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Personal DNA Testing in College Classrooms: Perspectives of Students and Professors

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Discourse on the integration of personal genetics and genomics into classrooms is increasing; however, limited data have been collected on the perspectives of students and professors. We conducted a cross-sectional survey of undergraduate and graduate students as well as professors at two major universities to assess attitudes regarding the use of personal DNA testing and other personalized activities in college classrooms. Students indicated that they were more likely to enroll (60.2%) in a genetics course if it offered personal DNA testing; undergraduate students were more likely than graduate students to enroll if personal DNA testing was offered ($p = 0.029$). Students who majored in the physical sciences were less likely to enroll than students in the biological or social sciences ($p = 0.019$). Students also indicated that when course material is personalized, the course is more interesting (94.6%) and the material is easier to learn (87.3%). Professors agreed that adding a personalized element increases student interest, participation, and learning (86.0%, 82.6%, and 72.6%, respectively). The results of this study indicate that, overall, students and professors had a favorable view of the integration of personalized information, including personal DNA testing, into classroom activities, and students welcomed more opportunities to participate in personalized activities.

Introduction

The decreasing cost and increasing accessibility of personal genetics/genomics make it feasible to integrate participatory genetics experiences into the classroom (Tyler *et al.*, 1995; Rogers and Taylor, 2011). Accordingly, a growing number of high schools, colleges, and universities across the United States are offering DNA experiments or testing in coursework as a pedagogical tool for creating an "experiential learning" environment (Moore and Barnett, 1992; Mascarenhas, 1994; Maradiegue *et al.*, 2005; Hark, 2008; Garrett and Triman, 2009).

Data on attitudes about DNA testing in the classroom have been limited to medical and graduate students (Moore and Barnett, 1992; Maragiegue *et al.*, 2005; Thurston *et al.*, 2007; Garrett and Triman, 2009; Metcalf *et al.*, 2010; Ormond *et al.*, 2011; Walt *et al.*, 2011). With the integration of personal DNA testing into coursework now occurring at a variety of levels (e.g., the undergraduate curricula at U.C. Berkeley, Penn State University, and University of Rhode Island; the graduate curriculum at Stanford University; the medical curricula at the University of Pennsylvania, Harvard University, and Tufts University; and the nursing curriculum at Duke University) (Korf, 2002; Puts and Shriver, 2011; Salari *et al.*, 2011; Shriver, 2011; Walt *et al.*, 2011; Baker, 2012; Callier, 2012), it is appropriate to expand dialog and investigations concerning the benefits, risks, challenges, and perspectives.

The most high-profile attempt to integrate DNA testing into a college setting occurred at U.C. Berkeley (DeVore, 2010; Ipaktchian, 2010; Jabr, 2010; Lewin, 2010; Rogers and Taylor, 2011). Its "Bring your Genes to Cal" program provided incoming undergraduate freshman and transfer students with the opportunity to submit their DNA for genetic analysis (DeVore, 2010; Ipaktchian, 2010; Jabr, 2010; Lewin, 2010). Samples were tested for polymorphisms associated with alcohol, lactose, and folate metabolism (DeVore, 2010; Ipaktchian, 2010; Rogers and Taylor, 2011). Initially, the program planned to return individual results to students; however, public criticism prompted the California Department of Public Health to insist that all DNA tests be ordered by physicians and analyzed by certified laboratories as required for medical testing (DeVore, 2010; Ipaktchian, 2010; Jabr, 2010; Katsnelson, 2010). In response, U.C. Berkeley opted to return only aggregate data on the participating students (DeVore, 2010; Jabr, 2010; Katsnelson, 2010; Rogers and Taylor, 2011).

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Teaching genetics in the classroom has become more important as personal genomics has increased in availability and utility (Childs *et al.*, 1981; Bowling *et al.*, 2007; Redfield, 2012). However, we are far from achieving high rates of genetic literacy. In 2011 the American Society of Human Genetics found that high school students received inadequate genetics education in 43 of 50 states and that adequate genetics education was provided in only North Carolina, Tennessee, Illinois, Michigan, Kansas, and Washington (Dougherty *et al.*, 2011). Innovative approaches to education may improve student and public understanding and awareness of the applications of genetic and genomic technologies (Childs *et al.*, 1981; Mascarenhas, 1994; McInerney, 1995; Shmaefsky, 1998; Hott *et al.*, 2002; Wood, 2009). The integration of personalized DNA testing into the classroom may increase student awareness of the ethical, legal, social, and scientific implications of DNA testing and the information alone may have value to students, but additional research is needed to confirm this and to better understand the perspectives of various stakeholders. The purpose of this study was to assess the attitudes of students and professors regarding the use of personal DNA testing in college classrooms and how personal DNA testing compares to other personalized classroom activities.

Materials and Methods

Recruitment

We e-mailed the administrative assistants and professors of 27 departments at Duke University and Penn State University inviting participation in our study. They were asked to complete (professors only) or forward the appropriate questionnaires to students and professors included on departmental and class listservs. Additionally, flyers were placed in professors' mailboxes and e-mails were sent to graduate and undergraduate student organization representatives at Duke requesting distribution of the student questionnaire to their listservs. Student participation was also solicited in-person at both universities. Recruitment occurred in late fall 2010 and early spring 2011.

Questionnaire

Separate questionnaires were administered to students and professors. Both questionnaires consisted of multiple choice, open response, and five-point Likert scale (e.g., strongly disagree, disagree, neutral, agree, strongly agree) questions. The questionnaires were constructed to assess respondents' beliefs, attitudes, and knowledge about different classroom activities, including those utilizing personal information. Both questionnaires contained four main categories of questions: (1) demographic information; (2) perspectives on various classroom activities; (3) perceived benefits and risks of personalized classroom activities; and (4) experiences with personal DNA testing in the classroom. Questionnaires were administered using Survey Monkey (Palo Alto, CA).

Data analysis

Data analysis was completed using R-2.15.1 (2012). To evaluate the association of any two categorical variables, a Fisher's exact test for independence was performed. To evaluate the relationship between a continuous variable (e.g., age and sex) with a categorical variable, one of two tests was performed: the Kruskal–Wallis test or the Wilcoxon test. The latter was used for professors' responses, as it is better suited for small sample sizes. A logistic regression model was used to analyze whether or not a student would take a genetics course with a personalized component against the following variables: university, sex, age, race/ethnicity, classification (e.g., graduate or undergraduate), number of genetics courses, and major. A multinomial logistic model was used to analyze students' opinions on the U.C. Berkeley freshman DNA testing program against major and number of genetics courses taken. Lastly, an ordered logistic model was used to analyze professors' levels of familiarity with the U.C. Berkeley freshman program against their academic disciplines and familiarity with genetics.

Results

Demographics

Survey responses were collected from 237 students—100 (42.2%) affiliated with Penn State and 137 (57.8%) with Duke. The majority of the students were female (70%), and the mean age reported was 21.3 years. Most of the students were undergraduates (84.5%) and had completed at least one genetics course (57.8%) (Table 1).

One hundred five ($n=105$) professors completed the survey: 81 (77.1%) affiliated with Penn State, 23 (21.9%) with Duke, and 1 not reporting an affiliation. Just over half of the professors were female (51.4%), and the mean age reported was 43.4 years. Roughly three-quarters (77.1%) of professors taught undergraduate courses, and 45.7% indicated non-tenure track professor status (Table 1).

Enrolling in a course with a personal DNA testing component

A majority (60.2%) of student respondents were more likely to enroll in a genetics course if it offered personal DNA testing to students. Undergraduate students were more likely than graduate students to enroll in a course if personal DNA testing was offered ($p=0.029$). Students who had taken a genetics course were also more likely to enroll than students who had taken no genetics courses ($p=0.042$). Furthermore, students who majored in the physical sciences were less likely to enroll than students in the biological or social sciences ($p=0.019$).

Most (66.9%) students responded that they distinguish personal DNA testing from other kinds of testing (e.g., fitness, physiology, and cognitive); however, the proportion of students who would enroll in a genetics class with a personalized component (as opposed to one without) is statistically equivalent to the percentage of students who would enroll in an accounting or psychology course with a personalized component. A significantly larger proportion of students would enroll in a sociology course without the personal component as opposed to a genetics course without a personalized component ($p=0.037$) (Table 2).

Personalization of classroom activities

As presented in Table 3, most students (91.4%) indicated that they would be "moderately" or "very excited" if a course presented an opportunity to learn something about themselves. Students overwhelmingly indicated that courses are more interesting when a professor personalizes the course

Table 1. Student and Professor Characteristics

Demographics	*Students*, % (n)	*Professors*, % (n)
University affiliation		
Duke	57.8 (137)	21.9 (23)
Penn State	42.2 (100)	77.1 (81)
NA	0	1 (1)
Classification[a]		
Undergraduate	84.8 (201)	77.1 (81)
Graduate	13.9 (33)	22.9 (24)
NA	1.3 (3)	0
Sex		
Male	29.5 (70)	46.7 (49)
Female	70.0 (166)	51.4 (54)
Other	0.4 (1)	1.9 (2)
Race/ethnic group		
White, European, or European American	63.3 (150)	92.4 (97)
Black, African, or African American	3.4 (8)	1 (1)
South Asian	4.6 (11)	3.8 (4)
Other	28.7 (68)	2.9 (3)
Genetics courses taken as a student		NA
0	41.3 (98)	
1	26.2 (62)	
2	18.1 (43)	
3 or more	13.5 (32)	
NA	0.8 (2)	
Familiarity with genetics	NA	
Very		27.6 (29)
Somewhat		53.3 (56)
Not at all		17.1 (18)
NA		1.9 (2)
Courses taken with personalized DNA testing		NA
Yes	12.7 (30)	
No	76.8 (182)	
NA	10.5 (25)	
Courses taught with personalized DNA testing	NA	
Yes		2.9 (3)
No		73.3 (77)
NA		23.8 (25)

[a]For professors this indicates the level of courses that they primarily taught.
NA, not applicable.

material (94.6% of responses) and that it is easier to learn when course material is personalized (87.3% of responses). Penn State students were more likely than Duke students to report that they found it easier to learn when course material is personalized ($p<0.01$). Students who identified as white, European, or European American were more likely than other students to report that they found it easier to learn when a course is personalized ($p=0.005$). Biological science majors were more likely than physical or social science majors to report finding courses with a personalized component more interesting ($p<0.05$).

Most students indicated they were "not" or only "slightly" concerned that their instructor (56.4%) or classmates (75.5%) might treat them differently if they refuse to participate in a classroom activity using personal information, that they might experience mental or emotional harms (67.3%), or that they might learn something surprising (81.3%) or traumatic (67.3%) about themselves in a course using personal information.

Almost 50% (49.5%) of professors had incorporated opportunities for students to learn something about themselves; 62.9% had incorporated a hands-on activity. Most instructors agreed that adding a personalized element to a course increases student interest, participation, and learning (86.0%, 82.3%, and 72.6%, respectively).

Participation in optional classroom activities

Most students (66.3%) indicated that whether classmates could know if they participated in an optional activity would "not change" the likelihood of their participation (Table 3). However, a sex-biased response was observed. More males indicated they would be more likely to participate if classmates knew whether they had participated ($p<0.05$), while more females indicated they would be less likely to participate if classmates knew whether they had participated ($p<0.05$). Duke students were less likely to participate if classmates would know who refused to participate in the activity ($p<0.05$). Younger students were less likely to participate if they did not know anyone participating ($p=0.007$) and undergraduates were more likely to participate if friends were also participating ($p=0.019$). However, having a friend participate would not affect the participation of older ($p=0.017$) or graduate ($p=0.019$) students.

Sharing of results from personalized classroom activities

As indicated in Table 3, Duke students were more likely than Penn State students to report that they would participate if personal information or results were shared with the entire class only in the aggregate ($p<0.05$). Interest in participation was more likely to decrease among social and physical science majors and to increase among biological science majors in the same situation ($p<0.05$). Duke students as well as female students were less likely to participate if personal information or results were to be shared with classmates as both aggregate

Table 2. Student Interest in Enrolling in Courses with a Personalized Component

	Genetics, % (n)	*Accounting*, % (n)	*Physiology*, % (n)	*Psychology*, % (n)	*Sociology*, % (n)	*Statistics*, % (n)
With personal component	43.9 (90)	52.7 (108)	28.3 (58)	43.9 (90)	26.8 (55)	28.3 (58)
Without personal component	56.1 (115)	47.3 (97)	71.7 (147)	56.1 (115)	73.2 (150)	71.7 (147)
p-Value[a]		0.342	0.062	1.000	0.037	0.062

[a]Fisher's exact test comparing proportions for genetics with proportions for other courses.

Table 3. Student Perspectives on Classroom Activities

Is it easier to learn the subject when the professor personalizes the course material to you?

	Yes, % (n)	*No, % (n)*
University		
Duke	82 (98/120)	18 (22/120)
Penn State	95 (88/93)	5 (5/93)
	p-Value[a]	0.006
Race/Ethnicity		
White, European, European American	93 (124/134)	7 (10/134)
Other	78 (62/79)	22 (17/79)
	p-Value[a]	0.005

When you are asked to participate in an optional classroom activity, how would the following affect the likelihood of your participation

If your classmates will know if you participate?

	Decrease, % (n)	*Would not change, % (n)*	*Increase, % (n)*
Sex			
Female	22 (34/153)	71 (108/153)	7 (11/153)
Male	23 (14/61)	56 (34/61)	21 (13/61)
	p-Value[a]	0.014	

If your classmates will know if you refuse to participate?

	Decrease, % (n)	*Would not change, % (n)*	*Increase, % (n)*
University			
Duke	40 (48/121)	42 (51/121)	18 (22/121)
Penn State	27 (25/93)	61 (57/93)	12 (11/93)
	p-Value[a]	0.022	
Number of genetics courses taken			
None	36 (31/87)	51 (44/87)	14 (12/87)
1	20 (12/60)	68 (41/60)	12 (7/60)
2	46 (19/41)	32 (13/41)	22 (9/41)
More than 2	42 (11/26)	39 (10/26)	19 (5/26)
	p-Value[a]	0.014	

If you are friends with others who are participating?

	Decrease	*Would not change*	*Increase*
	median (n)	*median* (n)	*median* (n)
Age	20 (7)	21 (48)	20 (159)
	p-Value[b]	0.017	
Classification	% (n)	% (n)	% (n)
Graduate	4 (1/28)	43 (12/28)	54 (15/28)
Undergraduate	3 (6/184)	19 (35/184)	78 (143/184)
	p-Value[a]	0.019	

(*continued*)

Table 3. (Continued)

If your personal information is shared with the class only in the aggregate?

	Decrease, % (n)	*Would not change, % (n)*	*Increase, % (n)*
University			
Duke	9 (11/120)	48 (57/120)	43 (52/120)
Penn State	15 (14/93)	58 (54/93)	27 (25/93)
	p-Value[a]	0.039	
Major			
Biological Science	8 (6/80)	42 (34/80)	50 (40/80)
Physical Science	14 (5/36)	56 (20/36)	31 (11/36)
Social Science	14 (13/96)	59 (57/96)	27 (26/96)
	p-Value[a]	0.028	

If your personal information is shared with the class in the aggregate but also with data that identifies you?

	Decrease, % (n)	*Would not change, % (n)*	*Increase, % (n)*
University			
Duke	74 (88/119)	22 (26/119)	4 (5/119)
Penn State	57 (53/93)	38 (35/93)	5 (5/93)
	p-Value[a]	0.028	
Sex			
Female	72 (110/152)	26 (39/152)	2 (3/152)
Male	52 (31/60)	37 (22/60)	12 (7/60)
	p-Value[a]	0.002	

[a]Fisher's exact test.
[b]Kruskal Wallis test.

and personally identifiable data ($p < 0.05$). Additionally, undergraduates were less likely to participate if personal information or results were to be used in a different instructor's research ($p < 0.05$).

Most (40%) professors shared students' personal information with the entire class but only in an aggregate form where only the instructor and the student knew the personal results or information. Only five professors indicated that they had ever shared personal results or information with the student's classmates in the aggregate form as well as data identifiable to the particular student.

Perspectives on U.C. Berkeley freshman testing program

The majority of students (75.9%) were unfamiliar with the debates surrounding the U.C. Berkeley's freshman DNA testing proposal. As might be expected, the greater the number of genetics courses a student had taken, the more familiar he/she was with the story ($p = 0.011$). Significantly more biological science major respondents had a positive opinion (i.e., selected response, "This project is awesome. The students are so lucky to have early access to this technology") of the debate than physical or social science majors ($p = 0.039$). Most professors were unfamiliar with the U.C.

Berkeley testing program; however, as with the students, professors who were more familiar with genetics were also more familiar with the story ($p = 0.042$).

Discussion

To our knowledge, the present study is the first quantitative assessment of undergraduate student and professor attitudes and experiences with classroom activities that incorporate a personalized genetic element.* The findings of this study indicate that students and professors believe that the integration of personalized information, including personal DNA testing opportunities, into classroom activities may increase student interest and ease of learning. Students were more likely to enroll in a course if it included a personalized component generally.

Perspectives on classroom activities

Overall, students had a favorable view of the integration of personalized information into classroom activities. However, Penn State students were more likely than Duke students to report that it is easier to learn when course material is personalized. Clump and Skogsberg (2003) have shown that the learning styles of students who attend academically similar schools in different geographical regions differ significantly. The specific reasons for the difference in beliefs among students at Duke and Penn State regarding personalized instruction and learning are unclear. It is possible that school size may play a role (Penn State has a much larger student enrollment than Duke); however, further research is needed to determine this and to identify other contributing factors.

Female students were less likely than male students to report that they would participate in a classroom activity if classmates knew whether they participated and if personal information or results were to be shared as personally identifiable data. These results seem to be consistent with findings from Fassinger (1995) showing that males are more likely to participate in classroom activities than females and that female participation is affected by the characteristics of the classroom (e.g., emotional climate and size) as well as their confidence. Instructors should be aware of these potential sex differences in crafting classroom activities. The finding that younger and undergraduate students were more likely than older and graduate students to participate because of the participation of friends or someone they knew possibly reflects the greater susceptibility of younger individuals to peer pressure.

Students who identified as white, European, or European American were more likely than other students to report that they found it easier to learn when a course is personalized. This seems consistent with research suggesting that "racial" and cultural differences affect learning style (Matthews, 1994; Joy and Kolb, 2009). For example, Matthews (1994) found that whites preferred applied styles of learning (i.e., by making theories operational and/or with hands-on experiences), while African Americans learned more conceptually (i.e., with language-oriented experiences and/or with people) in mathematics and science. We note that such generalized findings must be interpreted with caution, given the challenges with "racial"/ethnic categorization as well as the inevitable variation within any of these groups.

In general, students were most excited when presented with hands-on activities that provided an opportunity to learn something about themselves. Research has consistently shown that active learning increases student interest and is positively correlated with student learning (Gal and Klein, 2000; Campbell, 2002; Kwiek *et al.*, 2007; Hark, 2008; Wood, 2009; Metcalf *et al.*, 2010). Furthermore, national and state education guidelines advocate the use of hands-on activities connected to topics to which students can personally relate (Horsma, 1999; Wood, 2009). Courses with a personalized component were more interesting to students in the biological sciences. This might be a function of greater exposure of students in the biological sciences to hands-on activities and knowledge that facilitate a personal connection to the material. Offering a course as two different sections—one with a personalized element and one without—is a possible means of responding to diverse preferences among students from different majors.

In addition to finding the prospect of using new cutting-edge technology exciting, the majority of our student respondents indicated that they would enroll in a genetics course that uses personal DNA information. This is consistent with previous studies at the graduate level showing that students had a significant interest in genotyping their own DNA to satisfy personal curiosity (Ormond *et al.*, 2011). Our results show that undergraduates were not concerned about whether or not their peers would know if they participated in DNA testing.

In general, students were not concerned about the potential for harm from the use of personal information in a classroom activity. The majority (67.3%) of respondents were unconcerned about the revelation of unexpected or upsetting information. Most students had not taken a course in which his/her personal information was collected or used in some way, and very few had taken a genetics course or been a student in a class that offered personal DNA testing. Thus, these results could indicate unfamiliarity with the possible risks and implications of genetic testing. Alternatively, the results may indicate that students do not view genetic information as exceptionally different from or more sensitive than other types of personal information.

Less than half of the professors in this study reportedly incorporate new cutting-edge technology, opportunities for students to learn something about themselves, or opportunities to participate in research related to the courses they have taught–all of which are classroom activities that students have expressed a desire to experience. While this finding might suggest a possible mismatch between student desire and actual classroom activities, some disciplines are considered to be more suited to these kinds of opportunities than others.

DNA testing in the classroom

Findings from this study indicate that undergraduate students are more likely than graduate students to enroll in a course if personal DNA testing is offered. Having taken a

*While a summary of undergraduate perspectives has been published [Austriaco N (2012) Personalized genomic educational testing: what do the undergrads think? Am J Bioeth 12:43–45] that indicates some sort of questionnaire has been administered, the details of that study's design, sampling methods, and analysis have not yet been published to our knowledge. Accordingly, any reference to or conclusions drawn from that summary are avoided here.

genetics course was also associated with an increased likelihood of enrolling in a course that offers personal DNA testing. These results concur with numerous studies that have shown that younger respondents view DNA testing more favorably and are more willing to take part in DNA testing than older respondents (Andrykowski *et al.*, 1997; Aro *et al.*, 1997). Furthermore, individuals with a higher educational background tend to be more skeptical and less willing to undergo DNA testing (Andrykowski *et al.*, 1997; Aro *et al.*, 1997). Consistent with the finding from Rose *et al.* (2005) that advanced knowledge of genetics was correlated with positive attitudes about DNA testing, biological science majors in our study were more likely than social science or physical science majors to have a positive opinion of the U.C. Berkeley program.

Most students reported that they distinguish personal DNA testing from other kinds of testing (e.g., fitness, physiology, and cognitive). However, a significantly larger proportion of students would enroll in a sociology course without a personal component versus one with such a component. This may indicate that students consider family, community, and national information to be more sensitive than their genetic information or, alternatively, that perhaps students are less interested in the incorporation of sociological information into the classroom for a number of other reasons (e.g., students may assume they will not learn anything new; students may find this information unexciting). Our data indicate that students appear to view the inclusion of genetic information as an educational component in a classroom activity as qualitatively similar to the inclusion of other types of medical or personal information (e.g., psychological data and accounting data). These results suggest that genetic exceptionalism might not be prevalent among students enrolling in courses with personalized genetic testing. The intended uses of personal data collected in a classroom activity (i.e., if and how data will be shared) appear to be of greater concern to students than perceived sensitivity of the data (i.e., whether additional protections are needed). This is an important consideration for educators contemplating DNA testing or other personalized activities in the classroom.

There are some limitations to this study. First, the relatively small sample sizes, particularly for the professor group, compromise our ability to test certain hypotheses, increase the possibility that some findings could be spurious, and limit the generalizability of our results. Second, there is the possibility of selection bias, in that individuals with experience or interest in the topic may have been more likely to participate in the study, minimizing the diversity of responses. These limitations notwithstanding, this study helps to fill the gap in our knowledge of the perspectives of faculty and students concerning DNA testing in the classroom. This study is also among the first to examine these perspectives across different universities.

In summary, our data show that while DNA testing in higher education remains controversial, most students and professors surveyed saw value in including DNA testing and other forms of personal information in classroom activities. Duke and Penn State students and professors expressed a general excitement about and acceptance of such activities, and students would like to see additional opportunities to participate in more personalized activities than are currently being offered. Additional research involving more rigorous methodologies, multiple and diverse universities, and larger sample sizes is necessary to assess the pedagogical utility of DNA testing, the outcomes of using DNA testing in the classroom, and the long-term effects on genetic literacy.

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