

CLINICAL PRACTICE

Genetics and genomics integration into undergraduate nursing education

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Received: October 30, 2014
DOI: 10.5430/jnep.v5n4p13

Accepted: January 2, 2015

Online Published: January 18, 2015

URL: <http://dx.doi.org/10.5430/jnep.v5n4p13>

Abstract

Genetic and genomic science is redefining the understanding of the continuum of human health and illness. The required competency of providing essential information, support, guidance and education pertaining to genetic conditions is expected for all levels of initial pre-licensure preparation. How a nursing curriculum prepares these student nurses to function at their highest capacity depends on how genetics and genomics are integrated into the curriculum. Integrating genetics and genomics as a stand-alone course needs to be innovative and creative while teaching the scientific content. By exploring innovative and creative formats, nurse educators will learn how to enhance their students learning process to become active participants, engaged and focused as they learn to apply their knowledge of genetics and genomics. This paper will discuss practical suggestions for integrating a stand-alone genetic course for baccalaureate nursing students or for threading genetic content through-out the curricula.

Key Words: Genetics/Genomics, Nursing education, Baccalaureate

1 Introduction

The acquisition of knowledge with the human genome mapping and sequencing has led to numerous enhancements in our understanding of the importance of genetic and genomic education for healthcare practitioners.^[1] The identification of genetics and genomics as a learning need for nurses and nursing students led to the establishment of the National Coalition for Health Professional Education in Genetics which developed specific core competencies for the integration of genetics into healthcare education.^[2] Prominent nursing organizations developed specific documents providing guidelines for the integration of contemporary genetic and genomics knowledge related to nursing.^[3] The first genetics education framework was developed in 2003 by the United Kingdom, leading the way for defining genetic literacy for nurse education.^[4] The framework was recently updated to reflect advances in genomic technology, research and implications for integrating genetics into

practice.^[5] Trajectories for the development of genetics-genomics in nursing education and practice is an evolving process, which includes national and international countries working towards a common goal of enhancing the nurses knowledge base, promoting safe and effective care and competent practice^[6] (see Table 1).

It is imperative for nurses to remain at the forefront of the transformation in healthcare and as such, nurse educators must meet these educational learning needs and competencies. This paper will discuss practical suggestions for integrating a stand-alone genetic course for nursing students or for threading genetic/genomic content through-out the curricula.

1.1 Importance of genetic/genomic integration

Genetic/Genomic education should be included in all levels of initial pre-licensure preparation. Nurses in the clinical practice area will need this knowledge to provide ap-

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appropriate referrals and explanations of genetic conditions to patients. The application and integration of genomic information in clinical practice represents numerous areas of nursing involvement. As we begin to integrate genomic information in nursing education, future nurses will have the knowledge for evidence-based application of genomics in the clinical setting. Understanding how genomics is integrated with “preconception and prenatal testing; newborn screening; disease susceptibility; screening and diagnosis;

prognosis and therapeutic decisions and with monitoring disease burden and recurrence” is relevant for nursing practice.^[7] Incorporating genetic/genomic content into nursing education at the pre-licensure level will begin to familiarize students with necessary terminology while preparing them with the essential competencies providing them with the ability to effectively integrate genomic information in clinical care while promoting and protecting the public’s health.^[8]

Table 1: Genetic and genomics nursing documents

Core Competencies in Genetics for Health Professionals	National Coalition for Health Professional Education in Genetics	http://www.nchpeg.org/index.php?option=com_content&view=article&id=237&Itemid=84
Essentials of Genetic and Genomic Nursing: Competences, Curricula Guidelines, and Outcome Indicators	Consensus Panel on Genetic/Genomic Nursing Competencies, 2009	http://www.genome.gov/pages/careers/healthprofessionaleducation/geneticscompetency.pdf
Essentials of Baccalaureate Education for Professional Nursing Practice	American Association of Colleges of Nursing, 2008	http://www.aacn.nche.edu/education-resources/BaccEssentials08.pdf
Essential Genetic and Genomic Competencies for Nurses With Graduate Degrees	Consensus Panel on Genetic/Genomic Nursing & the American Nurses Association, 2011	http://www.genome.gov/Pages/Health/HealthCareProvidersInfo/Grad_Gen_Comp.pdf
Bringing Science to Life: NINR Strategic Plan	National Institute for Nursing Research (NINR)	https://www.ninr.nih.gov/sites/www.ninr.nih.gov/files/ninr-strategic-plan-2011.pdf
Genetics/Genomics in Nursing and Midwifery	Genetics in Nursing & Midwifery Task and Finish Group, 2011	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/215250/dh_131947.pdf
Fit for Practice in the Genetics Era A competence based education framework for nurses, midwives and health visitors	Genomics Policy Unit, University of Glamorgan, and the Medical Genetics Service for Wales, University Hospital of Wales	http://www.geneticseducation.nhs.uk/downloads/0050Fit_for_Practice_Extended_Summary.pdf

The importance of nurses understanding the implications of newborn screening and screening technologies, as a “public health approach to identify treatable conditions in early infancy”, is critical for improving outcomes of affected newborns and their families.^[9] Identifying children with genetic disorders and “facilitating their access to services and resources” is an important role of nurses.^[10] Nursing care of adults with neuropsychiatric conditions requires practicing nurses to identify persons at risk, provide follow-up support and administer medications.^[11] Educating patients while providing resources about cardiovascular genomics, cancer care, metabolic syndrome and autism spectrum disorder requires nurses having a basic working knowledge and understanding of the genetic concepts involved.^[12–15] In addition, nurses play a pivotal role in providing ethical, legal, social support and education to patients and families with genetic/genomic conditions. Nurses’ understanding of genomic science has the “potential to improve care outcomes” yet there still needs to be an “effective integration of genomic information in routine clinical practice” and the integration needs to begin with nursing education.^[7]

1.2 Competency of nurse educators to educate

As with all new competencies, it is incumbent of nurse educators to first become familiar and comfortable with a new topic prior to participating in the educational process of others. The gap between nurses’ genetic aptitude and genetic/genomic research has gradually expanded

over the last decade, leading to nurse educators feeling ill-prepared and under-educated to teach this topic. Nurse educators, in general, exhibit paucity of genetic information.^[16] Current nursing faculty received little formal genetic education and as such, may feel under-prepared to teach a genetic course.^[17] The gap between faculty knowledge and integration of genetic and genomic content in curricula continues today.^[18] Yet for nursing faculty to educate their students, they first must educate themselves. There are several exceptional genetic education programs geared towards the healthcare professional. Courses such as Cincinnati Children’s Hospital, Genetics Education Program/Web-based Genetics Education Institute (WBGI) (<http://www.cincinnatichildrens.org/education/clinical/nursing/genetics/cont/web-genetics/>) or Summer Genetics Institute offered by the National Institute of Nursing Research (<https://www.ninr.nih.gov/training/trainingopportunitiesintramural/summergeneticsinstitute#.UsWwBrRIUXc>) provide the knowledge and skills required to bring this competency to undergraduate (and graduate) education. In addition, the Genetics/Genomics Competency Center (<http://g-2-c-2.org/discipline/nurse>) offers free online material. These programs and numerous online material resources provide nurse educators with a multiplicity of genetic/genomic amelioration opportunities to foster an enhanced comprehension of this content, thus, enhancing nurse educators overall confidence in their own ability to teach this most thought-

provoking material. Once the identified genetic nurse educator has their own educational basis to draw upon, deciding if the genetic/genomic content will be a pre-requisite, stand-alone course or become an integrated part of the curriculum must be decided.

2 How to include genetics/genomics content

Faculty members must decide how the genetic/genomic content will be infused into their curriculum. Some nursing programs have decided to require this content as a pre-requisite to starting the nursing curriculum. Several second-degree nursing programs require genetic/genomic content as a pre-requisite (students continuing their education in nursing after obtaining a bachelors' degree in another area). The course is often taught by the biology department, providing the basic knowledge necessary, however it does not include nursing implications or perspectives.

2.1 Threading through-out curriculum

Threading genetics and genomics through-out the curriculum can provide the required content. However, it requires that the majority of faculty have a basic level of genetic literacy to supplement this content to their already demanding courses, with identification of courses to incorporate the content. Hallmark guidelines to assist nurse educators in how to create a curriculum thread focused on genetics and genomics was developed, thus providing an excellent checklist.^[19] Incorporating genetics/genomics into existing courses in more workable and feasible formats can meet the required competency, providing faculty can integrate additional learning resources for students' involvement.^[17] Foundational sciences (biology; anatomy and physiology; pathophysiology) can provide the basic understanding of DNA concepts (including polymorphisms; penetrance; epigenetics; frameshift mutations and modes of inheritance). Health assessment courses can introduce concepts of gathering patient histories; construction of a 3-generation pedigree; and explanations of genetic testing and screening and basic genetic terminology (such as genotype, phenotype and allelic expression). Nursing ethic courses can effortlessly introduce the ethic, legal and social implications to genetic conditions and genetic testing and screening, including prenatal screening and testing. Pharmacology courses can integrate concepts of pharmacogenomics and pharmacogenetics, including aspects of genetic differences that influence drug metabolism, leading to more individualized and personalized care. Specific didactic courses (medical/surgical; maternal-child; mental health nursing) can integrate precise genetic aspects, such as respiratory system discussion that focuses on the autosomal recessive genetic condition of Cystic Fibrosis and gene therapy; oncology discussions focusing on BRCA 1/BRCA 2 and PBLA mutations and their inherent patterns of breast cancer or discussions of Down

Syndrome Trisomy 21 in maternal-child nursing and the importance of prenatal testing and patient education.

Clinical specialty areas can infuse genetic concepts and expand on students' genetic literacy by providing additional opportunities for assessments and exploration of genetic conditions (including discussions on dysmorphology). In addition, clinical experiences can provide for discussion on genetic conditions, as well as patient education content, on newborn testing for PKU (phenylketonuria); sickle cell anemia, familial hypercholesterolemia, Marfan Syndrome and Alzheimer's Disease. Capstone courses can provide an opportunity for students' to discuss complex multifactorial polygenetic conditions; such as diabetes mellitus, bipolar disorders and schizophrenia, familial retinoblastoma and familial adenomatous polyposis exploring the concept of two-hit theory in cancer and the implications of pharmacogenomics and environmental substances (ecogenetics). Faculty should explore innovative ways to creatively introduce the material (such as with simulation; case studies; exploring their own student population for genetic diversity and cultural background differences).

2.2 Stand-alone course

A stand-alone required course can provide the basic general literacy knowledge that should be expanded upon with subsequent courses. By introducing genetics and genomics early in the program, students will glean a strong understanding of the basic elements, which can then provide for more detailed and inclusive application of the content as students' progress through the nursing program. However, adding a required course to an already heavy course load limits other requirements^[18] and the expectation that there will be further genetic and genomic discussions may be unattainable, as other faculty may not be able (and willing) to build upon the content nor have time to allow for further deliberations. Offering a stand-alone elective genetic and genomic course is also impractical as not all students would elect to take the course.

To be able to thread genetics content and/or continue to integrate it through-out the curricula, nursing programs should identify in-house experts who can work with colleagues to map genetics content to their specific course and then deliver that content. This would help establish faculty who are comfortable with the content and who are able to integrate the required competencies. In addition, it would enhance faculty level of confidence as they are able to augment their own knowledge base. Individual programs must decide what would benefit their program the most: have genetics as a stand-alone course or threading through-out the curriculum and taught by educators within nursing or from another discipline. Additionally, nurse educators need to be cognizant of the ethical, legal and social implications when they discuss this content. With genetics, transparency of the content must be clearly articulated for students to appreciate

that healthcare professionals have knowledge and capability to respond to complex health issues and provide appropriate information and competent care to patients, families and communities.^[20] Finally, educating students that healthcare professionals must ensure client privacy and all information is to be obtained and retained with professional ethical conduct.

2.3 Creating assignments for enhancing student learning outcomes

The author of this paper was asked to develop a stand-alone required course for a large urban, diverse nursing student body; however many of the following assignments can be facily assimilated into a curriculum-thread focused on genetic and genomic. Sixty-six first semester sophomore nursing students, just beginning their professional nursing education, were required to take this 2-credit course. The author participated in the Genetics Program for Nursing Faculty at the Cincinnati Children's Hospital Medical Center, simultaneously reading supplemental genetic and genomics nursing textbooks and articles. Release time was provided to allow for the demands of preparing a syllabus and developing the course and being a "student" of the content herself.

2.4 Development of assignments

The development of assignments, coupled with construction of the course via Blackboard 9.1 platform,^[21] required simultaneous occurrence. Assignments, both individual and group work, were designed to scaffold one another. Likert scale rubrics were developed for each assignment to assist in completion criteria and to provide students with instruction on maximizing their grades. Being conscious to make this an application course, ensuring that students' gained an appreciation for the content, while being creative and innovative for the 21st century student, was the challenge. Course development incorporated creating learning modules for topics (total of nine modules), over 25 URL hyperlinks, which directs the user to the entire document, was provided based on specific module topics. For example, students were provided hyperlinks to the Essential Nursing Competencies and Curricula Guidelines for Genetics and Genomics (<http://www.genome.gov/pages/careers/healthprofessionaleducation/geneticscompetency.pdf>), Human Genetic Variation Fact Sheet (<http://archive.is/9cws>) and Cancer Predisposition Genetic Testing and Risk Assessment Counseling (<http://www.ons.org/Publications/Positions/Predisposition/>).

The inclusion of numerous Mashups via YouTube videos provided basic Genetics 101 content. Mashups are web-pages or web applications and YouTube videos can be uploaded into Blackboard by providing the webpage address. Integrating specific YouTube videos allows students to develop a deeper appreciation of the subject and presents an

opportunity for experiential learning, facilitating dialogue about the content and exposing students to new insights and skills.^[22] In-class group activities provided additional application of the content. Vocabulary definition games were developed, pedigree analysis and construction questions and patterns of inheritance questions were provided as well as online tutorials/learning experiences, such as Genetics Practice Problems (<http://biology.clc.uc.edu/courses/bio105/geneprob.htm>) and Khan Academy/Hereditary & Genetics (<https://www.khanacademy.org/science/biology/heredity-and-genetics/v/punnett-square-fun>). A required textbook, appropriate for sophomore grade level students, provided the basic content for discussion and comprehension.^[23]

2.5 Group assignments

With such a large group of students, creating group activities was essential. Thirteen groups, with 5-6 students in each group, were created. The randomly assigned groups were intended to facilitate collaborative learning.

The first group assignment was to select a genetic condition from a provided list. Via a Wiki page, which was created for them, the group was expected to answer specific questions to provide information and references on their chosen condition. The format for the Wiki assignment was based on the concept of the Genetics Home Reference/Conditions (<http://ghr.nlm.nih.gov/BrowseConditions>). Instructions for reading and posting to Wikis in Blackboard were provided both in the syllabus and on the assignment page on the Blackboard course. This assignment was worth 10%.

The second group assignment was a brief online discussion of Healthy People 2020/Genomics, was worth 5% (<http://www.healthypeople.gov/2020/topicsobjectives2020/default.aspx>). Specific questions for a facilitated online discussion were provided. A summary of each group's discussion was posted on Discussion Board. The final group assignment consisted of a group presentation and paper, based on the same condition as the Wiki assignment, was worth 25%. The presentation consisted of genetic inheritance explanation; pathophysiology of the condition (including manifestations); nursing implications, nursing counseling and screening/tests; patient and healthcare professional resources and a pamphlet for the patient/family. This assignment complemented the Wiki assignment, whereby a significant amount of information from the Wiki assignment would be utilized for the group presentation. Students uploaded their presentation and pamphlet onto Blackboard, providing the entire class with the information.

2.6 Individual assignments

The first individual assignment was the completion of the Cincinnati Children's Hospital Medical Center/Genetic Education Certificate Program: Genetics is Relevant Now:

Nurses' Views and Patient Stories (<http://www.cincinnatichildrens.org/education/clinical/nursing/genetics/instruction/now/>). Students were expected to receive 80% or better to receive assignment credit and correctly upload the certificate in the assigned folder in Blackboard. A screen shot of the actual online website page was provided as well as instructions on various formats to upload the certificate. This assignment was worth 5%.

The second individual assignment, worth 35%, was a paper that required a 3-generation pedigree (using standard pedigree symbols) on their own family, a friend's family or a patient. Students were provided with numerous resources for pedigree construction. In addition to the pedigree with a detailed legend, students provided a brief narrative of relationships found in the family history. They were instructed to select one individual in the family history and evaluate that individual for specific risk factors, including medical conditions and possible genetic inheritance based on the family pedigree. Inclusion of Healthy People 2020 Genomics and other learning resource websites that would be beneficial for this individual were to be included, as well as aspects of what the nurse can teach this individual/family on preventive healthcare based on the pedigree.

3 Lessons learned

While the assignments were well received and students felt that they were fair and appreciated that they did provide information for subsequent assignments, as the educator, the author felt that there was significant lack of in-class participation. The author repeatedly requested that students be prepared for the in-class dialogue and gave several warnings that quizzes would be implemented if participation did not increase. Unfortunately, with only less than 10% of the students contributing to the in-class discussion content, the author felt compelled to have two separate quizzes based on the textbook readings. The module content was evenly divided among the two quizzes, with 30 multiple choice questions per quiz. Interestingly, the grades for the two quizzes were impressive, with only a small percentage receiving less than passing grades. Each quiz was worth 10%. The students themselves apologized for not engaging in the discussions, stating that they felt 'overwhelmed' with their first semester of nursing courses, not knowing how to prepare for nursing courses and underestimating the time required for preparation. However, they respected the assignments and understood the importance of being prepared for all future classes. In addition, the author felt that the group paper

based on the group presentation was unnecessary as the paper was a duplication of the presentation content. Thus, revisions to the syllabus will include implementing scheduled quizzes and omitting the group presentation paper. When the author approached the students with these revisions, they felt that this was appropriate and fair. Impressively, the average final grade was 90.95 (n = 66; median 91.55 + SD 3.09). The highest grade was 96.05 with the lowest grade being 80.15. Forty students final grade ranged 90-100 and twenty-six students had their final grade ranging 80-89.

4 Conclusion

The integration of genetics and genomics into the nursing curriculum was well received by the faculty. Providing a variety of learning strategies, engaging students intellectually as well as motivationally, succeeded in achieving the learning outcomes. The practical implications of integrating this content into nursing care begins with broadening students' perceived and actual knowledge while providing them with the tools to further their own self-directed learning. The author has already conducted a survey to obtain the students actual knowledge of genetics after completion of the stand-alone course and has obtained the students retained knowledge of genetics one year after course completion. The author intends to conduct the same survey to obtain results of retained knowledge post-two years after completing the course. In addition, the author hopes to be able to survey these students relating genetic content learned and its application to the clinical area.

An informed nurse begets an informed workforce who can understand basic genetic and genomic concepts, pharmacogenomics, provide patient education and make referrals when necessary. This is the future of the nursing profession and these are the essential elements for a 21st century nurse. The goal to increase genetic and genomic understanding, awareness and appreciation^[24] is the requirement of all nurse educators, nurses and healthcare providers. As such, the nursing profession, as a whole, must be prepared to be active participants with effective roles in genetic and genomic healthcare. With nursing students of all educational levels, is it necessary for nurse educators to provide a variety of learning strategies, to stimulate self-directed and collaborative learning.

Conflicts of Interest Disclosure

The author declares that there is no conflict of interest statement.

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