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Supplement 1. Genomics Education Partnership Classroom Undergraduate Research Experiences: Post-course Survey

*The entire post-course survey is included here. It is identical to the pre-course survey with the inclusion of the SURE Statements in **orange text.** Responses to the 20 SURE Statements were used in the comparison between SURE responses of GEP students with high and low TOSRA scores (shown in **Figure** 3). These 20 scores were averaged for each respondent to obtain an outcome score called "mean benefits." Statements in **green text** correspond to the positive perceptions of science survey, while statements in **purple text** correspond to the negative perceptions of science survey. Statements in **red text** correspond to the Grit survey. Statements highlighted in blue correspond to the TOSRA Enjoyment of Science survey. Statements highlighted in yellow correspond to the TOSRA Interest in Science Beyond the Classroom survey. Statements highlighted in pink correspond to the TOSRA Career Interest in Science survey.*

Welcome (or welcome back) to the GEP-CURE survey site. You are being invited to participate in a research study. This project is a collaborative effort involving faculty and students from several colleges and universities participating in the GEP. The purpose of this research is to learn more about how our science courses can empower student learning. To accomplish this task. we have developed a pre-course / post-course research design to measure learning gains and other outcomes of taking a research-oriented science laboratory course including genomics. This study is funded by the National Science Foundation. You probably filled out a pre-course survey at the beginning of the term. If you agree to participate, we will ask that you complete a post-course survey at this time. You may elect not to answer individual questions. A "not applicable" or "N/A" option is available for the questions as an alternative; use this if the question is irrelevant or if you choose not to answer.

Because of the complexity of tracking the data from many courses in many institutions, we asked you to identify yourself by giving your name (as it appears on your driver's license), to identify your college, and to identify your course. The computer used your name to generate an encrypted number sent with your responses. The encryption is done in such a way that it is not possible to convert from the number back to your name, to ensure anonymity. Now the reason for this identification becomes clear: we will match your pre- course information with your post-course evaluation using your personal identification number. This alignment of your pre-course responses with your post-course responses permits a sensitive measure of change. Your individual responses cannot be revealed to your course instructor. The lead analyst for the project, Prof. David Lopatto of Grinnell College, will keep all individual data sets confidential. Only aggregate pre-course / post- course data will be reported back to your institution and to the GEP administration. Your answers cannot affect your grade in the course, and in fact cannot be identified by anyone, as only the encrypted tag is entered into the data system.

We will keep the information you provide confidential. However, federal regulatory agencies and Washington University, including the Washington University Institutional Review Board (a

committee that reviews and approves research studies) may inspect and copy records pertaining to this research.

There are no known risks from being in this study, and you will not benefit personally. However we hope that others may benefit in the future from what we learn as a result of this study.

Taking part in this research study is completely voluntary. If you decide not to be in this study, or if you stop participating at any time, you won't be penalized or lose any benefits for which you otherwise qualify. If you change your mind about completing the survey, just leave the site. In a final box, we offer you an opportunity to be entered into a raffle for a $50 gift certificate from Amazon.com, as a "thank you" for your participation. Five email addresses will be selected at random in June, at the end of the academic year. If you wish to be entered in the raffle, we will need your email address to contact you if you win. Please be assured that the file containing these email addresses will be completely separate from the file of survey responses; this list of email addresses will not be used for any other purpose.

If you have any questions about the research study, please contact Dr. Elgin selgin@wustl.edu. If you feel that you have been harmed in any way by your participation in this study, please contact: selgin@wustl.edu. If you have questions about the rights of research participants, please contact the Human Research Protection Office, 660 S. Euclid Ave., Campus Box 8089, St. Louis, MO 63110, 1-(800)-438-0445 or email hrpo@wusm.wustl.edu. To offer input about your experiences as a research participant or to speak to someone other than the research staff, call the Human Research Protection Office at the number above.

Thank you very much for your consideration.

Part I: Some general information about you.
Please type in your personal identification (your name as it appears on your driver's license or student ID), identify your school, and type in your pertinent course name and number. Your personal identification will be used to generate a code number that will be used only to match pre-course information to post-course information. Only the code number will be sent to the GEP servers.
Personal identification code: (**Your name as it appears on your driver's license**)

Community College, College or University: [drop-down menu]

What is your anticipated year of graduation? If attending a community college, indicate your anticipated year of receiving an associate's degree and/or transferring to a 4-yr school.

2016 2017 2018 2019 2020 Not Applicable

What is your age?

- 17 yrs or younger
- 18 yrs or older

Your gender:

- Male
- Female
- N/A

Are you eligible to receive Pell Grant support?

Yes No N/A

Are you the first in your family to attend college/university?

Yes No N/A

Your race/ethnicity: (check all that apply)

- White
- Asian (including Filipino)
- Black/Afro-American (not of Hispanic origin)
- Hispanic or Latino (including persons of Mexican, Puerto Rican, Cuban, and Central or South American origin)
- American Indian or Alaskan Native
- Native Hawaiian or Other Pacific Islander
- Other
- N/A

Your GEP-affiliated course (department and number, title): [text box]

Is this your first time working on a GEP project?

Yes No N/A

For community college students: please indicate whether your goals include future work in the sciences:

- My goal is to obtain a job in the sciences
- My goal is to obtain a job in a non-scientific field
- My goal is to transfer to a four-year school, majoring in the sciences
- My goal is to transfer to a four-year school, majoring in a non-scientific field
- N/A or none of the above

For four-year school students: Have you declared a major or concentration yet?

Yes No N/A

For four-year school students: If you have declared a major or concentration, please indicate the field:

- Life sciences (biology, biochemistry, neurobiology, or similar)
- Environmental studies or similar
- Physical sciences (physics, chemistry, E&P, math, or similar)
- Computer Science

- Engineering (other than computer science)
- Social sciences
- Humanities
- A double major including a science major
- A double major not including a science major
- Other
- N/A

For all: If you have not yet declared a major or concentration, please indicate if you are considering a major/concentration in the sciences, either at your present school or after you transfer:

- Definitely yes
- It is likely
- I'm not sure
- It is unlikely
- Definitely no
- Prefer not to answer (N/A)

Part II: Course Benefits

Below are some possible gains you may have made as a result of taking this course. The scale measuring your gain is from 1 (no or very small gain) to 5 (very large gain). Select the number that reflects your experience in this course. If the item is not relevant or you prefer not to answer, please choose the "not applicable" option.

Course Benefits
(1=no gain or very small gain, 2=small gain, 3=moderate gain, 4=large gain, 5=very large gain, 6=Not Applicable)

- **Understanding of the research process in this field**
- **Understanding how knowledge is constructed in this field**
- **Readiness for more demanding research**
- **Tolerance for obstacles faced in the research process**
- **Skill in interpretation of results**
- **Clarification of my career path**
- **Ability to integrate theory and practice**
- **Understanding how scientists work on real problems**
- **Understanding that scientific assertions require supporting evidence**
- **Ability to analyze data and other information**
- **Ability to read and understand primary literature**
- **Understanding science**
- **Learning ethical conduct in this field**
- **Learning laboratory skills**
- Learning computer skills
- **Skill in how to give an effective oral presentation**
- Skill in reasoning from data

- Self-confidence in discussing science with peers
- Self-confidence in discussing science with mentors/instructors
- **Skill in scientific writing**
- **Understanding how scientists think**
- **Learning to work independently**
- Learning to work as part of a team
- **Becoming part of a learning community**
- Interest in taking other courses in this area
- Interest in taking additional courses in math and computer science
- **Confidence in my potential to be a teacher of science**

Learning Experiences

Overall Evaluation

For each item below please rate your own agreement with the item.

(Options: Strongly agree, Agree, Neutral, Disagree, Strongly Disagree, Not Applicable)

Evaluation

- This course was a good way of learning about the subject matter.
- This course was a good way of learning about the process of scientific research.
- This course had a positive effect on my interest in science.
- I was able to ask questions in this class and get helpful responses.
- I would take another research-oriented lab course if given the opportunity
- I expect to use these tools/techniques in future research
- Genomics is awesome! I love the power of data bases!
- Taking this course helped me to become a more active learner.
- Taking this course has helped me learn to think independently.
- Taking this course has increased my motivation to learn.
- I would recommend this course to a friend
- Knowing that my results will be part of a public database used by other students and scientists motivated me to do a careful and through job.
- Analyzing data is challenging; it doesn't matter to me whether I am working on my own project or analyzing a paper generated by other scientists.
- Having an opportunity to be a co-author on a scientific paper is important to me.
- I loved the fact that this project was for real! I've done enough cookbook labs in my life, I'm ready to move on to the real thing.

Part III: Your opinions about yourself and about science.

It has become common to say that no student is an empty bucket, waiting for a teacher to pour in knowledge. Research on learning acknowledges that students approach a course with well-formed opinions of themselves and of the subject matter. In this section we present questions about science and questions about you. These will help us put your learning in context. For each item below, please rate your agreement with the statement.

Opinions (Response options: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree, Not Applicable)

- **Even if I forget the facts, I'll still be able to use the thinking skills I learn in science.**
- You can rely on scientific results to be true and correct.
- **The process of writing in science is helpful for understanding scientific ideas.**
- When scientific results conflict with my personal experience, I follow my experience in making choices.
- Students who do not major/concentrate in science should not have to take science courses.
- **I wish science instructors would just tell us what we need to know so we can learn it.**
- **Creativity does not play a role in science.**
- **Science is not connected to non-science fields such as history, literature, economics, or art.**
- When experts disagree on a science question, it's because they don't know all the facts yet.
- **I get personal satisfaction when I solve a scientific problem by figuring it out myself.**
- Since nothing in science is known for certain, all theories are equally valid.
- **Science is essentially an accumulation of facts, rules, and formulas.**
- **I can do well in science courses.**
- Real scientists don't follow the scientific method in a straight line.
- **There is too much emphasis in science classes on figuring things out for yourself.**
- Only scientific experts are qualified to make judgments on scientific issues.
- Scientists know what the results of their experiments will be before they start.
- **Explaining science ideas to others has helped me understand the ideas better.**
- The main job of the instructor is to structure the work so that we can learn it ourselves.
- Scientists play with statistics to support their own ideas.
- Lab experiments are used to confirm information studied in science class.
- **If an experiment shows that something doesn't work, the experiment was a failure.**
- I faced challenges that I managed to overcome in completing my GEP research project.
- The findings of my GEP research project gave me a sense of personal achievement.
- In conducting my GEP research project, I actively sought advice and assistance.
- My GEP research project was interesting.

Please respond to the following 12 items; be honest – there are no right or wrong answers!

- **I have overcome setbacks to conquer an important challenge.**
- **New ideas and projects sometimes distract me from previous ones**
- **My interests change from year to year.**
- **Setbacks don't discourage me.**
- **I have been obsessed with a certain idea or project for a short time but later lost interest.**
- **I am a hard worker.**
- **I often set a goal but later choose to pursue a different one.**
- **I have difficulty maintaining my focus on projects that take more than a few months**

to complete.
- **I finish whatever I begin.**
- **I have achieved a goal that took years of work.**
- **I become interested in new pursuits every few months.**
- **I am diligent.**

These statements explore your reactions to science classes; please consider classes you have had in the last few years (response choices: Strongly agree, agree, neutral, disagree, strongly disagree, N/A).

- Sciences courses are fun.
- I would dislike a job in a science laboratory.
- I do or would like to belong to a science-related club or a campus / national group.
- I get bored watching science programs on TV or the Internet.
- I do or would like to do science experiments – be involved in a research project – beyond what we do in class.
- Working in a science laboratory would be an interesting way to earn a living.
- I dislike science courses
- I am planning to seek a job in science, genomics, medicine or engineering.
- I dislike reading books and online articles about science in my leisure time.
- Schools should have more science course options.
- Science courses bore me.
- Science is one of the most interesting subjects.
- I would like to be given a science book or a piece of scientific equipment as a present.
- I would dislike being a scientist.
- I would like to work with people who make discoveries in science.
- A career in science would be dull and boring.
- I am planning to attend graduate school in science, genomics, medicine or engineering.

Impact on Future Plans; How were your plans for future education impacted by participating in a course including genomics? (Choose one)

- I had a plan for post-BA education in the life sciences, and this has not changed.
- I had a plan for post-BA education in the life sciences, and this plan has been confirmed.
- My plan for post-BA education will now include a greater emphasis on genomics.
- I had a plan for post-BA education in the life sciences, and I have now decided to drop this because of this course
- I had a plan for post-BA education in the life sciences, and I have now decided to drop this for other reasons.
- I did not have a plan for post-BA education in the life sciences, and I have now decided to develop such a plan.
- I do not have a plan for post-BA education in the life sciences.

Please comment on the effort made to integrate research and teaching in genomics in this course. What were the strengths and weaknesses? What was of special value to you? Should this effort be continued? [text box]

Thank you for your assistance! If you would like to enter the raffle for an Amazon.com gift card, please check the box below.

Supplement 2. Modifications of the Original TOSRA Questions

Background on the TOSRA

In the GEP assessment of student attitudes we employed three scales derived from the TOSRA (Test of Science-Related Attitudes; Fraser, 1981). The table below shows our modification of the wording to update the items (e.g., we use "internet") or customize them by adding "genomics". Colors correspond to questions on the pre-course and post-course survey (**Supplement 1**).

TOSRA item	GEP survey item
Enjoyment of Science Lessons	
• Sciences courses are fun • I dislike science courses • School should have more science lessons each week • Science lessons bore me • Science is one of the most interesting school subjects	• Sciences courses are fun • I dislike science courses • Schools should have more science course options • Science courses bore me • Science is one of the most interesting subjects
Interest in Science Beyond the Classroom	
• I do or would like to belong to a science club • I get bored watching science programs on TV • I would like to be given a science book or a piece of scientific equipment as a present • I dislike reading books about science in my leisure time • I do or would like to do science experiments at home	• I do or would like to belong to a science-related club or a campus / national group • I get bored watching science programs on TV or the Internet • I would like to be given a science book or a piece of scientific equipment as a present • I dislike reading books and online articles about science in my leisure time • I do or would like to do science experiments – be involved in a research project – beyond what we do in class
Career Interest in Science	
• I would dislike being a scientist • I would like to work with people who make discoveries in science • I would dislike a job in a science laboratory • Working in a science laboratory would be an interesting way to earn a living • A career in science would be dull and boring • I would like to be a scientist when I leave school	• I would dislike being a scientist • I would like to work with people who make discoveries in science • I would dislike a job in a science laboratory • Working in a science laboratory would be an interesting way to earn a living • A career in science would be dull and boring • I am planning to seek a job in science, genomics, medicine or engineering • I am planning to attend graduate school in science, genomics, medicine or engineering

Supplemental Table 1. Student demographics: Pre-course survey, 2015-2017
This table shows the information provided by the 2115 participants who completely filled out the demographic information.

Gender	N	Percent of total responses
Male	798	37.7%
Female	1297	61.3%
N/A or no answer	20	1.0%
Eligible to Receive Pell Support		
Yes	881	41.6%
No	42	2.0%
N/A or no answer	1192	56.4%
First in Family to Attend College		
Yes	484	22.9%
No	105	5.0%
N/A or no answer	1526	72.1%
Ethnicity		
White	1011	47.8%
Asian	199	9.4%
African American	406	19.2%
Hispanic	285	13.5%
American Indian	20	0.9%
Hawaiian	6	0.3%
Other (mixed)	160	7.6%
N/A or no answer	28	1.3%

Supplemental Table 2. Numbers of student surveys and quizzes collected

Percentages are in reference to the pool of eligible student respondents, estimated to be 3,300. Sample sizes indicate the number of quizzes submitted or the number of surveys submitted that include responses to the measure indicated. All measures other than the knowledge quiz were administered as part of the pre/post surveys. The "learning gains" measure is based on the SURE survey of gains in the understanding of science and preparation to engage in science practices. The "complete sample" includes only those students who submitted all four instruments (pre/post quizzes and pre/post surveys), including responses to the measures indicated.

Measure	Pre-course sample	Post-course sample	Complete sample
Knowledge quiz	1903 (58%)	1272 (38%)	704 (21%)
Grit	1450 (44%)	1222 (37%)	915 (28%)
TOSRA interest	2037 (62%)	1307 (40%)	711 (22%)
TOSRA enjoyment	2032 (62%)	1317 (40%)	708 (21%)
TOSRA career interest	2014 (61%)	1295 (39%)	696 (21%)
Learning gains (post only)	---	1094 (33%)	---

Supplemental Table 3. Descriptive Statistics of the Outcome Measures

Outcome Measure	Mean	Median	Skew
Post-Course Quiz	9.7	10.0	-0.035*
Post-Course Survey	3.60	3.67	-0.4*

*Conventional wisdom is that a skew of less than 0.5 (or -0.5) is acceptable normality. In addition, for all the ANOVAs presented in the figure captions, Levene's test of homogeneity (Levene, 1960) of variance is nonsignificant, meaning that there is homogeneity of variance across the comparison groups.

Levene, H. (1960). In Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling, I. Olkin et al. eds., Stanford University Press, pp. 278-292.

Supplemental Table 4. Summary of Spearman Rank-Order Correlations Between Student Outcome Measures and Student Interest

These are bivariate correlations (not partial correlations). ns = non-significant.

	Post-course quiz score	Average self-reported benefits
Pre-Course		
Positive Perceptions	0.20	0.27
Negative Perceptions	-0.33	ns
TOSRA Enjoyment	0.22	0.17
TOSRA Interest	0.16	0.24
TOSRA Career	0.15	0.20
Grit	ns	0.19
Post-Course		
Positive Perceptions	0.31	0.29
Negative Perceptions	-0.38	ns
TOSRA Enjoyment	0.25	0.15
TOSRA Interest	0.26	0.25
TOSRA Career	0.24	0.18
Grit	ns	0.19