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Kathleen A. Calzone, PhD, RN, APNG, FAAN[1], Bonnie Jerome-D'Emilia, PhD, MPH, RN[2], Jean Jenkins, PhD, RN, FAAN[3], Constance Goldgar, MS, PA-C[4], Michael Rackover, MS, PA-C[5], John Jackson, MS[6], Ye Chen, MS[7], John Voss, MD[8], W. Gregory Feero, MD, PhD[9]

1 *Xi*, Senior Nurse Specialist, Research, National Institutes of Health, National Cancer Institute, Center for Cancer Research, Genetics Branch, Bethesda, MD
2 *Eta Mu*, Assistant Professor, Director RN to BSN Program, Rutgers, The State University of New Jersey, Camden campus, Department of Nursing, Camden, NJ
3 *Kappa*, Senior Clinical Advisor, National Institutes of Health, National Human Genome Research Institute, Bethesda, MD
4 Assistant Professor (Clinical), Family and Preventive Medicine, University of Utah; Salt Lake City, UT
5 Associate Director, Physician Assist Program and Associate Professor, Philadelphia University, Philadelphia, PA
6 Assistant Professor, School of Medicine, Medical Education Support, University of Virginia, Charlottesville, VA
7 Web Application Programmer, School of Medicine, Medical Education Support, University of Virginia, Charlottesville, VA
8 Professor, Department of Medicine, General Medicine, University of Virginia, Charlottesville, VA
9 Special Advisor to the Director for Genomic Medicine, National Institutes of Health, National Human Genome Research Institute, Genomic Healthcare Branch, Bethesda, MD; Faculty, Maine Dartmouth Family Medicine Residency, Augusta, ME

Key words
Genetics, genomics, toolkit, repository, nursing curricula, nursing education, physician assistant curricula, physician assistant education

Correspondence
Kathleen A. Calzone, National Cancer Institute, Center for Cancer Research, Genetics Branch, 41 Center Drive, Building 41, RM B622, MSC 5055, Bethesda, MD 20892.
E-mail: calzonek@mail.nih.gov

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Abstract

Purpose: Develop a trans-disciplinary repository of genomics education resources using a Web-based learning management system. The repository maps and organizes genetic-genomic information and materials relevant to educators by healthcare discipline-specific competencies and performance indicators.
Methods: An interdisciplinary project team was established to guide toolkit repository building and usability testing. The toolkit was built using the X-CREDIT software on the Moodle learning management platform, which includes a mapping matrix and browsing function that captures teaching resources in a searchable database linked to competencies, knowledge areas, performance indicators, learning activities and resources, and outcome assessments. Discipline-specific advisory groups assisted in resource identification, competency mapping, and peer review. The toolkit is multidisciplinary, currently including physician assistants and nurses, and provides a resource crosslink to discipline-specific competencies. All resources have a detailed description, and users may contribute new resources, which are peer reviewed for relevance and accuracy by an editorial board. Alpha and beta testing using online usability surveys that included toolkit exercises helped refine the structure, look, and navigation of the final website.
Findings: One hundred thirty faculty– 124 nursing and 6 physician assistant faculty– agreed to participate. Of those, 59 users (45.4% response rate) completed the online usability survey. Nearly all users (94.9%) were able to find a competency that was relevant to their topic, and 85.4% were able to locate the relevant performance indicators. The majority (86.5%) felt the model adequately described the relationships between competencies, performance indicators, learning activities-resources, and assessments, and made conceptual sense. Survey respondents reported font color and size made the information difficult to read, windows were not large enough, and the "shopping cart"

concept was confusing; all of these areas have been modified for the final toolkit version.

Conclusions: Alpha and beta testing of the toolkit revealed that users can successfully obtain educational materials by searching competencies and performance indicators. The platform is accessible on the Internet at http://www.g-2-c-2.org and can be continually updated as new resources become available.

Clinical Relevance: Faculty members need easy access to a wide range of accurate, current resources to facilitate integration of genomics into the curriculum.

Advances are occurring rapidly in our knowledge of how genetic variation influences health and illness (Hunter, Khoury, & Drazen, 2008). Ongoing research and clinical translation of these findings has already moved beyond single gene disorders and expanded into genomics (Feero, Guttmacher, & Collins, 2010). Genomics refers to all genes in the human genome interacting together, with the environment, as well as with personal, psychosocial, and cultural factors (Guttmacher & Collins, 2002). The genome influences the entire healthcare continuum from prior to birth through the end of life. The direct applications of genomic discoveries to clinical care are occurring at an escalating rate. This is most evident in the diagnosis and treatment of single gene disorders: as of February 2011, GeneTests reported 597 laboratories testing for more than 2,200 diseases (GeneTests, 2011). Genome-informed healthcare applications related to common multifactorial conditions, cancer, and pharmacogenomics are increasingly becoming part of routine care. These advances have significant potential for improving health outcomes and have stimulated calls for integration of genomics into health professional continuing education and academic curricula.

Establishing genetics and genomic literacy among all healthcare disciplines is a crucial 21st century task. The translation of these discoveries into health care is hinged on an informed healthcare workforce that can discern when and how to best use genetic and genomic information, technology, and therapeutics. Yet until recently, many healthcare providers as well as educators have had little to no preparation in genomics (Harvey et al., 2007). For example, genomics was only integrated into the American Association of Colleges of Nursing Baccalaureate Essentials in 2008, which are used to establish accreditation standards used by the Commission on Collegiate Nursing Education, one of two nursing program accrediting bodies (American Association of Colleges of Nursing, 2008). Consequently, educators are being challenged to become competent to prepare their students and other practitioners in genomics. To clarify what healthcare providers need to know, both the nursing and physician assistant communities have developed genetic and genomic competencies applicable to their disciplines (Jenkins & Calzone, 2007; Rackover et al., 2007). The primary care physician community has also begun a similar effort (Marshall, 2011). Regardless of the discipline, to facilitate education initiatives faculty members need access to resources that are accurate, current, and readily available to teach genomics. There are several major challenges facing educators, including a lack of financial resources, insufficient training to independently develop curricular materials, and poor access to materials developed by other healthcare disciplines. This article provides an overview of the Genetic/Genomic Competency Center for Education (G2C2), an interdisciplinary online education genetic-genomic resource toolkit (http://www.g-2-c-2.org) designed to help meet these needs.

Methods

Aim

The overall goal of the toolkit initiative was to develop a sustainable, easily accessible resource repository that assists academic and continuing education faculty from multiple disciplines to prepare their constituencies to competently integrate genetics-genomics advances into healthcare practice. The repository concept followed two underlying principles: optimize use of valid education materials and facilitate sharing between healthcare disciplines.

Development Phases

Phase 1. An expert panel was convened in September 2007 to advise the National Institutes of Health development group on content, format, and preferred method of dissemination of materials to be included in a genetic-genomic competency toolkit for faculty utilization in the classroom and clinical setting. Panel members consisted of nursing leaders from schools of nursing, education

support organizations including the American Association of Colleges of Nursing, clinical practice, and genetics organizations. Individuals invited to serve on the panel were selected based on their genetic-genomic expertise, knowledge of academic faculty needs, or individuals who were representing specific nursing organizations. The panel consensus recommendation was to develop a Web-based learning management system that maps and organizes genetic-genomic information and materials relevant to educators by the provider-specific competencies and clinical practice indicators, which consist of specific areas of knowledge and clinical performance indicators. Clinical practice indicators are activities designed to assess the proficiency of a specific competency.

Phase 2. In 2008, the development group selected the Achieving Competency Today (ACT) competency-based education software development group at the University of Virginia to assist them in creating the toolkit. Based on their work, the G2C2 conceptual framework uses the PLA model (professional abilities, learning activities, assessments; Voss, Jackson, Goodkovsky, Chen, & Jerome-D'Emilia, 2009), which links competencies, performance indicators, learning activities, and assessments. Learning activities are the curricular material used to prepare the learner to accomplish professional abilities, and assessments measure the outcomes of the learning activities. The PLA model represents competencies as hierarchical trees with terminal branches consisting of professional abilities (**Figure 1**). To create the Web repository, the ACT X-CREDIT software tool (https://act.med.virginia.edu/) was chosen for its ability to map these various learning tools back to a defined set of competencies. The X-CREDIT tool is built on the open-source learning management system, Moodle (Moodle, 2010).

Phase 3. An interdisciplinary advisory group was established to guide the development of G2C2 utilizing the X-CREDIT platform. This group included development team members from ACT as well as leaders from education, clinical practice, and genetics organizations from within nursing, physician assistant, genetic counselor, and physician communities. The nursing and physician assistant disciplines were selected as the first groups to populate the toolkit because they both had current genetic-genomic competencies and outcome indicators (Calzone, Jenkins, Prows, & Masny, 2011; Jenkins & Calzone, 2007; Rackover et al., 2007).

The first discipline-specific group meeting that was convened was nursing. Representatives to this meeting included nurses who were genetic experts, nursing faculty, and an international consultant from the National Health Service National Genetics Education and Development Centre in the United Kingdom. This group modified the PLA mapping matrix to display the competencies and outcome indicator structures developed by and implemented by both disciplines. The final mapping matrix (see **Figure 1**) includes competencies and core knowledge, performance indicators, learning activities and resources, and assessments. Definitions of content associated with each category are provided in **Table 1**. To illustrate how the mapping matrix functions, **Figure 2** illustrates one family history competency and the specific knowledge, mapping performance indicators, learning activities and resources, and assessments.

Features built into G2C2 include a user's guide to facilitate navigation and use. Discipline-specific competencies and performance indicators can be reviewed and downloaded. Searching can be performed from any of the mapping matrix headers: Competencies and Core Knowledge; Performance Indicators; Learning Activities and Resources; and Assessments. Alternatively, searching can be done using key words (e.g., family history). Resources selected by faculty may be downloaded immediately or stored for future download. After completing selections, faculty can download their choices as a file or e-mail it as a zip file.

Phase 4. This phase involved discipline-specific peer review of available genomic educational materials and resources, primarily Web-based resources. Each discipline (nurses followed by physician assistants) brought together individuals with expertise in genetics or genetic education to form an interdisciplinary team. These groups met face to face in discipline-specific meetings to review the mapping and resources for currency, accuracy, leveling for the specific discipline scope of practice, and applicability to the discipline-specific competencies. Resources that met peer review criteria were then mapped by the discipline-specific teams to the G2C2 matrix (see **Figure 1**). Each resource included in the toolkit has a brief summary as well as detailed description that includes type of resource, cost, estimated "shelf life", specific learning objectives, who peer reviewed the resource, suggested audiences, format including languages, keywords, author, where to locate the resource (including hyperlinks if applicable), activity type such as self-study or book, and relevant copyright information. The ACT development team then populated G2C2 and the entries were peer reviewed by members of the advisory group.

Alpha and Beta Testing

Alpha testing. Alpha testing was designed to evaluate G2C2 functionality and was conducted with members of the advisory group. Each advisory group member was provided with instructions on how to access the toolkit website, information on how to login, and a functional

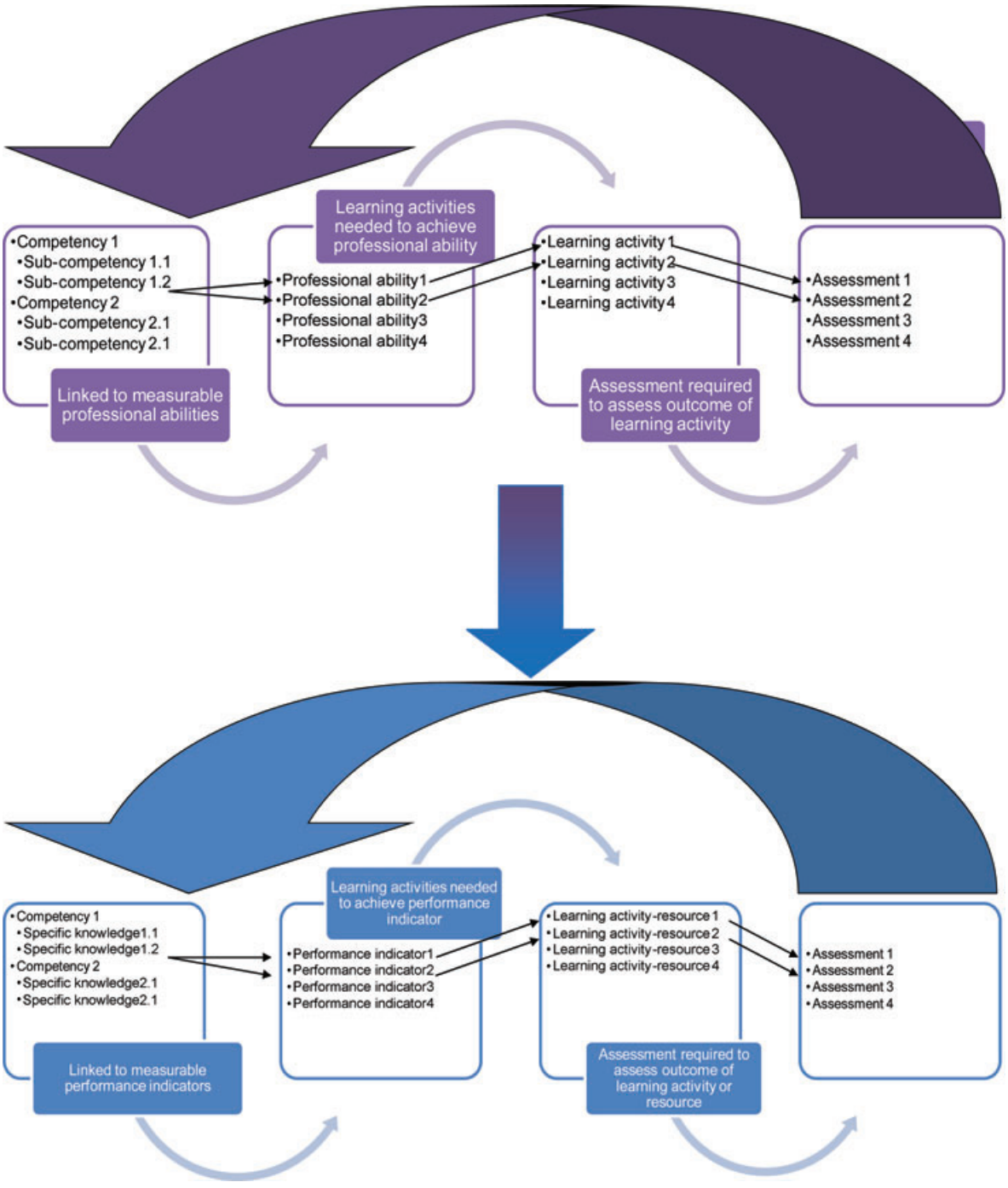

Figure 1. Mapping matrix. (A) PLA curriculum model. (B) Genetic/Genomic Competency Center for Education mapping matrix.

pilot exercise designed for the search and uploading of a specific resource. Revisions to the site were made based on the pilot outcomes and consisted of inclusion of the discipline-specific competencies on the site home page, addition of a tutorial for site navigation, organization of mapping display to be consistent with the competencies, and revisions to the detailed descriptions of the resource.

Beta testing– recruitment and enrollment. Beta testing was targeted primarily toward nurse educators because the nursing portion of the repository was complete

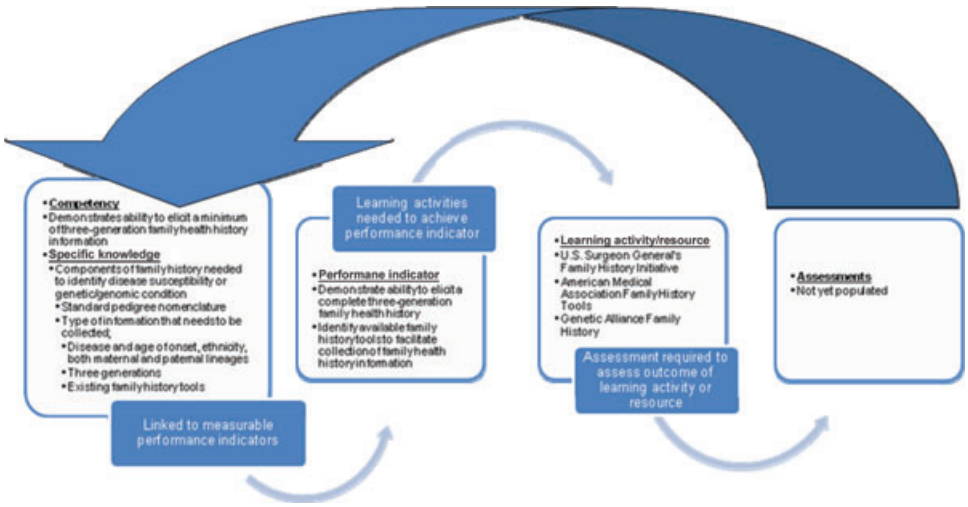

Figure 2. Genetic/Genomic Competency Center for Education family history example.

Table 1. Genetic/Genomic Competency Center for Education (G2C2) Definitions

G2C2 Terms	Definition
Competencies	A high level educational goal for learners
Core knowledge	Specific areas of knowledge learners need to achieve a competency
Performance indicator	A measurable knowledge, skill, or ability of a professional that demonstrates competency
Learning activity and resources	Content designed to develop professional ability
Assessments	Exercises designed to measure the outcome of a learning activity

with regard to the resource peer review, mapping, and uploading of all resource information. Invitation e-mails were sent to the American Academy of Nursing Genetics Healthcare Expert Panel as well as the National Institutes of Health genetic-genomic competency listserve. The invitation informed the educator that participation involved locating resources in the repository and completing an online survey on the experience. Individuals interested in participating were given a Website to sign up for the beta testing. One hundred thirty faculty members, of which 124 were nursing and 6 were physician assistant faculty, agreed to participate. When the beta test was launched, each participating educator was sent an e-mail with G2C2 log-in instructions, the beta test exercise, and a URL for the website to complete the outcome survey. Participants were given 6 weeks to complete the exercise. A reminder e-mail was sent at 4 weeks, 2 weeks, and again 7 days and 2 days prior to the deadline.

Results. All results from the survey were tabulated and analyzed using descriptive statistics. Written comments were categorized and summarized. Surveys were completed by 59 of the 130 educators who had agreed to participate, for an overall response rate of 45.4%. No demographics were collected as part of beta testing. **Table 2** provides an overview of the findings from the exercise portion of the beta test. The majority of participants agreed or strongly agreed that they were able to find a relevant competency (95%), related performance indicator (85%), and associated learning activity or resource (76%). The ability to understand the copyright restrictions and educational value of a resource was less certain, with approximately 23% of respondents reporting that they were undecided as to whether the information provided was sufficient to understand these elements.

Table 3 provides the data associated with the assessment of the mapping matrix used to organize the competencies, outcome indicators, resources, and assessments. More than 90% reported that they agreed or strongly agreed that the competency-based framework improved their understanding of what genetic-genomic content needed to be included in the curriculum. In addition, most felt that the mapping matrix (competencies and specific knowledge, performance indicators, learning activities and resources, and assessments) made conceptual sense.

General comments about the site included confusion about how to use the shopping cart, and text color, font, and layouts were noted as difficult to read. In addition, people commented that the site has resource and assessment gaps.

Table 2. Genetic/Genomic Competency Center for Education Functional Assessment

I was able to:	Strongly disagree *n* (%)	Disagree *n* (%)	Undecided *n* (%)	Agree *n* (%)	Strongly agree *n* (%)	No answer *n* (%)
Find a competency that was relevant to my topic	1	0	2	37	19	0
	(1.7%)	(0%)	(3.4%)	(62.7%)	(32.2%)	(0%)
Locate the relevant performance indicators	1	4	3	31	19	1
	(1.7%)	(6.8%)	(5.1%)	(52.5%)	(32.3%)	(1.7%)
Locate appropriate learning activities/resources to use for teaching the knowledge/skills required for my selected performance indicator	2	6	5	31	14	1
	(3.4%)	(10.2%)	(8.5%)	(52.5%)	(23.7%)	(1.7%)
Find the author/source organization of a learning activity or resource	2	6	4	27	18	1
	(3.4%)	(10.2%)	(6.8%)	(45.8%)	(30.5%)	(1.7%)
Understand the copyright restrictions for a chosen activity	4	5	14	26	8	2
	(6.8%)	(8.5%)	(23.7%)	(44.1%)	(13.5%)	(3.4%)
Assess a learning activities potential educational value based on the detailed description	4	5	17	25	8	0
	(6.8%)	(8.5%)	(28.8%)	(42.4%)	(13.5%)	(0%)

Table 3. Genetic/Genomic Competency Center for Education Mapping Matrix Assessment

	Strongly disagree *n* (%)	Disagree *n* (%)	Undecided *n* (%)	Agree *n* (%)	Strongly agree *n* (%)	No answer *n* (%)
A competency-based framework helps me understand what subject content should be included in the curriculum.	1	1	3	34	20	0
	(1.7%)	(1.7%)	(5.1%)	(57.6%)	(33.9%)	(0%)
The repository model describing the relationships between competencies, performance indicators, learning activities and assessments makes conceptual sense.	2	0	5	25	26	1
	(3.4%)	(0%)	(8.5%)	(42.4%)	(44.1%)	(1.7%)

Discussion

Although preliminary, analysis of the beta test data revealed some important findings. First, the mapping matrix appeared to be useful to educators. However, the survey respondents indicated resource information could be enhanced, and the appearance of the site required modifications for readability and clarity.

At this time, the mapping matrix is predicated on the existence of discipline-specific competencies and outcome indicators. Not all health professionals have developed genetic-genomic competencies. As such, educators from disciplines without established competencies may find the competency framework makes it more difficult to locate resources.

Despite this limitation, the G2C2 development process can be a useful model for other disciplines beyond nurses and physician assistants. As of this time, the genetic counseling profession is actively building their competency mapping matrix and selecting appropriate learning resources. With the ability to crosslink to other disciplines' resources, the addition of the genetic counselors' competency map will be especially valuable to educators interested in additional peer-reviewed genetic resources.

Sustainability of G2C2 is a critical priority. This includes not only maintaining the existing resources but

continuing to populate the site with new resources as they become available. A G2C2 editorial board has been established to ensure that the materials in the toolkit are current, accurate, and of sufficient quality. Editorial board members consist of representatives from disciplines participating in the site. Members are responsible for peer review of new educational resources and assessment materials submitted to G2C2 for consideration of inclusion on the site; they will also conduct periodic evaluation of materials already in the repository to ensure that materials are up to date and accurate.

Next steps for G2C2 are to expand the scope of the information provided for a given resource, including offering the opportunities for educators to rate a given resource they have used. In addition, with the existence of the G2C2 editorial board, an active solicitation of new genetic-genomic educational resources and assessments is planned. As ongoing evaluations indicate ways to improve G2C2's look and function, modifications will be made to improve site usability and efficiency. Continued development and expansion of G2C2 for other disciplines will also be explored as the relevancy of genetic-genomic education expands. The genetic counseling discipline is going through the process to peer-review and upload their resources. Regardless of which disciplines opt to participate in G2C2, any individual from any discipline can access G2C2 at no cost, and search and upload genetic-genomic education resources for their own use.

Conclusions

Alpha and beta testing of G2C2 (http://www.g-2-c-2.org) suggest that health professional educators will be able to successfully locate resources for genetics-genomics education using the repository. This should facilitate education based on approved competencies and performance indicators for at least two health professional disciplines. The mapping matrix provides a rapid mechanism for identifying resource gaps that can target resource development and minimize overlap. The platform is accessible on the Internet to anyone worldwide and can continually be updated as other disciplines develop genetic-genomic competencies or as new resources become available, making G2C2 a sustainable resource for multiple health professional groups both within the United States and in other countries.

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Clinical Resources

- Centers for Disease Control and Prevention, Public Health Genomics: http://www.cdc.gov/genomics/default.htm
- Genetics Home Reference, National Library of Medicine: http://ghr.nlm.nih.gov/
- GeneTests: http://www.ncbi.nlm.nih.gov/sites/GeneTests/
- Surgeon General's My Family Health Portrait: http://www.hhs.gov/familyhistory/

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