

ii. Grantwriting

The Education working group will help identify funding opportunities in the education space and support grantwriting efforts.

iii. Outreach and potential partnerships

The committee will cultivate relationships with other organizations whose education goals are consistent with ours. Collaborations with like-minded groups has the potential to amplify our educational efforts.

iv. Educational materials

The Education group will aid in the production of educational content for distribution In schools, museums and other venues. In collaboration with the Communication working group, they may produce content such as infographics, short prose, or educational videos to explain key concepts in synthetic biology and genome synthesis. The ultimate goal of producing these materials is to equip learners with the base of knowledge to be able to engage with the advances coming from GP-write.

v. Sharing of resources

Key resources should be kept accessible, and expanded and updated as project develop. Access to these resources should be widely publicized among working groups, and resources from the other working groups should be periodically solicited.

VI. Education Timeline

Five Year Plan

Year One
Our initial efforts will focus on leveraging current resources to create modular programming. We will generate curricula to be used by high school teachers that would complement and expand their current genetics/genomics/DNA lessons. The goal for Year One would be submission, funding, and the initiation of the creation of at least three modules around GP-write topics. A suite of materials will be produced which might include online and printed resources, podcasts, etc. A version of these would be made available at no cost to educators, ensuring accessibility for all schools regardless of science budge, through the creation of web-accessible curricular suites that include low- or no-cost in-class activities and supporting media. The RockEDU website could potentially be the hosting space for these materials, and will have clearly marked authorship for all materials generated. Please note that the Education group is quite small, and some of the activities listed as longer term goals could be developed simultaneously if staffing permits.

Years Two-Five

Programming developed in Year One would be expanded and more widely disseminated in Year Two. In subsequent years additional types of programming would be created, including expansion into K-6 and higher education students. Other mechanisms such as contests, scholarships and events would be explored. Widespread adoption of GP-write educational programming internationally would be facilitated.

Year One Milestones:

1) Identification of potential funding sources, draft proposal, including identification of partners and budgeting.

   Responsibility: Ellen Jorgensen with advice & support from other committee members.

   Resources Needed:
   160h (one month) of time for primary responsible person, with additional person-hours contributed by other committee members as needed in an advisory capacity.

2) Proposal submission.

   Responsibility: Ellen Jorgensen with support from other committee members.
   Resources Needed:
   30h of time, any submission fees

3) Commencement of proposed activities:

   Module creation & prototyping at the local level
   Module testing/gather feedback
   Module refinement

   Responsibility: TBD
   Resources Needed: Year One proposal will have an overall budget of approximately $300,000.

Year Two Milestones:

Refined module version tested by wider range of students & teachers
Evaluation & final version released

Initiate creation of new modules to expand to K-6 level

Year Three Milestones:

Adoption of high school modules at the national level.

Complete K-6 modules (steps as for HS modules)

Initiate development of competitions, scholarships and events.

Year Four Milestones:

Refine competitions, scholarships, events
Initiate creation of museum outreach programming.

Year Five Milestones:

Expansion of programming internationally