

ORIGINAL RESEARCH

Perceived genetic knowledge among pre-licensure undergraduate nursing students

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ABSTRACT

Objective: This study assessed the perceived retention of genetic knowledge of pre-licensure undergraduate nursing students who received a stand-alone genetics course.

Methods: Design: Two analyses of total score were of interest: 1) Assessment of retention of knowledge of education group at sophomore level [n = 62; 2013], junior level [n = 60; 2014] and senior level [n = 42; in 2015] and 2) Comparison of the education group [n = 62] to a control group who learned genetic content that was woven into their clinical courses [n = 74]. Methods: Data were analysed using analysis of variance (ANOVA), as the total scores were approximately normally distributed. *p*-values less than or equal to alpha = 0.05 were considered statistically significant. Some subjects in the assessment of retention knowledge over time remain the same.

Results: The education group had a statistically significantly higher total score than the control group: mean \pm standard deviation = 70.1 ± 13.8 vs. 54.2 ± 19.6 , respectively for education and control groups; *p*-value < .001. Although education clearly had an impact on total score, the perceived knowledge was not retained over the years: average total scores of 70.1 in 2013 to 67.2 in 2014 and 61.6 in 2015; *p*-value = .006.

Conclusions: Education has a significant effect on perceived knowledge, yet maintaining that knowledge base requires reiteration of the content through-out the curriculum. Clinical Relevance: Nurse educators' need to be able to integrate genetic/genomic competencies into nursing curricula and reinforce the content to ensure nursing students are able to retain and utilize this knowledge when in practice.

Key Words: Genetics, Genetic knowledge, Genetic education, Clinical comfort, Nurse

1. INTRODUCTION

The recognition of the importance of genetic knowledge for healthcare professionals has exponentially increased within the last decade. The 21st century healthcare provider must be capable of interpreting evidenced-based science relating to genetics in clinical settings as well as actively participating in the education of patients, practice and policy making regarding genetic information, knowledge and utilization. The most current transformation in healthcare within the last several decades has been the study of the human genome

as part of the Human Genome Project (HGP), an international, collaborative research program whose goal was the complete mapping and understanding of all human genes (NIH/National Human Genome Research Institute.^[1] The exponential expansion of our understanding of medical genetics is transforming medicine, nursing and health care as a whole. The original instructive agenda in genetics, established in the United Kingdom, reflected the expansion in genomic knowledge, research and inferences for incorporating heredities into practice.^[2,3] Multinational countries

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are collaboratively working to augment genetics/genomics in nursing education and practice, ensuring safe, proficient and effective care, by promoting nurses' genetic knowledge base.^[4] The National Coalition for Health Professional Education in Genetics developed fundamental competencies for the incorporation of genetics into healthcare education, ensuring the advancement of learning needs of nurse educators, clinicians and students.^[5] These core proficiencies for the incorporation of genetics/genomics into education for healthcare professionals from all disciplines describe the essential minimum knowledge and skills.^[5,6] These core competencies provide the foundational structure for the educational preparedness of practicing nurses and nursing students. All nurses, including pre-licensure, are required to be able to deliver proficient direction and gen to their patients and family concerning hereditary conditions.^[7]

1.1 Purpose

As nurses, nurse educators and scientists, it is important to be aware of the current knowledge base of nursing students. The purpose of this study was to assess the retention of perceived knowledge over time of pre-licensure baccalaureate nursing students who were required to take a newly developed stand-alone genetics education course as sophomore students in 2013 (2nd year), collecting data when they were sophomores (2nd year), juniors in 2014 (3rd year) and as seniors (4th year) in 2015. Comparison of the education group (having taken the stand-alone course) to a control group (genetic content threaded through curriculum) was completed by looking at data from 2013, when the sophomore level (2nd year) received the education/stand-alone course and the junior and senior students (3rd & 4th year did not have a stand-alone genetics course, thus serving as the control group). In addition, comfort levels in obtaining and explaining genetic conditions was also obtained. Erudition of the students' perceived genetic knowledge will empower nurse educators to further implement genetic and genomic content into nursing curricula, and broaden students' understanding of the need for future nursing research in this exciting new area. The nursing profession including current nursing students, is now required to be familiar and, hopefully, comfortable with these competencies in order to successfully integrate into their practice, leading to safe and competent patient care.

1.2 Literature review

Genetic and genomic knowledge and understanding is essential for the 21st century nurse in order to provide safe and effective practice. With new knowledge come new responsibilities and required competencies that must be integrated into the current educational process. Integrating genetics into pre-licensure curricula will provide the core required

competencies leading to an informed workforce that utilizes evidence-based practical knowledge to explain genetic concepts, provide patient education and participate in the care of patients as a valued member of the inter-professional team. "There is no standard measure of genetic literacy for nurses at any level of education or practice"^[8] yet there is a significant gap in nurses' genetic knowledge and ability to integrate that knowledge into practice.^[9,10] Studies exploring perceived genetic knowledge and teaching strategies related to the inclusion of genetic content into curricula has been conducted in the United Kingdom;^[11,12] New Zealand;^[13] Japan;^[14] Turkey;^[15] Taiwan;^[16] and the United States.^[7,8,17-21] These studies revealed that perceived genetic knowledge and clinical comfort remain inadequate among pre-licensure nursing students or advanced practice nursing students.^[16] Studies exploring nurse faculty members' perceived knowledge of genetics continue to demonstrate the limitation of faculty to teach this content.^[22-25] Based on the current findings of these various studies, continued exploration into the grasp of perceived genetic/genomic of students and their comfort level in integrating this knowledge into their practice and future careers as healthcare professionals is required. A nurse who is prepared to integrate and explain this new discipline will be able to assist "an individual or family in understanding their condition or treatment regimen by answering questions or clarifying information that has been provided by other healthcare professional".^[26]

2. METHOD

A descriptive comparison of an education group to a control group assessed the perceived retention of genetic knowledge and comfort level of pre-licensure nursing students during their education. Institutional review board (IRB) approval was obtained prior to the beginning of data collection, with data collection occurring between 2013-2015. Permission to utilize Genetics Literacy Assessment Instrument (GLAI) questionnaire survey by its original creator and IRB approval to utilize the survey were received. All pre-licensure undergraduate baccalaureate nursing students, in a diverse urban public university, were invited to participate in this study, with an IRB-approved announcement read by proctors/research assistants (RA) in all student grade levels. Participation was voluntary, anonymous and confidentiality was assured. Returning the survey was considered to have given consent. All students were informed that they were not required to partake in this study, nor would their course grade be affected by not participating. The researcher was not present for any of the data collection process.

Data collection was collected in the fall semester of each academic year during the student's major didactic lecture,

except for the original education group in 2013. The data for these 2nd year sophomore level students was collected on the last day of the stand-alone required genetic course by the RA. All other forms of data collection occurred either in the first two weeks or last two of the major didactic lecture, with the RA present to read the IRB-approved script and hand out/collect the GLAI survey. The didactic educator, based on his/her teaching priorities, determined when it would be best to conduct the survey, as to not disrupt his/her class.

2.1 Instrument/assessment of perceived genetic knowledge and comfort level

A systematic literature review to identify instruments to explore nursing students' perceived genetic literacy was conducted and the GLAI was chosen as the instrument for this study.^[27,28] This instrument, initially developed to evaluate genetic education in undergraduate nonscience majors, has been utilized in nursing studies and has been validated as a reliable assessment of nursing students' and faculty's knowledge of genetic concepts, providing accurate assessment of foundational genetic/genomic knowledge.^[8,20] The GLAI, a 31-item multiple choice survey assessing 17 sub-concepts organized around six larger domains: nature of genetic material; transmission; gene expression; gene regulation; evolution; and genetics and society, providing a well-grounded level of perceived knowledge of genetics/genomics concepts correlating to the nursing professions' concepts. In addition to the GLAI, participants were asked to complete three demographic questions (grade level, gender and age) as well as two questions to explore students' perceived comfort level: How comfortable in collecting a patients' family history/drawing/analyzing a three-generation pedigree and how comfortable in explaining the various Mendelian inheritance patterns to patients (such as autosomal dominant, autosomal recessive, X-linked disorders and mitochondrial disorders). These two questions had responses of comfort ranging from extremely, very, somewhat, not comfortable or unsure of comfort level. Exploring clinical comfort level is an important concept as it relates to level of knowledge (genetic concepts and diseases) and ability to inform patients about the risk of genetic conditions.^[15,19,24]

2.2 Education group

The author of this paper developed a stand-alone 2-credit required didactic class for sixty-six first semester sophomore (2nd year, fall 2013) pre-licensure baccalaureate nursing students, in a large urban school of nursing.^[7] Prior to this stand-alone course, genetics and genomics content was expected to be threaded through the major didactic lectures, however, as evidence has proven, nursing faculty are not adequately equipped to provide that knowledge. The stand-alone course was based on an application model, providing

12 students with numerous strategic experiential learning opportunities and scaffolding of assignments to enhance their ability to integrate the content into their nursing knowledge base. This course explored the implications of genetics on nursing practice, including the basic principles of gene action and inheritance models; innovations in genetics and genomics research and the integration of genetic information into nursing practice including ethical, legal, and social issues. The premise for introducing the genetics course at the beginning of the students' educational process was intended to develop basic comprehension of genetic content, furthering that knowledge through the program progression.^[7] The sophomore level students (2nd year, 2013) were the first to begin with a newly revised and updated curriculum, which included the stand-alone genetics course. Assessment of retention of perceived knowledge over time, as well as comfort level, was completed by looking at the 2013 sophomores (2nd year) data and collecting data when they were juniors in 2014 (3rd year) and as seniors (4th year) in 2015.

2.3 Control group

These students were in their junior (3rd year) and senior (4th year) levels in 2013. Comparison of the education group (having taken the stand-alone course) to a control group (genetic content threaded through curriculum) was completed by looking at data from 2013, when the sophomore level (2nd year) received the education/stand-alone course and the junior and senior students (3rd & 4th year) did not, thus serving as the control group. Genetics and genomics content was expected to be threaded through-out the curriculum, therefore, the expectation was that they received their genetic education by this indirect route in addition to the standard requisite biology course. The curriculum was identical for both junior and senior level students and was being phased out.

2.4 Participants

In 2013, one hundred and thirty-six pre-licensure undergraduate nursing students completed the GLAI, with sixty-two sophomores (2nd year), 32 juniors (3rd year) and 42 seniors (4th year). In 2014, one hundred and twenty-four students completed the GLAI, with 60 juniors (3rd year) and 64 seniors (4th year). It is important to remember that in the education group, the juniors in 2014, were sophomore students (2nd year) in 2013. While the seniors in 2014 were juniors (3rd year) in 2013 and were part of the control group who did not participate in the stand alone course. Finally, in 2015, forty-two senior level (4th year) pre-licensure undergraduate nursing students completed the GLAI. These students were junior level (3rd year) in 2014 and sophomore level (2nd year) in 2013. All participant demographics are shown in Table 1.

Table 1. Participant demographics

Year/Grade Level [n =]	Percentage	Year/Grade Level [n=]	Percentage
2013: Sophomore [2 nd year] n = 62			
18-20, n = 27	15.56%		
21-25, n = 13	4.30%		
26-30, n = 2	0.66%		
Male, n = 8/2.65%; Female, n = 54/17.88%			
Junior [3 rd year] n = 32		2014: Juniors [3 rd year] n = 60	
18-20, n = 9	2.98%	18-20, n = 34	11.26%
21-25, n = 18	5.96%	21-25, n = 24	7.95%
26-30, n = 3	0.99%	26-30, n = 2	0.66%
31-35, n = 1	0.33%		
35+, n = 1	0.33%	Male, n = 15/4.97%;Female, n = 45/14.9%	
Male, n = 5/1.66%; Female, n = 27/8.94%			
Seniors [4 th year] n = 42		Seniors [4 th year] n = 64	
18-20, n = 2	0.66%	18-20, n = 4	1.32%
21-25, n = 34	11.26%	21-25, n = 51	16.89%
26-30, n = 3	0.99%	26-30, n = 3	0.99%
35+, n = 1	0.99%	31-35, n = 2	0.66%
Male, 8, 2.65%; Female, n = 34/11.36%		35+, n = 4	1.32%
		Male, n = 13/4.30%; Female, n = 51/16.89%	
		2015 Seniors [4 th year] n = 42	
		18-20, n = 5	1.66%
		21-25, n = 35	11.59%
		26-30, n = 2	0.66%
		Male, 2, 0.66%; Female, n = 40/13.25%	

2.5 Statistical analysis

Student performance was examined quantitatively by calculating overall test scores. Data were analyzed using analysis of variance (ANOVA), as the total scores were approximately normally distributed. *p*-values less than or equal to alpha = 0.05 were considered statistically significant, which is a common choice for alpha. Some subjects in the assessment of retention knowledge over time remain the same, but data were not paired as they were de-identified and thus the more conservative, independent assumption was used in the analyses. Levene's test for equality of variances was used to test the difference between the means of several subgroups of a variable (multiple testing). The regular Levene's test available through the one-way ANOVA procedure was utilized. Even though there are three different groups being assessed (sophomores, juniors and seniors), there is only one independent variable, and thus the one-way ANOVA is

appropriate.

3. RESULTS

As shown in Table 2, the education group had a statistically significantly higher total score than the control group: mean \pm standard deviation = 70.1 ± 13.8 vs. 54.2 ± 19.6 , respectively for education and control groups; *p*-value < .001. Although education clearly had an impact on total score, the knowledge was not retained over the years: average total scores of 70.1 in 2013 to 67.2 in 2014 and 61.6 in 2015; *p*-value = .006, as seen in Table 3. For the self-perceived assessment of comfort level, Table 4 shows how the education group had a statistically lower score than the control group. Although education clearly had an impact on the scores, Table 5 shows that the information was not retained over the years, yet it tended to improve over time.

Table 2. Education versus control group self-perceived genetic knowledge. Education Group = 2013, Sophomore (2nd year) [Students who had genetics course] Control Group = 2013, Junior (3rd year) & Senior (4th year) [Students who did not have genetics course]

Group	N	Avg Total Score	Std Dev	Median	Minimum	Maximum	p-Value
Control	74	54.2	19.6	58.0	11.0	83.0	
Education	62	70.1	13.8	72.0	22.0	96.0	< .001

Table 3. Knowledge retention over time [Students who took genetics course]

Year	Grade	N	Avg Total Score	Std Dev	Median	Minimum	Maximum	p-Value
2013	Soph	62	70.1	13.8	72.0	22.0	96.0	
2014	Junior	60	67.2	12.8	68.5	36.0	93.0	.006
2015	Senior	42	61.6	12.9	64.0	31.0	81.0	

Table 4. Education group vs. control group comfort level in collecting and explaining genetics Education Group = 2013, Sophomore (2nd year) [Students who had genetics course] Control Group = 2013, Junior (3rd year) & Senior (4th year) [Students who did not have genetics course]

Group	N	Avg Collecting Score	Std Dev	Median	Minimum	Maximum	p-Value
Control	74	3.0	1.2	3.0	1.0	5.0	
Education	62	1.9	1.0	2.0	1.0	5.0	< .001
Group	N	Avg Explaining Score	Std Dev	Median	Minimum	Maximum	p-Value
Control	74	2.9	1.2	3.0	1.0	5.0	
Education	62	2.1	1.0	2.0	1.0	5.0	< .001

Table 5. Education group vs. control group retention over time in collecting and explaining genetics

	Year	N	Mean	Std Dev	Median	Minimum	Maximum	p-Value
Collecting	2013	62	1.9	1.0	2.0	1.0	5.0	
	2014	60	2.5	1.1	2.0	1.0	5.0	.004
	2015	42	2.5	1.0	3.0	1.0	4.0	
Explaining	2013	62	2.1	1.0	2.0	1.0	5.0	
	2014	60	2.9	1.0	3.0	1.0	5.0	< .001
	2015	42	2.4	0.9	3.0	1.0	4.0	

4. DISCUSSION

The 31 multiple choice GLAI questions plus the two ‘comfort level’ questions were analyzed with a one-way ANOVA. Data are distributed appropriately and tests of skewness revealed normal distribution (Skew = -.71). This study revealed significant differences in the perceived retention of genetics/genomics knowledge of the education group as sophomore (2nd year), junior (3rd year) and senior (4th year) nursing students. Unfortunately, the perceived knowledge was not retained, as demonstrated by the decline in the average total scores. From a high of 70.1 in 2013 for the sophomore (2nd year) students, by the time these students were seniors (4th year, 2015), their average total scores dropped by 8.5.

Though the premise that genetic content would be continually integrated through-out the curriculum would occur, faculty either did not have the knowledge or the time to meet this expectation. In addition, “while faculty may believe that the genetic/genomic content is being threaded, the recommended content based on the competencies may not be what is included, thus causing lower student perceived knowledge scores”.^[10] In addition, the required competency essentials may not have been well disseminated outside of those educators who are truly interested and comfortable teaching the

content.^[29] A strategy to enhance nursing students’ knowledge retention and application of content is required. As such, faculty needs to become innovative and creative to continue the educational process with regards to the ever-expanding required competencies within a curriculum. One strategy, mobile learning (m-learning) such as podcasts, is an effective and flexible educational format that is grounded in “pedagogically sound characteristics to ensure effective implementation and learning” in nursing education.^[30] Intentional supplemental podcasting of genetics/genomic content could potentially enhance the retention and application of this content. However, development and production of the podcast itself is a time-consuming endeavor.

The education group had a statistically significantly higher total score than the control group. This can be attributed to the education group having a stand-alone genetics course while the control group of students did not. One explanation for the relatively weaker performance of the juniors (3rd year) and seniors (4th year) may be that these students took their required biology course one-two years prior to their nursing education, and did not retain sufficient genetic knowledge. The threading of genetics through the nursing curriculum

may not have met the essential competency criteria. A U.S. study demonstrated senior nursing students (4th year) having a greater perceived knowledge of genetic terms than either freshman (1st year), sophomore (2nd year) or junior (3rd year) nursing students.^[19] The students in this study did not have a stand-alone course but basic genetic content was covered in the biology class and integrated in some of the nursing courses in the advanced nursing levels.^[19] The findings of this current study support that educational processes lead to knowledge gain. As previously stated, the singular didactic genetics course was developed, at the beginning of the students' educational process, to establish the basis for the comprehension of genetic content, with an assumption that the furthering of this knowledge would occur as the student progressed through the curriculum. To date, there is a literature gap exploring perceived genetic knowledge based on how and when genetics is taught in a pre-licensure baccalaureate nursing curricula. The advancement in genetics and genomics has occurred at an exponential rate yet the educational process of students has not kept pace.^[16] Nursing schools and professional organizations must take the lead in preparing the 21st century health professional, in the post-genetic/genomic era, to fully integrate, interpret, and inform patients safely and appropriately about genetic issues, including ethical, legal, social and psychological implications of the information.^[17,23,31]

However, when exploring the comfort level of pre-licensure nursing students, the education group had lower scores than the control group. Although education clearly had an impact on the scores, the information was not retained over the years, though it tended to increase over time. The degrees of clinical comfort with obtaining and explaining genetics were not statistically significant enough to warrant not providing the stand-alone genetics course in the sophomore (2nd year). Clinical comfort with genetics may not vary significantly among the different levels of nursing students.^[16] Since the sophomore (2nd year) students were just beginning their educational process, their overall self-confidence with this new professional content was still immature. With additional education comes self-confidence and comfort in the clinical setting when applying knowledge.^[32]

Future research with a broader sample is needed for a more comprehensive understanding of current nursing students' perceived genetic knowledge base. Nurses can make distinctive contributions to genetics/genomics knowledge and complement other healthcare practitioners to advance the health and well-being of the global population. The "goal of nursing research in clinical genetics and genomics is to improve the quality of health care... investigating the behavioral, social and physiological benefits and risks... to verify

the value of this new science to patient and family care".^[19] One step to attain this goal is to adequately and sufficiently educate nurses, beginning with the educational process. However, ensuring that nurse educators are adequately educated is truly the first endeavor.

Limitations

Inherent in all research are limitations. For this study, it was conducted in one school of nursing; consequently results cannot be generalized to other schools. There was significant inconsistency to the number of participants for each year the GLAI was surveyed. Perhaps offering it on Survey Monkey should be considered in the future in an attempt to provide for more consistency. In addition, collecting date either in the first two weeks or the last two weeks of the didactic course provided additional inconsistency to the methodology. Finally, education has a significant effect on knowledge as measured via the "total score". This implies that some of the subjects in the later years may not have had the education, but there is no way to weed those participants out due to the de-identification of the subjects. This may have biased the results and serves as a limitation to the study's ability to assess retention of knowledge over time. Genetic content mapping threaded through the curriculum was not conducted. Hence, future studies would be strengthened by correlating concepts threaded through the curriculum with student perceived knowledge.

5. CONCLUSION

Findings of this study will add to the emerging body of evidence that a significant gap exists in pre-licensure baccalaureate nursing students' perceived knowledge and comfort level with regards to genetic and genomic content, collecting and explaining concepts and participating in the healing-caring process of patients with genetic conditions. As advancements in genetic and genomic understanding continues and impacts the way healthcare is provided, the nursing profession must continue to expand on how this knowledge is introduced, disseminated and integrated into the educational process. Unfortunately, the profession as a whole, including academia and clinical professionals, lag in the integration of the core proficiencies. Nursing faculty must become knowledgeable and comfortable with this content to provide creative innovative strategies to incorporate this important science into nursing education. Current nursing students represent future nurse scientists, educators and healthcare professionals, and as such, they must be skilled at assessing patients and their families for genetic risk and provide appropriate care and referrals. However, research has exposed the lack of adequate preparation of nurses and nurse educators to incorporate and apply the content of genetics and genomics.^[33]

Future research should examine the actual knowledge of genetics/genomics among nursing students in all levels of education, since this study assessed only the perceived knowledge of baccalaureate nursing students. Also, nursing curricula should be examined to identify areas for improvement to enhance retention of knowledge. A plan to progress in complexity of sample for a descriptive design or extend to other populations is currently under review. Finally, nurse educators' perceived genetic knowledge should be explored, as nurse educators must be sufficiently educated to address genetics and genomics content and its global applications to health promotion, disease prevention and diagnostic and

treatment strategies.^[29]

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CONFLICTS OF INTEREST DISCLOSURE

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

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