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Abstract

***Objectives**: To evaluate a weblog (blog)-based course introducing pharmacogenetics (PGt) and personalized medicine (PM) relative to freshmen pharmacy students' knowledge base. **Methods**: Incoming freshmen pharmacy students were invited by email to enroll in a one semester-hour, elective, on-line blog-based course entitled "Personal Genome Evaluation". The course was offered during the students' first semester in college. A topic list related to PGt and PM was developed by a group of faculty with topics being presented via the blog once or twice weekly through week 14 of the 15 week semester. A pre-course and post-course survey was sent to the students to compare their knowledge base relative to general information, drug response related to PGt, and PM. **Results**: Fifty-one freshmen pharmacy students enrolled in the course and completed the pre-course survey and 49 of the 51 students completed the post-course survey. There was an increase in the students' general, PGt and PM knowledge base as evidenced by a statistically significant higher number of correct responses for 17 of 21 questions on the post-course survey as compared to the pre-course survey. Notably, following the course, students had an increased knowledge base relative to "genetic privacy", drug dosing based on metabolizer phenotype, and the breadth of PM, among other specific points. **Conclusions**: The study indicated that introducing PGt and PM via a blog format was feasible, increasing the students' knowledge of these emerging areas. The blog format is easily transferable and can be adopted by colleges/schools to introduce PGt and PM.*

Introduction

Healthcare providers, health professions students, and the lay public face a growing need for knowledge of genetics, pharmacogenetics (PGt) and personalized medicine (PM).[1-4] Genetics education, including PGt, of current and future healthcare professionals is lagging as compared to other components of PM.[5] Thousands of individuals graduate from health professions programs annually and will enter their professions at a time when genetic, including PGt, information will likely be available for a larger population of patients. A benchmarking survey to represent the U.S. physician population regarding adoption of PGt testing was performed. With respect to PGt, only 29% of 10,303 physicians (M.D. and D.O.; specialists and general practitioners) had received any level of education regarding this type of testing.[6] While 53% of 728 pharmacists had received any type of education in genetics, only 18% rated their current understanding of PGt as good, very good, or excellent.[7] Similarly, only 13% of 206 nurses rated their knowledge of PGt testing above poor or fair.[8]

A 2010 report indicated that 92% of colleges and schools of pharmacy included PGt in their curricula, an increase from 78% as reported in 2005.[9,10] However, the extent to which PGt was incorporated into curricula as required didactic hours varied greatly, with approximately 41% of colleges offering 10 or fewer hours, 42% offering 11 to 30 hours, and 14% of schools offering 31 to 60 hours of instruction.[9] Three percent of colleges did not report the number of didactic hours dedicated to PGt in their curricula.[9]

The study described here measured freshmen pharmacy students' knowledge of PGt and PM before and after an elective one-semester course (15 weeks) offered via a weblog (blog). The specific aim of this study was to evaluate the impact of the blog course on the students' knowledge base relative to PGt and PM. The course served to introduce the

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topics of PGt and PM, allowing the students to build on this foundational information as they progressed through the pharmacy curriculum. The pharmacy curriculum at Ohio Northern University (ONU) includes over 30 hours of instruction regarding PGt, PM, and related topics as has been previously described.[11] However, the curriculum lacks an introductory component of basic PGt, and other fundamental aspects of PM as a foundation. The emerging field of PGt has resulted in the inclusion of "Pharmacogenomics/genetics" in Appendix B, "Additional Guidance on the Science Foundation for the Curriculum" of the Accreditation Council for Pharmaceutical Education (ACPE) standards effective 2011 and more recently as "Required Elements of the Didactic Doctor of Pharmacy Curriculum" in the draft 2016 ACPE standards.[12,13] Therefore, with a need to introduce PGt and PM education in our curriculum, we evaluated an innovative approach to presenting introductory material; Specifically, we utilized a weblog approach applying a faculty member's direct-to-consumer (DTC) genetic testing results, including PGt test results, in the context of the broader topic of PM as a means to introduce these topics.

The "Personal Genome Evaluation" Course Design

Over the last seven years, the Raabe College of Pharmacy at ONU has worked to expand PGt education throughout the zero-six program. In an effort to develop an introductory course in PGt and PM, a study was undertaken to evaluate the use of a blog course to increase the knowledge base of freshmen students. The blog course content was designed by a group of faculty members encompassing various disciplines with interests related to PGt and PM (pharmacy, genetics, law, and ethics). The faculty developed "discussion points" which were based on information from various sources including the "Accreditation Standards and Guidelines - Professional Program In Pharmacy Leading to the Doctor of Pharmacy Degree", effective February 14, 2011 from the ACPE, "The Case for Personalized Medicine", 3rd Edition, from the Personalized Medicine Coalition, and general biology and genetics reference textbooks.[5,12,14,15] The discussion points were grouped into categories, including general knowledge, disease risk, drug sensitivity, personalized medicine, ethics, and law, all of which addressed PGt and/or PM. A "master list" of the discussion points was developed for use during a 15 week semester elective course entitled "Personal Genome Evaluation". This design was used to identify key aspects of PGt and PM with the intent to increase foundational knowledge by providing examples of the application of PGt and PM. As an example, during week four of the course, the topic was "Would you want to know?" and presented information related to Alzheimer's disease, raising the issues of disease risk and ethics, related to PM.

A faculty member served as the course coordinator and utilized six general knowledge, three disease risk, three drug sensitivity, four personalized medicine, and two ethics/legal discussion points as a basis for the course. The discussion points were presented through 14 weeks of the 15 week course via the blog found at www.pgxcheck.com (Table 1). Some of the discussion points presented during a given week were related to more than one category, e.g. disease risk/ethics (Week 4). A weblog template purchased through an online vendor (www.networksolutions.com; Web.com™, Jacksonville, FL) was used to house the blog content. The course started on August 26, 2013, with the first blog entry on September 4, 2013 and the course ended December 20, 2013. A faculty member utilized their own DTC testing results, provided by 23andMe, for the blog discussion. The faculty member information was used as it was related to an actual individual the students would recognize, making the information more "tangible" to the students. The faculty member agreed to use their own data and did not have to provide "third-party" data to the students.

A description of the course was emailed to approximately 165 incoming freshmen pharmacy students. The freshmen students were considered "P1" students in a "zero-six" program. The email described that the course was offered to the students to present and discuss data/ information from a DTC company for an individual, relative to "disease risk, drug response, and ethical, legal, and social issues". The course was graded satisfactory/unsatisfactory and was available for academic credit as a one-hour semester course.

The DTC company 23andMe was chosen because of the breadth of disease risk and drug response information provided and the lower cost of testing compared to other DTC companies. For the purposes of this course the disease risk and drug response information provided by 23andMe was utilized. Throughout the 15-week semester, on six occasions, results from the genetic testing of this individual were presented via the blog for discussion (Table 1).

A computer-based pre-course survey to test the students' knowledge base was developed using the above mentioned documents and was tested by ten freshmen students at the end of the previous spring semester. The test group students were not enrolled in the "Personal Genome Evaluation" course and had no formal coursework in PGt or PM. However, seven of the students noted they had "some exposure" to PGt and PM, while three students had never heard of the topic. The pre-course survey consisted of three demographic, four general knowledge (GK), ten personalized medicine (PM) questions, and seven drug response (DR) questions (see Tables 3 through 5). The test group responded to items

regarding the survey questions. All ten of the test group students found that the survey "was clear as to what each question was asking", and confirmed that no single question "gave away" the answer to another question. Six of the students admitted "guessing" the answer to at least one question. The test group students took five to 18 minutes to complete the survey, with four students noting the survey "took too long", while the remaining six students noted the time to complete the survey was "just right". Having tested the survey, the pre-course survey was then distributed via email to the students enrolled in the Fall 2013 elective course. The intent of the surveys was to allow for summative assessment relative to the "instructional unit" that was the blog course. The pre-course survey served as the "benchmark" to which an identical post-course survey, minus the demographic questions, was compared. The pre- and post-course surveys were identical to that tested by the 10 freshmen students the previous semester. Each survey was distributed to the students via an email utilizing the Qualtrics survey system (www.qualitrics.com; Qualtrics® LLC, Provo, UT).

Students enrolled in "Personal Genome Evaluation" were required to read the blog entry and response posts during each week. The response posts were to be provided by students and faculty. The students were not required to post a reply, although they were encouraged to do so by prompting in the original once- or twice-weekly blog posts. The response posts were to be provided during the week following original post and at anytime thereafter until the end of the course. Faculty response posts were to be provided, when desired to respond to the student posts. Therefore, the discussion of any given topic would progress as desired by the students via their posts to the blog until the end of the course. The students were required to take short; three to five question "self-tests", approximately every two weeks in an effort to keep them informed of blog entries, including the original posts and subsequent comments. The self-tests were not graded events, rather they asked questions directly from the original and response posting to the blog in order to help keep the students "up to speed" with the blog content. At the conclusion of the course, students were required to submit a one- to two-page paper describing three things they learned about "Personal Genome Evaluation" relative to PGt and PM. The topics of the "Three things I learned" paper were chosen from four categories, including disease risk, drug response, privacy, and other. Additionally, at the conclusion of the course, a course evaluation instrument was sent to all students enrolled in the course as part of Ohio Northern University (ONU) institutional research. This instrument consisted of standardized questions used across all courses at the University. The ONU Institutional Review Board exempted the study from review.

Students received a "satisfactory" grade for the course if they completed all of the "self-tests" and turned in the "Three things I learned paper".
Survey results were evaluated using summary descriptive statistics. Overall correct responses from the pre-course and post-course surveys were compared using a two-sample T-test assuming equal variance. Comparisons of individual pre-course and post-course survey question responses were made using the Chi-Square test for the categorical data. For all statistical analyses, the level of significance was set *a priori* at a p-value of less than 0.05. Microsoft Excel 2007 (Microsoft Corp., Redmond, WA), and GraphPad Prism v5.04 (GraphPad Software Inc., La Jolla, CA) were utilized for statistical analyses.

Results

Demographics of Students

Fifty-one freshmen students enrolled in the "Personal Genome Evaluation" elective course. Additionally, three upperclassmen enrolled in the course. Table 2 presents the demographic information for these groups. Twelve freshmen students (23.5% of the freshmen cohort) noted that they had "some exposure" to PGt or PM prior to this course.

Pre- and Post-Survey

All 51 freshmen students completed the pre-course survey, while 49 (96%) completed the post-course survey. Upperclassmen were excluded from the survey analysis. Tables 3, 4, and 5 present the pre- and post-course survey comparison of the number and percentage of correct responses for GK, PM, and drug response related to PGt, respectively. The correct answer for each question in Table 3, 4, and 5, are presented in the Appendix. Overall, 17 of 21 post-course survey questions had a statistically significantly higher number of correct responses as compared to the pre-course survey. When taking the total number of students with correct responses pre- and post-course, there was a statistically significant increase in freshmen student knowledge base, following the course (20 ± 13 vs. 37 ± 10; $p < 0.001$). For the cohort of freshmen students, there was a statistically significant increase in GK as noted in three of the four representative survey questions (Table 3). There was increase knowledge of PM in the freshmen student group as nine of ten questions showed a statistically significant increase in correct responses post-course as compared to pre-course (Table 4). With respect to the DR questions, a statistically significant higher number of correct answers were provided by the freshmen students post-course as compared to pre-course for five of seven questions (Table 5).

Blog Participation
In total, there were 121 response postings to the blog covering the breadth of topics as described in Table 1. Most of the comments were related to disease risk (34.7%), personalized medicine and drug sensitivity (29.8%), and ethical/legal issues (23.1%), with the remainder of the responses being related to other topics.

"Three Things I Learned" Paper
The freshmen students were required to write a paper describing "three things I learned" from the "Personal Genome Evaluation" course. The papers included 41 descriptions (26.5% of all descriptions) of what students learned about disease risk, 45 descriptions (29%) related to drug response, 44 descriptions (28.4%) related to privacy, and 25 descriptions (16.1%) of what students learned about "other" topics, e.g., drug targets. It should be noted that some students included more than three descriptions.

Course Evaluation
Seventy percent of all students (n = 38) completed a course evaluation instrument offered by the Office of Institutional Research at ONU. As this course was intended to introduce the topics of PGt and PM, a question addressed to what extent the students felt that the course ("Personal Genome Evaluation") "provided them with the skill set (here knowledge base) needed for further studies in the field." Of these students, 84% (n = 32) of the evaluation instrument respondents agreed or strongly agreed with the statement, while 13% (n = 5) neither agreed nor disagreed with the statement and 3% (n = 1) disagreed with the statement.

Discussion
Graduates of health professions programs will likely encounter more patients that have had genetic testing performed with specific panels (e.g. *CYP2C9*, *CYP2C19* and *CYP2D6*) or genome sequencing in part, or in whole as the cost of technology continues to decline.[17] These healthcare professionals will need to understand the information provided and be able to interpret data and communicate the information to their patients. The "Personal Genome Evaluation" course was intended to introduce freshmen pharmacy students to PGt and PM. As compared to the pre-course survey, the post-course survey reflected that the student's knowledge of PGt and PM had increased after the blog discussion of data/information for an individual as provided by a DTC genetic testing company.

There was a significant increase in general knowledge when considering three of four questions including what chemicals are considered DNA "building blocks", the genetic influence on drug response being consistent over one's lifetime, and the DNA similarity between individuals. There was no difference however; in pre- versus post-course knowledge relative to understanding that DNA is found in all nucleated cells in the body. With this specific topic, 88.2% of the students chose the correct answer on the pre-course survey and 96.1% of the students chose the correct answer on the post-course survey. The high percentage of correct responses on the pre-course survey likely reflects the influence of high-school or other pre-college/college biology education. Additionally, the freshmen students were enrolled in a general biology course during the same semester, which introduced the concepts underlying the structure and function of cells including their organization, chemical foundations, metabolism, and the principles and mechanisms of heredity and gene expression. When discussing the questions included in the pre- and post-course survey with the coordinator of the general biology course, it was confirmed that the general knowledge question content for questions 1 and 2 (Table 3) were definitively discussed in the general biology course. There was likely some impact of the concurrent general biology course on the post-course survey results relative to GK. Regardless, the blog approach introduction of the general biology information was new material, reinforced by the biology course information, or reinforced the material presented in the biology course.

Personalized medicine in the context of inclusion of genetic test results is relatively new and with no freshmen student having had formal education on the subject, it was expected that "Personal Genome Evaluation" would be of benefit relative to the freshmen students' knowledge base. Here, students increased their knowledge relative to genetic privacy and legal protections being introduced to the Genetic Information Nondiscrimination Act of 2008 (Table 4; questions 1 and 8). The students were introduced to health information technology and became familiar with the Health Information Technology for Economic and Clinical Health (HITECH) Act (Table 4, question 4). Disease risk stimulated much conversation on the blog with the posts relative to this topic receiving the most student responses (42; 34.7% of all response postings). Importantly, the post-course survey showed that 85.7% of students correctly identified disease risk as being relative as compared to 14.3% of the students pre-course. All questions related to disease risk (Table 4; questions 5, 6, and 7) showed a statistically significant increase with respect to correct answers being chosen post-course as compared to pre-course. More students understood "participatory medicine", where molecular genetic information is combined with the patient's environment, lifestyle, diet, and family history, as well as the patient's observation of their own symptoms post-course as

compared to pre-course (Table 4, question 9; $p < 0.0001$). A statistically significant higher percentage of students recognized the breadth of personalized medicine post-course as compared to pre-course (83.7% vs 41.2%), understanding that many sectors must be integrated to reach full implementation of PM (Table 4; question 10).
Students were introduced to "drug targets" with 91.8% being able to identify the targets post-course as compared to 23.5% pre-course ($p < 0.0001$; Table 5, question 1). While pharmacodynamics was discussed, students did not improve their knowledge base relating gene-drug receptor variation as a pharmacodynamic interaction (Table 5, question 2), with 11.8% and 22.4% of students identifying the correct answer on the pre-course and post-course surveys, respectively. Students grasped the idea of metabolic phenotypes having increased their knowledge base when asked to identify a phenotype or determine how a phenotype would be related to dose (Table 5; questions 3, 4, and 7). While 63% of the students post-course versus 55% pre-course identified that extensive metabolizers would require a higher dose than an intermediate metabolizer to achieve the same drug exposure, the difference did not reach statistical significance (Table 5; question 5).

Of interest, the majority of topics discussed in the "Three Things I Learned" papers were related to "disease risk". The papers included ethical, legal, and social issues as well as the Food and Drug Administration's actions toward 23andMe relative to reporting disease risk and drug response information. Importantly, as was noted in the post-course survey, students discussed the understanding that disease risk data was relative and not absolute. Similarly, students expressed some caution when using the drug response data, noting other influences of how a drug may affect an individual.

An important aspect of the blog format was the "conversation" that occurred as students posted responses to the topics. This approach encouraged student to "voice" their opinion and ask questions. Responses by the three upperclassmen likely added to the education of the other students as the upperclassmen comments were a result of having had formal courses which included PGt and PM information. While one faculty member served as the course coordinator and posted the blog topics, other faculty added their comments to the discussion. Again, this served as an important process for providing the students with more information to assimilate, further increasing their knowledge base. The weblog format of the course allowed for broad discussion, with discussion points being a permanent part of the weblog, such that students could return to the discussion as many times as desired. Unlike the classroom setting where a discussion occurs and then ends, with details often being lost, the documentation of the discussion via the weblog provides a "retrievable dialogue" that students can refer to and contemplate. While not specifically recorded, it is likely the students visited the discussions more than just once as comments were added to each discussion throughout the 15 week semester. Additionally, the weblog format may have allowed for broader representation of opinions as students are more likely to participate in an online discussion as opposed to offering an opinion in the "live" classroom setting. Importantly, this format also allows for responses to instructor and participant posts in a broader context of differing viewpoints.[18]

The purchase of a blog template was important as it minimized the time for set-up and maintenance of the blog course. There was no programming experience required and template functions allowed for addition of tables and images to enhance explanation of information. The instructor simply entered the blog topic and initial post in the fields provided in the template and respondents posted in the "comment" field. The cost of the blog template, including the domain name (www.pgxcheck.com) was approximately $7 per month and in total the annual cost with additional features, such as advanced technical support was approximately $250. The cost of online resources through Network Solutions was comparable to other vendors. The choice of this vendor had to do with the apparent online support made available. The associated cost of the technology was deemed to be justified and was supported by College funds. These considerations, i.e., the blog template, relatively low cost and available support, by the noted vendor and others, make the weblog course approach readily adoptable by other colleges/schools. Additionally, the pharmacogenetic testing results, as part of broader genetic testing via a DTC company were obtained at a cost of $207. The saliva sample for genetic testing was provided to the company eight weeks in advance of the offering to allow for test results to be returned in time for the course offering. The total cost to present the "Personal Genome Evaluation" course was just over $450.

Faculty time commitment per week included approximately 20 to 40 minutes to write and post the blog topic and up to 10 minutes to read reply comments. The development and posting the "self-tests", based on the blog posts required 30 minutes of faculty time every other week. The largest time commitment was related to reading the "Three things I learned" papers at the end of the semester. The papers were submitted electronically to the instructor during week 14 of the semester. This allowed for reading time during week fifteen, prior to course grade submission. The time to read all 54 papers was approximately seven hours.

Conclusions

As the need for PGt education increases, colleges/schools of pharmacy will be looking to include introductory material in their curricula. As described, the weblog-based course, "Personal Genome Evaluation" provided freshmen students with an introduction to PGt and PM which increased their knowledge base and prepared them for further study of the subjects. The blog format, via available, affordable online technology, when combined with pharmacogenetic testing results can be easily transferable and can be adopted by colleges to introduce PGt and PM.

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Table 1. The website (www.pgxcheck.com) blog topics relative to the "Personal Genome Evaluation" course from faculty derived points of discussion and direct-to-consumer testing data.

Week	Topic	Category	Specific Discussion Points
1	www.pgxcheck.com - Blog site for the course	-	Confirmation of blog URL.
2	Looking at a Personal Genome. Why?	General	Described the rationale for getting tested.
2	Personal Genome...The Process and Initial Thoughts	General	Described the process of sample collection and the procedure for sending the sample and obtaining the results.
2	Introductory Information and Disease Risk: Prostate Cancer!	Disease Risk (PM[a])	Background information on DNA and single nucleotide polymorphisms (SNPs) and risk of prostate cancer.
3	A quick look at DNA, Amino Acids, and Proteins	General (GK[b])	Background information on DNA, Amino Acids, and Proteins.
3	Disease Risk - Coronary Heart Disease (CHD)	Disease Risk (PM)	Background information on DNA and SNPs and risk of coronary heart disease. Via drugsandgenes.com.[16]
4	Would you want to know?	Disease Risk/ Ethics (PM)	Background information and SNPs and risk of Alzheimer's Disease.
5	Genetic Discrimination - An example and the law	Ethics/Law (PM)	Examination of the Burlington Northern & Santa Fe Railway company case and introduction to the Genetic Information Nondiscrimination Act (GINA).
5	Expanding GINA	Ethics/Law (PM)	A look at what some states are doing beyond the federal GINA.
6	Let's Talk Personalized Medicine, Pharmacogenetics, and Pharmacogenomics!	General (PM)	Definitions of and an introduction to personalized medicine, pharmacogenetics, and pharmacogenomics.
6	A preliminary look at drug response: Caffeine	Drug Sensitivity (DR[c])	An example of relating genetics to drug response.
7	Chest Pain, Coronary Artery Blockage and My Antiplatelet Therapy!	Drug Sensitivity (DR)	A second example of relating genetics to drug response.
8	Metabolizer Phenotypes	General (DR)	Defining phenotype and relating genotype to phenotype.
9	If I had atrial fibrillation and needed warfarin...	Drug Sensitivity (DR)	An example where two genetic variations can influence drug response.
10	What is a drug-gene interaction?	General (DR)	Defining a drug-gene interaction with examples.
11	The Breadth of Personalized Medicine - Personal Genome Evaluation	Personalized Medicine (PM)	Examination of the components of personalized medicine.
12	Education and Personalized Medicine - A challenge to you!	Personalized Medicine (PM)	Identifying the need for education in personalized medicine and citing informational sources.
13	23andMe	Personalized Medicine (PM)	A discussion about recent events related to the Food and Drug Administration's letter to the direct-to-consumer DNA testing company 23andMe.
14	The Personalized Medicine Pie and related items	Personalized Medicine (PM)	Revisiting, with more specificity, the components of personalized medicine. Here introducing the document "The Case for Personalized Medicine".[5]

[a]Personalized Medicine; [b]General Knowledge; [c]Drug Response

Table 2. Demographics of pharmacy student population that enrolled in the "Personal Genome Evaluation" course, based on the pre-course survey.

Age Range:	n[a] (%)
17 through 19 years	52 (96.3)
20 through 25 years	2 (3.7)
Academic Year:	
Freshmen	51 (94.4)
Junior	3 (5.6)
Gender:	
Male	10 (18.5)
Female	44 (81.5)
Primary Language:	
English	54 (100)
Prior Use of DTC Genetic Testing:	
No	54 (100)
Previous PGt or PM Education:	
Formal course work	0 (0)
Some exposure	15 (27.8)
Never heard of topics	39 (72.2)
Member of sPMC Chapter[b]	
Yes	1 (1.9)
No	53 (98.1)

[a]n = 54. [b]sPMC refers to the student chapter of the Personalized Medicine Coalition.

Table 3. General knowledge questions; Pre- and post-course correct responses (number; percentage), and p value.[a, b]

Question	Pre-course Number Correct (%)	Post-course Number Correct (%)	p Value
1. True or False. All nucleated cells in the body contain DNA.	45 (88)	47 (96)	0.1569
2. The four chemicals that are the "building blocks" of DNA include which of the following?	39 (76)	48 (98)	0.0014
3. True or False. Genetic influence of drug response changes over a person's lifetime.	11 (22)	29 (59)	<0.0001
4. Based on DNA only, humans are _____ % alike.	16 (31)	48 (100)	<0.0001

[a]statistical significance set *a priori* at a p value < 0.05. [b]see Appendix for correct answers

Table 4. Personalized medicine questions; Pre- and post-course correct responses (number; percentage), and p value.[a, b]

Question	Pre-course Number Correct (%)	Post-course Number Correct (%)	p Value
1. The U.S, federal legislation enacted to protect individuals from discrimination relative to personal genetic information is known as:	5 (10)	47 (96)	<0.0001
2. Personalized medicine can improve patient care by:	43 (86)	45 (94)	0.2054
3. Personalized medicine and pharmacogenomics have been brought closer to clinical use mainly because:	11 (22)	32 (63)	<0.0001
4. Electronic health records and other information technologies must be implemented for use in healthcare. Which legislation states that hospitals and physicians face penalties if they do not use these technologies in a "meaningful way" after 2015?	16 (31)	32 (65)	p<0.0001
5. A person sends their saliva to a direct-to-consumer genetic testing company. The results show that the individual has a single nucleotide polymorphism (SNP) which is related to increased risk of coronary heart disease. This risk is considered:	16 (31)	42 (86)	<0.0001
6. True or False. In cancer patients, the genetics of some tumors can be used to identify drugs that can target the cancer cells.	35 (69)	45 (92)	0.0037
7. True or False. The genetics of all tumor cells associated with cancer have been determined.	40 (78)	47 (96)	<0.0001
8. The legislation passed to prohibit discrimination based on a person's genetics is aimed at which two groups?	16 (31)	46 (94)	<0.0001
9. Participatory medicine includes which of the following along with molecular genetic information?	7 (14)	24 (50)	<0.0001
10. Which of the following must "converge" in order for personalized medicine to be fully implemented? (check all that apply)	21 (41)	41 (84)	<0.0001

[a]statistical significance set *a priori* at a p value < 0.05. [b]see Appendix for correct answers

Table 5. Drug response questions; Pre- and post-course correct responses (number; percentage), and p value.[a, b]

Question	Pre-course Number Correct (%)	Post-course Number Correct (%)	p Value
1. Drug targets that are under genetic control include which of the following?	12 (24)	45 (92)	<0.0001
2. An individual has the genetic constitution that results in decreased formation of a specific drug receptor. This causes the individual to be more "sensitive" to the effects of drugs that target this receptor. This interaction between a drug and a receptor is called:	6 (12)	11 (22)	0.1551
3. A person sends their saliva to a direct-to-consumer genetic testing company. The testing results show that this individual has a single nucleotide polymorphism (SNP) which is related to decreased activity of a metabolizing enzyme. Specifically, the individual has the genetic constitution showing that one parent passed along a deficient gene, while the other parent passed along the "normal function" gene. This individual is typically classified as a/an:	16 (31)	30 (61)	0.0028
4. Given a prodrug, a patient with a heterozygotic polymorphism reducing the metabolism of the drug would require a/an:	9 (18)	28 (57)	<0.0001
5. As compared to an intermediate metabolizer, an individual who is an extensive metabolizer would need a _____ dose to achieve a similar drug exposure.	23 (45)	31 (63)	0.0684
6. A drug is being studied in a large clinical trial. The results indicate that only a small percentage of the patients in the study benefit from the drug. Which of the following statements describes a rational "next step" in the development of the drug?	33 (65)	41 (84)	0.0306
7. Which individual would likely have two "common" copies (one from each parent) of the genes coding for a metabolizing enzyme?	14 (27)	32 (65)	<0.0001

[a]statistical significance set *a priori* at a p value < 0.05. [b]see Appendix for correct answers

Appendix: Answers to pre- and post-course survey questions (see Tables 3, 4, and 5).

General knowledge questions
Q1. True
Q2. Adenine, Cytosine, Guanine, and Thymine
Q3. False
Q4. 99.9%

Personalized medicine questions
Q1. Genetic Information Non-discrimination Act; GINA
Q2. Identifying correct drug, avoiding adverse effects, increase medication adherence
Q3. Technology making DNA testing more affordable
Q4. Health Information Technology for Economic and Clinical Health; HITECH
Q5. Relative
Q6. True
Q7. False
Q8. Employers and health insurers
Q9. The patient's observations and the patient's lifestyle, environment, diet and family history
Q10. Technology/ tools, Regulation, Insurance coverage/ reimbursement, Genetic privacy/legal protections, Medical education, Healthcare information technology

Drug response questions
Q1. Receptors, Transporters, Drug Metabolizing Enzymes
Q2. Pharmacogenetic – pharmacodynamic interaction
Q3. Intermediate metabolizer
Q4. Increased dose
Q5. Higher
Q6. Study the drug in the small group to identify if there is a genetic similarity among the patients
Q7. E