An Innovative Integration of Genetics and Genomics Content into a Baccalaureate Nursing Curriculum: The Web-Based Mini-Course in Genetics and Genomics

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Abstract— **The purpose of this project was to develop a self contained web-based mini-course which meets the identified genetics and genomics competencies for undergraduate nursing education so that it can be utilized by a baccalaureate nursing program. The Plan-Do-Study-Act model for quality improvement was used to guide this project that included assessing knowledge in genetics and genomics of 2 cohorts of baccalaureate nursing students. Clear outcome measures were established and both groups took a 16 question quiz based on established genetic competencies for baccalaureate nursing education. Additional outcomes were measured regarding a family pedigree construction and a genetics resource/referral activity. The mean genetics quiz score for the pre-intervention student cohort was 49.3% versus the mean genetics quiz score of 88.7% for the student cohort who completed the web-based mini-course in genetics and genomics. Nursing scholars and educators have clearly documented the need to integrate genetics and genomics into the baccalaureate nursing curriculum, but limited documentation exists on how to do so. This quality improvement project offers an innovative and effective method in which to accomplish this challenging task and suggests additional application to master's and doctoral level nursing educational programs as well.**

Keywords – Genetics; genomics; nursing education.

I. Introduction

A. Clinical Issue

The Human Genome project was completed in 2003 and with it a plethora of healthcare applications and possibilities came into existence. As a result, the majority of future healthcare endeavors will most likely include a genetic component. Vocabulary such as genotype, phenotype, karyotype, pharmacogenomics, oncogenes and pedigree analysis will become plentiful in health care literature and practice. In the future it will be common public expectation that nurses when providing care be knowledgeable regarding genetics and genomics [1].

As growth of knowledge regarding genetics and genomics explodes, our profession is not prepared to meet the challenge. The literature reveals that our practicing nurses, our nursing faculty, and our nursing students all have limited knowledge regarding genetics and genomics. Thus the problem exists, how best to integrate genetics and genomics information into nursing practice and nursing education. It is time to resolve this dilemma. Our profession must start now by integrating this information into its basic educational programs. This project not only suggests an innovative method for integration of genetics and genomics content, but carries out this practice improvement project in an established baccalaureate nursing education program.

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B. Significance to Healthcare

While nursing leaders have adequately identified an immediate need for enhancing genetics and genomics knowledge within the profession [1], [2], the challenge is how to educate nurses for their expanded role in the genomic era [3], [4]. Unfortunately, it is noted that "current academic nursing education does not adequately prepare nurses for the evolving role in today's genomic era."[1] Thus, the largest health profession, nursing, must resolve this dilemma now and begin by integrating essential genetics and genomics information into its baccalaureate educational programs by innovative and effective means. Since the majority of future of healthcare endeavors will most likely have a genetic based component, the profession must make a move now to include this content in educating its students, faculty and clinicians. If our profession fails to do so, we may be left behind in the future genomic age.

C. Evidence/Literature Review

Competencies have indeed been established for nursing education regarding genetics and genomics [5], [6], [7], [8]. Despite established competencies, the literature indicates limited student knowledge in both undergraduate and graduate nursing education regarding genetics and genomics content, and additionally nursing faculty are not prepared to teach this content [9], [10]. Documented efforts to determine the best method(s) to effectively teach genetics and genomics content are limited. One study found a negative relationship between genetics in the curriculum, perceived student knowledge, faculty who attended a genetics institute and student competency [11]. Though few studies have documented effective ways to teach genetics and genomics content, one found that a web-based educational approach shows promise [12]. Ultimately, the goal is that nurses are able to integrate genomics into daily practice. Calzone, et al. using a convenience sample of licensed registered nurses found genomic competency is limited among respondents with nurses expressing inadequate preparation in the area, and the majority rated their knowledge base in genomics as poor or fair, but most were eager to increase their knowledge regarding genomics [13].

[1]*Calzone et al., 2010, p. 29*

D. Purpose

The purpose of this practice improvement project is to develop a self-contained web-based mini-course to be utilized by an existing baccalaureate nursing program that meets identified genetics and genomics competencies for undergraduate nursing education. The goal is that this genetics and genomics mini-course can be utilized now and with future student cohorts within the baccalaureate nursing program.

II. Methods

A. Clinical Question

Does a self-contained, web-based mini-course in human genetics and genomics prepare undergraduate nursing students to meet the established competencies for baccalaureate nursing education?

B. Project Design

The design for this practice improvement project utilizes the Plan-Do-Study-Act (PDSA) model of quality improvement developed by the Agency for Healthcare Research and Quality [14]. The Plan encompasses the entire project development including defining the clinical issue with its significance to health care, gathering the evidence by reviewing the literature, defining the purpose, identifying the setting and target population, applying a theoretical framework, planning the intervention, and developing the outcome measures. The Do portion includes implementation of the genetics and genomics educational module along with collection of outcome measures. The Study portion includes data analysis. The Act step is actual integration of the genetics and genomics module permanently within the baccalaureate program.

C. Setting/Sample

The setting is a small well established private university in the southeast United States with a long standing, successful baccalaureate nursing program which was the first such program in the state. The target population included 27 junior level traditional baccalaureate nursing students enrolled during the summer of 2013. The student population and the placement of the course within the curriculum were both determined by the BSN director.

D. Framework

Rogers's Diffusion of Innovations [15] was used as the framework for the intervention. With the innovation identified as the genetics and genomics educational content, and the diffusion as the integration of the genetics and genomics content into the BSN curriculum, an identified change agent was essential to the success of the intervention. Rogers defines a change agent, as the person who influences innovation decisions within the group [15]. In this quality improvement project the director of the BSN program was the change agent and played an integral role in the adoption and intervention phases. The BSN faculty recognized that the content area regarding genetics and genomics was minimally meeting essentials for baccalaureate nursing education, and welcomed the project, and thus were identified as early adopters [15].

E. Intervention

Pre-intervention determination of existing knowledge regarding genetics and genomics took place during the summer of 2012 when a cohort of graduating senior nursing students was given a 16 item quiz based on the expected competencies for baccalaureate nursing education. The quiz results were tabulated and measures of central tendency determined. Next, the intervention step occurred with the development a self contained web-based course entitled "The Web-Based Mini-Course in Genetics and Genomics". The project director developed the course after course objectives (Table 1) were written based on the expected genetics competencies within *The Essentials of Baccalaureate Education for Professional Nursing Practice* [6] and *Essentials of Genetic and Genomic Nursing: Competencies, Curricula Guidelines, and Outcomes Indicators* [5].

TABLE 1 COURSE OBJECTIVES

Upon completion of this course the student will be able to:

1. Differentiate between genetics and genomics.
2. Differentiate between mitosis and meiosis.
3. Differentiate between genotype, karyotype, and phenotype.
4. Distinguish between conditions which are euploid as aneuploid.
5. Construct a 3 generation pedigree based on family history.
6. Analyze a three generation pedigree based on family history.
7. Classify the mode of inheritance of a genetic condition based on a three generation family pedigree.
8. Discuss environmental factors that affect genetic outcomes.
9. Identify various multifactorial genetic conditions.
10. Discuss ethical implications of management of genetic conditions.
11. Discuss genetic testing resources for patients and families.
12. Identify resources for genetic services, referrals, and support groups.

Measurable learning outcomes were established in order to evaluate the effectiveness of the educational intervention. The course was offered via the university on-line learning platform *Moodle*, and it contained five distinct modules that could very easily be completed on-line within 8 – 10 clock hours. The project director developed the course which included *PowerPoint* mini-lectures, interactive open access government based genetics web-sites, family case studies, family pedigree construction exercises, and on-line access to genetics resource and referral sites. The intervention phase took place from June 27 - July 15, 2013 with 27 junior level baccalaureate nursing students enrolled in the summer session participating in the course. Participants did not take the course for college credit, did not receive a final grade on an official college transcript, and their decision to participate did not affect grades in any other current or past courses.

F. Data collection and analysis

The pre-intervention data collected in August 2012 based on the 16 item multiple choice quiz revealed that much improvement was needed in meeting the recommended competencies. In summer 2013 the 27 student participants took the same 16 item multiple choice quiz after completing the "Web-Based Mini-Course in Genetics and Genomics". The post completion quiz scores were tabulated via scantron with standard item analysis and point biserial determination. Data regarding quiz results from both groups was entered into *Excel* 2007 (Microsoft USA) and analyzed for measures of central tendency with statistical significance determined by a two sample t-test. Statistical significance was established at $p < 0.05$. Additionally, students in the post-intervention group completed a genetics based family case study and pedigree construction project which was designed to document achievement of the additional outcome measures. Scores on the family case study pedigree construction project and the resource and referral plan were determined via grading rubrics listed in Table 2 and Table 3.

TABLE 2 FAMILY PEDIGREE – SCORING RUBRIC

Grading Criteria	Percent of Grade
1. The pedigree is titled.	10%
2. The pedigree contains 3 generations.	10%
3. Each generation is denoted by a Roman numeral; each person in a generation is denoted by an Arabic number.	10%
4. Correct symbols are used for gender.	10%
5. The proband is identified.	10%
6. Correct symbols are used for relationship lines and deceased relatives.	10%
7. Consanguinity is correctly labeled if present.	10%
8. Twins are labeled correctly if present.	10%
9. The pedigree is signed and dated by the history taker.	10%
10. The mode of inheritance is identified.	10%
	Total 100%

TABLE 3 RESOURCE & REFERRAL PLAN - SCORING RUBRIC

Grading Criteria	Percent of Grade
1. Inherited or multifactorial condition(s) are identified per family pedigree.	20%
2. At least two referral sites are identified for the specific condition(s) identified.	40%
3. Patient education information is made available based on the specific condition(s) identified and posted via an attachment or website.	40%
	Total 100%

Each of these sets of data was also entered into *Excel* 2007 (Microsoft USA) with determination of measures of central tendency. Achievement of the project outcomes was determined by comparing results of the three student activities with the established outcome measures seen in Table 4.

TABLE 4 LEARNING OUTCOMES WITH ASSESSMENT METHOD AND OUTCOME MEASURES

Expected Outcome	Assessment Method	Outcome Measure	Results
Student participants will demonstrate mastery of basic principles of genetics and genomics.	Mastery of basic genetics and genomics principles will be assessed by completion of a sixteen question multiple choice quiz.	Ninety percent of all student participants will score 70% or better on the quiz.	Outcome achieved. Score of ≥70% achieved by 93% of participants. Mean quiz score 88.7%. n = 27
Student participants will construct and analyze a three generation family pedigree based on a given family case study.	Construction and analysis of a three generation pedigree by student participants will be assessed for accuracy based on the established grading rubric.	Ninety percent of all student participants will score 80% or greater on the construction and analysis of the family pedigree based on the grading rubric.	Outcome achieved. Score of ≥ 80% achieved by all participants. Mean score 95%. n = 18
Student participants will develop a resource and referral plan for a family or individual with a given genetic condition.	A resource and referral plan for a family and/or individual with a genetic condition will be developed by each student based on the established grading rubric.	Ninety percent of all student participants will score 80% or greater on the genetics resource and referral plan based on the grading rubric.	Outcome not achieved. Score of ≥ 80% achieved by 85% of participants. Mean score 94%. n = 20

G. Ethical Issues

Students were enrolled in the "Web-Based Mini-Course in Genetics and Genomics" by using an assigned log-in and password number rather than name. Student information and identifiers were not available to the project director. All quiz results were submitted without student identifiers and tabulated via scantron. The final case study was also submitted without student identifiers and results were scored via the established grading rubrics. By enrolling in the course, students implied consent to participate and students were free to choose not to complete the course at any time if they so desired. The project was approved as a quality improvement initiative as delineated in the quality improvement checklist established by the Medical University of South Carolina Institutional Review Board.

III. RESULTS

A. Quiz Results

The pre-intervention group included 19 baccalaureate students and the post-intervention group included 27 baccalaureate students. The mean quiz score for the pre-intervention student group was 49.3% as compared to the mean quiz score of 88.7% for the post-intervention student group (Figure 1). The difference in results between the pre–intervention and the post-intervention groups was found to be statistically significant using a two sample t-test ($p < 0.001$).

B. Family Pedigree with Resource and Referral Plan

Not all of the students who enrolled in the "Web-Based Mini-Course in Genetics and Genomics" chose to complete the family pedigree construction assignment and the resource and referral plan assignment. Eighteen students completed the family pedigree assignment and 20 completed the family resource and referral plan assignment. Those students in the post-intervention group that completed the family pedigree construction assignment had a mean score of 95% as scored per grading rubric (Table 4). Those students who completed the genetics resource and referral plan had a mean score of 94% based on grading rubric (Table 4).

C. Learning Outcome Measures

All learning activity results were compared to the established learning outcome measures. As shown in Table 4, expected outcomes were achieved on two of the three student activities. Of the 27 students who completed the course and took the quiz, 93% achieved a score of ≥ 70% on the genetics quiz. Of the 18 students who participated in the family pedigree construction activity, a score of ≥ 80% was achieved by all participants. Of the 20 students who participated in the genetics resource and referral plan, a score of 80% was achieved by 85% of the students.

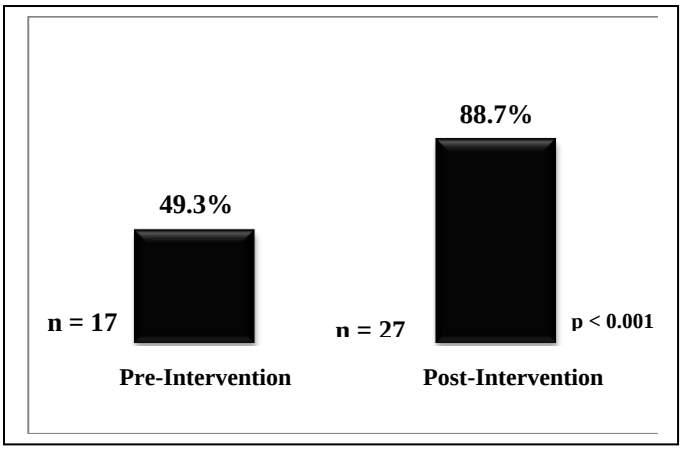

FIGURE 1 WEB-BASED MINI COURSE IN GENETICS AND GENOMICS PRE-INTERVENTION AND POST-INTERVENTION MEAN QUIZ SCORES

IV. Discussion

This quality improvement project proposes an option for educating baccalaureate nursing students regarding genetics and genomics content. The "Web-Based Mini-Course in Genetics and Genomics" was carefully designed and written to meet *The Essentials of Baccalaureate Education for Professional Nursing Practice [6]* and *Essentials of Genetic and Genomic Nursing: Competencies, Curricula Guidelines, and Outcomes Indicators [5]*. Prior to course development, course objectives were written along with clearly measurable outcomes. The student participants were junior level baccalaureate nursing students and the outcomes were achieved in two of three areas. The mean score on the genetics quiz given to the pre-intervention group of baccalaureate nursing students was 49.3 % as opposed to the post-intervention baccalaureate student quiz score of 88.9%. Student participants were also able to construct and interpret a three generation family pedigree for an individual with a genetic condition as delineated per the outcome measures.

Dramatic improvement in quiz scores along with positive achievement on 2 of the 3 proposed outcome measures suggests that this approach is a viable option for teaching genetics and genomics content to baccalaureate nursing students. The one outcome measure that was not achieved related to development of a resource and referral plan for a patient or family with a genetic condition. Though this outcome measure was not met, a full 85% of all the students who developed the referral plan scored 80% or greater with the mean score of 94% on the activity. These findings though not meeting the established outcome measure are still noteworthy and impressive. Those students who did not score as expected omitted a portion of the referral plan by obviously failing to refer to the grading rubric.

The literature abounds with documentation that the nursing profession must enhance its knowledge regarding genetics and genomics [1], [2], [8], [17] and with nurses' desire to increase understanding of genetics and genomics [13], [16]. As knowledge regarding genetics and genomics explodes nursing is not prepared to meet this challenge. Documented methods to resolve this dilemma are limited.

Limitations of this project include that it is of a quality improvement nature and therefore findings may not be generalized to other educational settings. Since the project was based on the PDSA model of quality improvement, it was ideal for this academic institution that had identified a particular need for improvement and then offered a viable solution of just how to integrate genetics and genomics content into its curriculum. As a result of this quality improvement project, the faculty of this institution has decided to integrate the "Web-Based Mini-Course in Genetics and Genomics" into the curriculum at both the baccalaureate and graduate level. At this time, the content will not be offered as a standalone course, but as a mini-course embedded in the undergraduate pediatrics and graduate level pathophysiology courses.

It is imperative to note that not only is it essential to integrate genetics and genomics content into baccalaureate nursing programs, but also into graduate nursing programs, on both the master's and doctoral level, as well. The American Association of Colleges of Nursing [18], [19] and the American Nurses Association with the International Society of Nurses in Genetics [8] both address genetic and genomic competencies for graduate nursing education. Therefore, the "Web-Based Mini-Course in Genetics and Genomics" most definitely may also be utilized in both the master's and the doctor of nursing practice curriculum and in part serve to meet competencies for graduate nursing education.

V. Conclusions

With the completion of the Human Genome project in 2003, the likelihood of extensive genetic based health care applications exists. Nursing, the largest health care profession, is not currently prepared to meet the challenge of integrating this explosive growth of knowledge into its practice or educational programs. Though nursing scholars and educators have clearly documented the need and desire to integrate this genetic and genomic knowledge, limited documentation exists on exactly how to do so. It is now time to move forward by integrating genetics and genomics across the entire spectrum of nursing education from the baccalaureate level to master's and doctoral level nursing programs.

This quality improvement initiative offers an innovative and successful method for integrating genetics and genomics content into a baccalaureate nursing curriculum. In this project an interactive web-based course in genetics and genomics was carefully designed to meet the established essentials for undergraduate nursing education. The project proved to be very successful with 2 of the 3 learning outcome measures achieved and resulted with subsequent integration of genetics and genomics into the curriculum of this particular baccalaureate nursing program. The challenge now is for all

nursing schools to consider such innovative methods to integrate genetics and genomics into their curricula across the entire educational spectrum – baccalaureate, master's and doctoral - so that present and future generations of nurses are not left behind in the ever expanding age of genomics.

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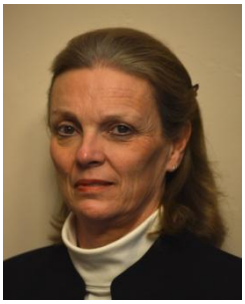

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