










## Development of Competency-based Online Genomic Medicine Training (COGENT)

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The fields of genetics and genomics have greatly expanded across medicine through the development of new technologies that have revealed genetic contributions to a wide array of traits and diseases. Thus, the development of widely available educational resources for all healthcare providers is essential to ensure the timely and appropriate utilization of genetics and genomics patient care. In 2020, the National Human Genome Research Institute released a call for new proposals to develop accessible, sustainable online education for health providers. This paper describes the efforts of the six teams awarded to reach the goal of providing genetic and genomic training modules that are broadly available for busy clinicians.

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Increasing evidence demonstrates that utilizing genetic information in clinical decision-making can improve routine clinical care for a wide range of conditions [1–6]. Genetic testing and genomic sequencing have expanded across medical disciplines, with as many as ten new genetic tests introduced daily [7]. Despite the growing influence of genomic medicine in clinical practice, surveys continue to show that many clinicians, particularly primary care providers, feel inadequately prepared to order and interpret genetic tests or discuss genetic test results with patients [8–11]. Clinicians also report a lack of confidence in using genetic information to make clinical decisions [12]. These challenges are compounded by the rapidly expanding and changing knowledge base, the range of providers involved and the scope of care and the need for high-quality training that is adaptable to the skill level and time constraints of the busy clinician.

For more than 20 years, several collaborative projects have focused on enhancing education in genetics and genomics for nongeneticist practitioners, particularly in pediatrics, family and internal medicine, to insure widespread access and appropriate utilization of these tools [13–17]. In 2001, a group of geneticists and educators proposed a set of genetics core competencies for all health providers [18], which have been continually revised and updated [19]. Subsequently, other professional groups developed their own genetic competencies, including nurses [20–24], physician assistants [25], pharmacists [26,27], physicians [28] and genetic counselors [29]. These guidelines were assimilated into a National Human Genome Research Institute (NHGRI) repository [30] called the Genetics/Genomics Competency Center, or G2C2 [31].

The genetics and genomics community continues to engage with a broad range of partners to enhance provider knowledge and skills and develop continuing education opportunities [32–34]. Yet, the sheer complexity and volume of information appear to have outpaced efforts by individual educators and schools, and it remains uncertain if clinicians are aware of the diverse educational opportunities that are available. Furthermore, the delivery of continuing medical education has substantially shifted from traditional, in-person learning to remote learning on a much broader scale, with increasing evidence of its comparability to traditional modes of learning [35–37]. The COVID-19 pandemic has only accelerated the transition. Despite the conveniences of online learning, many hurdles remain to deliver education in genomics for clinicians, such as institutional support, the need for continual updating of content as the genomics landscape changes, competing priorities for busy clinicians and limited availability of engaging, just-in-time instruction.

The development of online modular genomic educational opportunities is one method to address some of these challenges. In 2020, NHGRI announced the availability of supplemental funding for its grantees “to support the development and implementation of modules aimed at providing healthcare professionals with genomic medicine training” [38]. The modules could be designed to stand alone or to build upon each other to form a certificate in genomic medicine or other recognition of healthcare professionals with specialized expertise and consultative capabilities. NHGRI funded six teams around the USA, recognized leaders in the fields of genomic medicine and education, to develop online scalable training modules for a wide range of healthcare professionals. The collection of teams was self-named the Competency-based Online Genomic Medicine Training (COGENT) group. Although each group’s educational projects were unique, there were several areas of potential synergy. Working together, the groups harmonized definitions, identified new methods for the delivery of educational materials and discussed ways to develop mechanisms to recognize healthcare professionals who complete the training, including through continuing education credits or certificates. In particular, six overlapping topics were identified across multiple teams (i.e., family health history; ethical, legal, and social implications; clinical testing and interpretation; basic biology; cardiovascular disease and pharmacogenomics [PGx]) and working groups were established to enable sharing of materials and harmonization where possible. The groups are discussing ways to support and coordinate these efforts over the long term to sustain high-quality genomic medicine modules that can provide healthcare professionals the competence and confidence they need to use genomics in patient care.

The following sections include a brief overview of each team’s objectives, the target audience, topics, assessment and types of recognition awarded upon completion (e.g., continuing education credits or certifications, digital badges; Figure 1).

### Cincinnati Children’s Hospital Medical Center/University of Cincinnati

The goal of the University of Cincinnati and Cincinnati Children’s Hospital Medical Center (CCHMC) was to develop a genomics education program titled, “Reduce or Prolong the Diagnostic Odyssey: You Decide”. The CCHMC program sought to provide an opportunity for clinicians to increase their confidence in selecting genetic tests, interpreting results and identifying implications for patient care. Self-paced online learning modules were created that used unfolding pediatric cases.

The CCHMC clinician target audience consists of physicians, advanced practice nurses and physician assistants. Learning objectives were primarily skills-based and map to existing genetics/genomic competencies to demonstrate relevance to practice [25,28,39]. Figure 2 shows an overview concept map for genetic/genomic diagnostic testing. Each type of test contains a link to currently available online information. In addition, basic genetic and genomic concepts, in the form of short 1 to 3 min videos, infographics and definitions appear as options as the learner clicks through each module. Many of these basic elements are reused per module, aligning with basic concepts. Each module ends with a short video of the clinician who submitted the case summarizing key points and lessons learned.

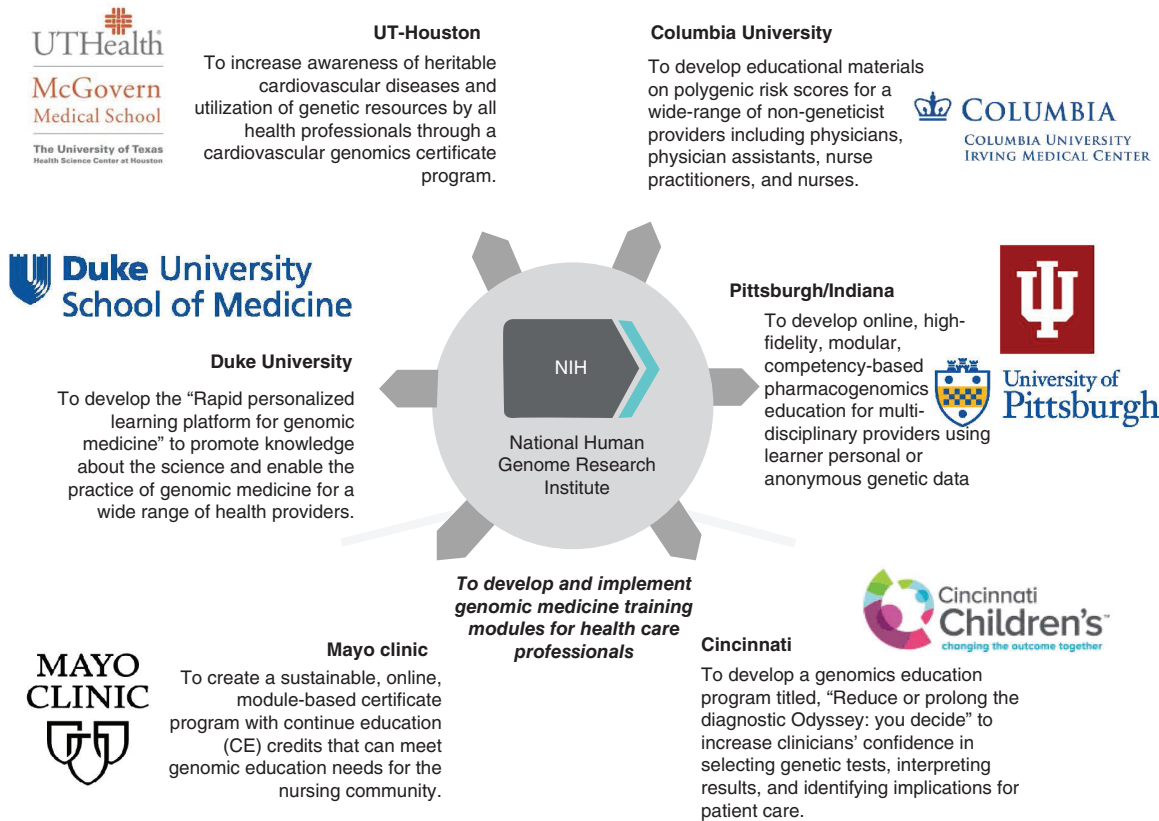


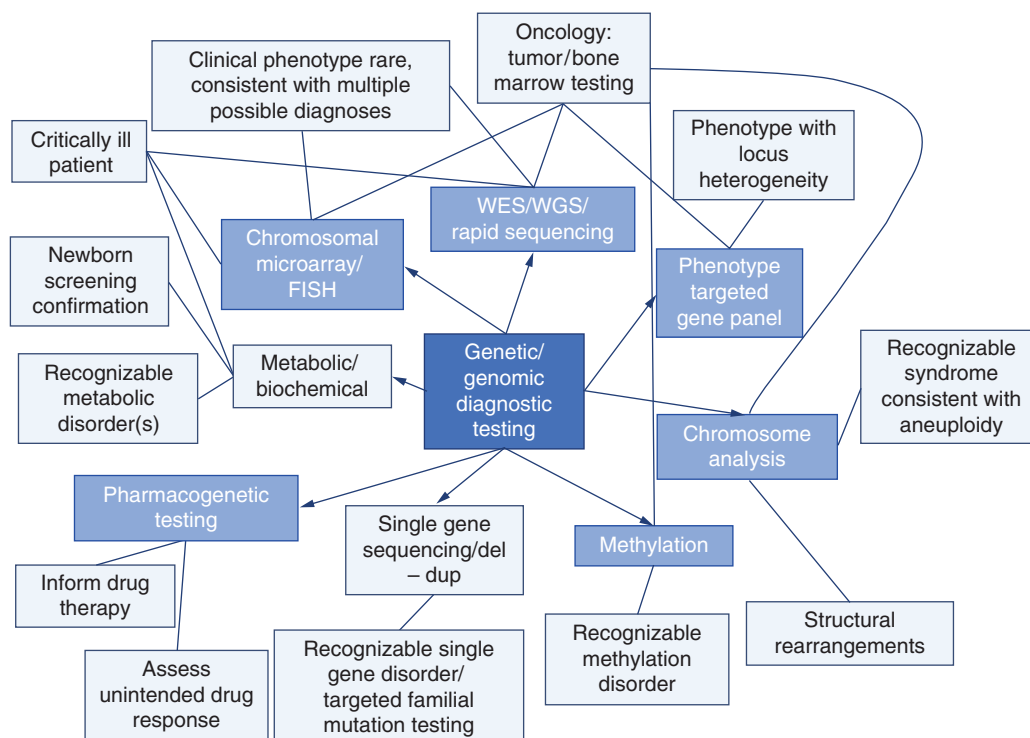
Figure 1. Main learning objective for each team.

All learners will need to register and answer questions about demographics, use of genetics in the past month and 12 questions adapted from the Genetic Counseling Self-Efficacy Scale (GCSES) [40]. The GCSES asks the learner to rate how certain he/she is that each activity can be performed independently utilizing a continuous 0–100 Likert-like scale. Learners will be asked to complete the GCSES questions again after completing the full set of modules. Change in perceived ability to perform skills will be analyzed, as well as a comparison of the number of genetic tests ordered.

Before making modules widely available, the CCHMC team will randomize specialty divisions at CCHMC to receive invitations to select a division clinician to be part of a ‘genomic champions’ group that includes completion of the online modules followed by monthly case discussion or receive advertising for the availability of the online modules only (a control group). All clinicians who complete the modules will receive continuing education credits. CCHMC hypothesizes that a larger proportion of clinicians from divisions with a champion will complete the full set of modules and demonstrate a greater gain in confidence and use of genetics than learners from divisions without a champion.

### Columbia University Irving Medical Center

The overall goals of the Columbia University Irving Medical Center program were to develop educational materials on polygenic risk scores (PRS) for a wide range of nongeneticist providers including physicians, physician assistants, nurse practitioners and nurses. The online modules will also be incorporated into healthcare training programs. The educational modules build upon provider education materials developed in support of the NHGRI-funded Electronic Medical Records and Genomics (*eMERGE*) Network (phase IV) study on PRS, which will return PRS scores to over 25,000 participants and providers for select actionable diseases. Genomic medicine implementation has heretofore focused largely on rare genetic variants associated with high risk; however, most common diseases are largely polygenic and the feasibility of using PRS to identify high-risk patients was first demonstrated in 2018 for conditions including coronary artery disease and Type 2 diabetes [41]. In 2019, it was reported that individuals



**Figure 2. Concept map for genetic/genomic diagnostic testing developed by the Cincinnati team.** Starting from white boxes around the outside, each case presents options for different types of testing, with the appropriate type of test indicated with a line. Short videos are presented describing the usefulness and limitations of the type of testing, as well as other basic concepts like inheritance, nomenclature and cascade testing. del: Deletion; dup: Duplication; WES: Whole-exome sequencing; WGS: Whole-genome sequencing.

in the top 2–5% of PRS have risk equivalent to many of the rare variants currently tested for diseases such as breast cancer, colon cancer and coronary artery disease [42].

The PRS educational materials are adaptable to different target audiences. The modules incorporated the following competencies shared across different health professions: describe the major forms of genetic variability and contribution to disease risk; identify and describe monogenic and polygenic risk and understand how a PRS is developed including the limitations of its application. In addition, the modules addressed how to incorporate a PRS into clinical care including the recommended care and surveillance, effective communication of PRS risk to patients and patient-specific limitations and identification of and discussion about the patient-specific barriers to following recommendations.

All materials are accessible to the public and permitted to be used by other groups for educational purposes. In addition to self-learning through the online modules, the modules can also be incorporated into in-person presentations on continuing medical education courses and are included in a library of PRS educational materials hosted on the Columbia Precision Medicine website and the eMERGE websites. The team developed ACTion (ACT) Sheets, a one-page just-in-time reference resource for select high-risk PRS diseases (e.g., breast cancer, heart disease, diabetes) that can be adapted and integrated into clinical decision support tools in electronic health record systems.

### Duke University School of Medicine

The Duke University School of Medicine team aimed to develop the Rapid Personalized Learning Platform for Genomic Medicine to promote knowledge about the science and enable the practice of genomic medicine. The platform includes a suite of short online modules that are designed to be free-standing but can also be combined to develop a comprehensive learning program for a range of health providers. In contrast to the other teams, the modules are intended to be introductory to genome sciences and medicine and include an overview of clinical applications across different specialties. Therefore, there is no specific target audience.

The modules are grouped into two levels and learners can choose to view them in any order (Level 1 topics will address general/foundation topics and Level 2 topics are divided by specialty and incorporate professional organization recommendations and case studies). As the field of genome medicine continues to rapidly develop, these short modules can be updated as needed with limited disruption and effort. Continuing education credits will be provided through the Duke University Health System Office of Clinical Education and Professional Development for physicians, pharmacists, physician assistants and nurses upon completion of the brief assessment at the conclusion of the module. Learners can also consent to receive a 60-day follow-up survey to gauge the impact of learning on attitudes and clinical practice behaviors (e.g., learner competence, performance and perceived barriers to implementing practice changes). A companion website will include resources to supplement continuing learning and clinical implementation. These online learning modules will serve as the foundation of a Certificate Program in Genomic Medicine.

### Mayo Clinic

The Mayo Clinic Center for Individualized Medicine team's goals were to create a sustainable, online, module-based certificate program with continuing education (CE) credits to meet genomic education needs specifically for the nursing community. Nursing professionals are a key component of the medical care team and play a significant role in both patient care and patient education. While nurses who have specific education and training in genetics and genomics exist, they are limited in number. To keep pace with the growth in genomic testing and the increasing use of genomics in clinical care, there is a critical need for updated, broad, accessible and practical genomics education for all nurses [43]. This education is needed to support direct clinical care and the role nurses have in supporting patients and patient education.

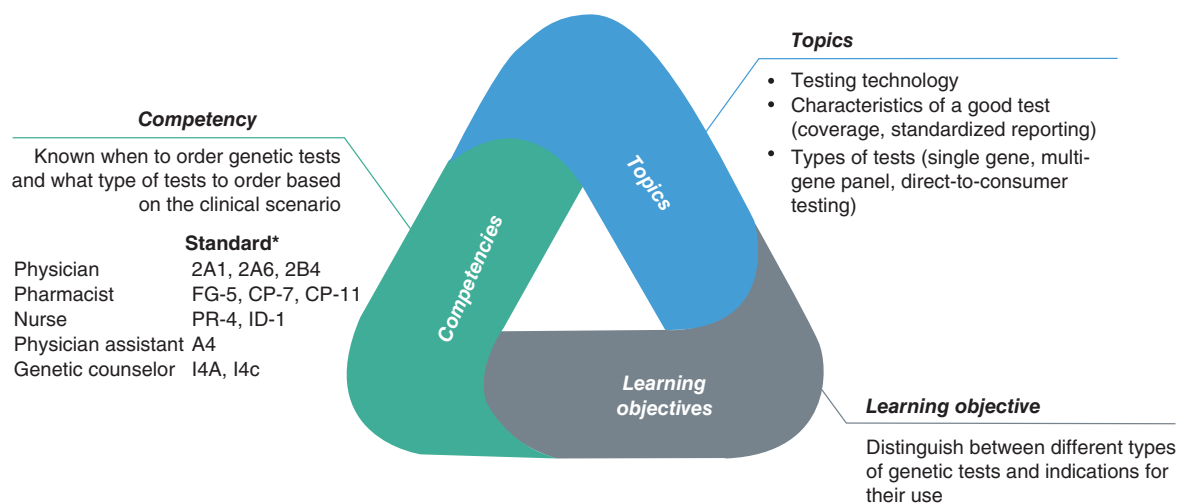
As there are no well-defined and agreed-upon competencies for genomics across nursing practices, the curriculum for the Mayo certificate program was developed based on the scope and standards of practice for genetics/genomics nursing published by the American Nurses Association with support from the International Society of Nurses in Genetics [44]. Among the key learning objectives of the certificate program are fundamentals of genomics, integrating genomics into practice, patient education and ethical issues, and will include primary care nursing along with specialty care. The effectiveness of the program will be assessed using a mixed-method analysis using pre/posteducation comprehension testing, online surveys, focus groups and quarterly content reviews by course directors and content experts. The results from these efforts will be used to make quarterly updates to topics, content and delivery mechanisms. The educational modules, while designed to be delivered as a single program specifically tailored to nurses, can be repurposed as individual modules for a range of learners.

### University of Pittsburgh/Indiana University

The University of Pittsburgh School of Pharmacy and Indiana University School of Medicine partnered to develop online, modular, competency-based PGx education for multidisciplinary providers (pharmacists, physicians, nurse practitioners, physician assistants, nurses and genetic counselors). The overall goal was to accelerate the use of increasingly available PGx testing data in prescribing decisions. Currently, over 300 medications have genetic data in their FDA-approved labeling [45] and > 50 drugs have level A prescribing recommendations in published Clinical Pharmacogenetics Implementation Consortium (CPIC) guidelines [46].

The educational program is competency-based to promote the attainment of practical skills important for the integration of PGx into clinical care. These are strictly based on contemporary genomics competency standards for each discipline (Figure 3) and are comprised of stackable modules to allow learners to tailor their education to meet individual needs regarding the depth and duration of training. Topics covered include nomenclature, PGx testing, clinical decision-making, regulatory issues, reimbursement, communication and ethical, legal and social issues. The program will focus on clinically actionable PGx gene–drug pairs across a variety of diseases, such as oncology, cardiology, psychiatry, neurology, infection diseases and pain control.

The approach is highly innovative in that it leverages the Test2Learn platform [47] to deliver high-fidelity participatory education [48]. Trainees learn by undergoing testing personally (or using anonymous data if preferred) and using these data in interactive cases. Several groups have demonstrated participatory learning using real genomic data to be an engaging and effective approach [49–54] that produces superior learning outcomes. Source data can be from institutional laboratories, 23andMe, file upload or 1000 Genomes. Integrated online genomic resources, such as from CPIC, will further support the learning objectives. Microcredentialing (digital badges) and continuing education credits are awarded in a scalable model to achieve long-term sustainability. The project involves



**Figure 3. Competency mapping to inform development of a learning module on pharmacogenomic testing by the University of Pittsburgh/Indiana University team.** Genomics competency standards for each healthcare provider are aggregated and mapped to learning objectives to inform content development for a module topic.

\*Competency standard numbers from the listing for each discipline on the G2C2 website.

implementations at both institutions, pre/post and longitudinal assessments to evaluate the impact of training and sustainability end points.

### University of Texas Health Science Center at Houston (UTHealth)

The goals of UTHealth’s Cardiovascular Genomics Certificate (UTHCGC) program were: to fulfill an unmet need for adult cardiovascular genetics education, to increase awareness of heritable cardiovascular diseases by all health professionals with a focus on primary care providers who are gatekeepers and partners in the diagnosis and treatment of these patients and to improve the recognition and referral of patients with genetically triggered cardiovascular diseases. In the last 20 years, genomics research has identified thousands of genetic variants that influence cardiovascular disease risk. Adult-onset cardiovascular diseases are influenced by highly penetrant variants that cause early onset disease and common variants that modify the timing or severity of disease. The development of clinical genetic tests for cardiovascular diseases has enabled the use of genetic information to improve outcomes and save lives by identifying patients at risk before they develop life-threatening cardiovascular complications and by altering treatment strategies based on the genetic variant.

The target audience for the UTHCGC program is primary care providers, nurses, nurse practitioners and cardiovascular clinicians (i.e., cardiologists, cardiovascular surgeons and cardiovascular anesthesiologists) who do not have specialized training in genetics. The team identified three core competencies as essential end points for training in genomic medicine: to obtain and interpret genomic information, including family history and pedigree data; to order genetic tests or to provide referrals for genomic medicine consultations and to understand and apply appropriate treatment decisions based on genomic data. The courses are designed to appeal to busy clinicians by emphasizing a concise, case-based format focusing on genetic issues that providers are likely to encounter in clinical practice and allowing learners to customize their experience by providing a range of learning formats including short presentations on basic genetic concepts and terminology (Tier 1), workshop-style activities to apply these concepts (Tier 2) and longer clinical cases where learners can demonstrate that they are able to contextualize these concepts in the practice of genomic medicine (Tier 3). Learners can revisit and master a set of core competencies as they progress through the tiers of modules.

The case presentations in Tier 2 and Tier 3 modules feature relatively common hereditary diseases such as cardiomyopathies, hyperlipidemias and arrhythmias, as well as aortic aneurysms and pharmacogenetic questions that can impact clinical management. By the end of the course, learners will be able to recognize genetically triggered diseases based on clinical features and family history, distinguish actionable results on laboratory and direct-to-consumer genetic test reports and identify and monitor individuals who are at risk for disease based on genetic information. The modules are designed to stand alone, with individualized quizzes and pre- and post-assessments,

but may also be combined flexibly according to specialties and interests. The UTHCGC will be accredited for continuing medical and nursing education credit. In addition, learners who complete at least 3.5 h will be eligible to receive a UTHealth Cardiovascular Genomics Certificate.

The UTHCGC team will continually revise and restructure the modules to provide more interactive and engaging learning opportunities based on learner feedback (collected through anonymous Qualtrics questionnaires). Target benchmarks will include >90% of modules being rated as helpful and >90% of participants rating the program as moderately or highly impactful. Baseline and annual follow-up surveys will also be sent to those who complete the entire certificate program to assess changes in clinical practice. These surveys will provide data on the long-term effectiveness of the certificate program to improve the recognition and referral of patients with genetically triggered cardiovascular diseases.

## Conclusion

Funding from NHGRI has brought together six innovative educational programs to create a highly interactive and crossdisciplinary approach to genomic education for healthcare providers. The result is a set of modular and flexible web-accessible learning resources for health professionals, clinicians, nurses, pharmacists, physician assistants, genetic counselors and even students of the profession. Each institution will roll out the modules and make them accessible to learners outside of their institutions. The work by the teams represents a concerted effort to develop depth in the online modules across a wide range of topics linked to published competencies that will be widely accessible to health providers at all levels and specialties.

## Future perspective

The COGENT platform will address a critical need and gap at the intersection of genetics, genomics and clinical care and a series of tools will be generated that would not have otherwise been developed had the six groups not partnered. This collaborative effort was effective in providing a mechanism for the exchange of content as well as innovative ideas and best practices for education. Future collaborations will aim to increase access through a single interface to multiple genomic medicine training modules. Each institution will continue to provide updates and expand to new topics while being seamless to learners, particularly regarding evaluation tools (e.g., validated measurements of e-learning) and the impact of learning modules on provider behavior (pre/postlearning).

### Executive summary

- The rapid pace of developments in genetics and genomics and advances in clinical practice across disciplines has created a challenging scenario for educators.
- Over the past several decades, multiple initiatives have resulted in the creation of disparate genetic educational resources and learning opportunities.
- Online modules are convenient and widely accessible, allowing for educational opportunities in genetics and genomics for multiple types of providers that are geographically diverse.
- Collaborations between institutions represent an effective and efficient way to innovate in genomic education and should be supported in the future.

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