Impact of Pedagogical Approaches on Cognitive Complexity and Motivation to Learn: Comparing Nursing and Engineering Undergraduate Students

Abstract

Background

The changing higher education landscape is prompting nurses to rethink educational strategies. Looking beyond traditional professional boundaries may be beneficial. We compare nursing to engineering because engineering has similar accreditation outcome goals and different pedagogical approaches.

Purpose

We compare students' cognitive complexity and motivation to learn to identify opportunities to share pedagogical approaches between nursing and engineering.

Method

A cross-sectional questionnaire study of 1167 freshmen through super senior students. Comparisons were made across years and between majors.

Discussion

Overall nursing and engineering students advance in cognitive complexity while maintaining motivation for learning. Sophomores reported the lowest scores on many dimensions indicating their experiences need review. The strong influence of the NCLEX exam on nursing students may drive their classroom preferences. Increased intrinsic motivation, coupled with decreased extrinsic motivation, suggest we are graduating burgeoning life-long learners equipped to maintain currency.

Conclusions

The disciplines' strategies for incorporating real-world learning opportunities differ, yet the students similarly advance in cognitive complexity and maintain motivation to learn. Lessons can be exchanged across professional boundaries.

Keywords:

Nursing Education, Cognitive Complexity, Motivation to Learn, Engineering Education

Introduction

The higher education landscape is changing. University faculty are striving to, for example, provide learner-centered instruction (e.g., Wright, 2011), increase four-year graduation rates (e.g., Akers & Chingos, 2013), and develop interprofessional educational opportunities (e.g., Interprofessional Education Collaborative Expert Panel, 2011). Pedagogical differences across disciplines result in a myriad of approaches to address these changes. More systematic, rigorous research is necessary to examine the effectiveness of these approaches, and to develop an understanding of how they prepare graduates for the complex practice world they are preparing to enter. This need is particularly salient for nursing educators (Broome, Ironside, & McNelis, 2012). The looming faculty shortage and shrinking resources for clinical teaching (American Association of Colleges of Nursing (AACN), 2015b), in addition to the recent report from the National Council of the State Boards of Nursing (Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014), are challenging nursing faculty to rethink the traditional clinical education model.

To address the research gap and inform nurse educators, we look beyond the clinical education paradigm of the healthcare professions to engineering. Engineering is a practice-oriented profession that requires critical thinking and problem solving; yet, uses very different educational methods for providing students with real-world learning experiences. Our research purpose is to compare nursing and engineering students' cognitive complexity and motivation to learn across their programs of study. This examination of an alternative approach for garnering practice experience may lead to an expanded portfolio of pedagogies available to nurse educators.

Nursing and engineering have many commonalities that make comparing their pedagogies relevant. They are both professional disciplines where students learn how to improve people's lives and can practice their professions with their undergraduate degrees. Moreover, the accreditation outcomes of both nursing and engineering are very similar (AACN, 2015a; ABET, 2015). For instance, in addition to

possessing a broad foundational education and discipline-specific knowledge, both disciplines focus on developing (i) an ability to collect meaningful data and apply evidence to practice, (ii) the skills needed to communicate and collaborate effectively with others, (iii) an appreciation for the role of technology and other tools available to support practice, and (iv) professional values that guide ethical practice (Gauci, Perz, Purzer, Kirkpatrick, & McComb, 2012). Finally, both professional disciplines have been challenged to better contextualize the learning experiences (Benner, Sutphen, Leonard, & Day, 2010; Committee on the Engineer of 2020, 2005).

The two disciplines have traditionally taken different approaches, however, with respect to how accreditation outcomes are translated into the curricula and how students experience real-world learning (Gauci et al 2012). Nursing students are exposed to direct patient care early in their curricula, with many programs beginning weekly clinical experiences supervised by faculty preceptors as early as the sophomore year. Thus, students have the opportunity to apply their knowledge in context (i.e., the environment where they will eventually practice) and observe how others in their professional communities conduct themselves in the workplace. Nursing students may also seek summer employment opportunities as interns, but these experiences are independently arranged.

Alternatively, engineering students are (1) expected to apply engineering knowledge through class projects based on real-world problems without an active link outside the classroom, (2) encouraged to seek internship and/or cooperative opportunities throughout their undergraduate years, but these experiences are typically unstructured and have no faculty oversight and (3) required to take a senior design course where student teams undertake a real-world problem with minimal faculty oversight. Thus, the most striking tradeoff between nursing and engineering is in their distinctly different pedagogical approaches for garnering practical experience. Nursing students are exposed to consistent, structured, and supervised experiences, whereas engineering students have ad hoc immersive and simulated real-world experiences.

To better understand how these different pedagogical approaches may impact students, we focus on two constructs: cognitive complexity and motivation to learn. Cognitive complexity, conceptualized by Perry (1981), represents student intellectual development over time (Wankat & Oreovicz, 1993) and the depth with which they can synthesize disparate perspectives (Granello, 2010). As individuals' levels of cognitive complexity increase so will their use of questions, ease with uncertainty and ambiguity, ability to adjust as new information is obtained, etc. (Granello, 2010). Motivation to learn encompasses the beliefs held by learners about their capacity for learning, the value they associate with an activity, and the degree of interest they have in the activity (Kramarski & Michalsy, 2009). Such motivation is necessary because it may be indicative of academic engagement (Estepp & Roberts, 2015; Pintrich & Zusho, 2007). These two outcomes were selected because they align with recommendations from external influences, such as accrediting bodies and experts in student-centered learning, and are impacted by the learning environment designed by faculty.

First, cognitive complexity and motivation to learn are needed for students to succeed at the professional and technical skills identified by accrediting bodies (Shuman, Besterfield-Sacre, & McGourty, 2005). Two such examples are a broad foundational education (e.g., AACN Essential I (AACN, 2015a) and ABET Student Outcome h (ABET, 2015)) and work within an ever-changing context that is subject to various constraints that must be identified and understood (e.g., AACN Essentials II and V and ABET Student Outcomes c, j, and i). Students need to envision broad impacts of their actions and realize the relevance of contemporary issues in their day-to-day responsibilities. This depth of thinking is captured by cognitive complexity. At the same time, they also must be motivated to engage in life-long learning in order to stay abreast of contextual and contemporary issues that are evolving and changing professional practice.

Second, experts in student-centered learning recommend approaches for enhancing the student educational experience that align with the way in which cognitive complexity and motivation to learn

are operationalized. For instance, Weimer's (2002) framework has been used by a variety of disciplines in higher education, ranging from liberal arts to the sciences, to help faculty shift from teacher-centered instruction to student centered (Wright, 2011). The Weimer framework articulates five areas that promote faculty design of student-centered instruction: balance of power in the classroom, function of the course content, role of the teacher versus the role of the student, responsibility of learning, and purpose/processes of evaluation. In Table 1, the dimensions of cognitive complexity and motivation to learn are aligned with Weimer's framework.

Table 1. Comparison of Weimer's (2002) Learner-centered Teaching Principles, Moore's (1998b) Cognitive Complexity, and Pintrich, Smith, Garcia, & McKeachie (1991) Motivation for Learning

Learner-Centered Teaching Principles	**Cognitive Complexity**	**Motivation for Learning**
Balance of power in the classroom	• Classroom Atmosphere/ Activities	• Extrinsic goal orientation
Function of the course content	• Course Content/View of Learning	• Task value
Role of the teacher versus the role of the student	• Role of Instructor • Role of Student/Peers	• Intrinsic goal orientation • Extrinsic goal orientation
Responsibility of learning	• Role of instructor	• Control beliefs • Self-efficacy for learning and performance
Purpose and processes of evaluation	• Evaluation	• Self-efficacy for learning and performance • Intrinsic and extrinsic goal orientation

Finally, the learning environment may influence cognitive complexity and motivation to learn. For example, individuals are better served when their environmental demands align with the level of cognitive complexity at which they are capable of functioning (Bullough, Young, Hall, Draper, & Smith, 2008) and levels of self-efficacy can be manipulated by the learning context to affect motivation for additional learning (Schunk & Zimmerman, 2008). Moreover, self-regulation, connotes agency in the

choices learners make in response to the learning environment and their experiences, where self-regulation is an iterative process that incorporates metacognitive monitoring and influences one's motivational state (Winne & Hadwin, 2008). Given the differences in the manner in which the nursing and engineering curricula are constructed, we anticipate differences in cognitive complexity and motivation to learn between the two groups across grade levels.

Methods

Design, setting, and sample

Institutional Review Board approval was granted to conduct this research. Cross-sectional data were collected from Nursing and Engineering freshmen, sophomore, junior, senior, and super seniors (i.e., those students requiring five or more years to obtain their degrees) in Spring and Fall 2013. In both disciplines, students are directly admitted into their majors as freshmen.

The majority of data was collected via paper survey in classes; data were double entered to ensure accuracy. For freshmen and junior nursing students in Fall 2013, links to an online version of the survey were sent to students with a request to complete the survey outside class time. This alternative mechanism for collecting data was used to minimize the impact of this research project on class time. A total of 1676 students were enrolled in the courses we targeted for data collection. The resulting sample size was 1167 usable surveys, which corresponds to a 70% response rate. In Table 2, sample sizes and demographics are presented.

Table 2. Sample Size, Age, and Gender

	Sample Size			**Mean (*SD*) Age**			**Percentage Female**		
	Engineering	Nursing	Total	Engineering	Nursing	Total	Engineering	Nursing	Total
Freshmen	147	39	199*	18.1 (0.5)	18.4 (0.6)	18.1 (0.5)	29.6%	91.2%	46.5%
Sophomore	249	153	402	19.4 (0.7)	19.3 (1.7)	19.4 (1.2)	39.1%	95.4%	60.6%
Junior	187	111	302*	20.4 (1.2)	20.4 (0.9)	20.4 (1.1)	36.0%	98.2%	59.8%
Senior	92	120	213*	21.5 (1.5)	21.6 (1.4)	21.5 (1.4)	22.0%	93.3%	62.7%
Super Senior	33	18	51*	22.8 (1.9)	23.3 (4.7)	23.0 (3.2)	12.1%	88.9%	39.2%
Total	708	441	1167*	19.9 (1.6)	20.3 (2.0)	20.0 (1.8)	33.0%	95.0%	57.6%

* 18 respondents did not indicate major (13 freshmen, 4 juniors, 1 senior)

Table 3. Construct Subscale Definitions and Sample Items

	Subscale	Definition	Sample Items
Cognitive Complexity (Moore, 1989b)	Course Content/View of Learning	Student perceptions about what, and how, course material should be delivered during class.	My ideal learning environment would: • Emphasize basic facts and definitions. • Stress the practical applications of the material.
	Role of Instructor	Student perceptions about instructors' responsibilities in the learning process.	In my ideal learning environment, the instructor would: • Teach me all the facts and information I am supposed to learn. • Utilize his/her expertise to provide me with a critique of my work.
	Role of Student/Peers	Student perceptions about students' responsibilities in the learning process.	In my ideal learning environment, as a student I would: • Study and memorize the subject matter–the teacher is there to teach. • Expect to be challenged to work hard in the class.
	Classroom Atmosphere/ Activities	Student perceptions about how they should be engaged in the learning process through classroom activities and assignments.	In my ideal learning environment, the classroom atmosphere and activities would: • Include specific, detailed instructions for all activities and assignments. • Include lots of projects and assignments with practical, everyday applications.
	Evaluation	Student perceptions about the aspects of their performance that should be assessed.	Evaluation activities in my ideal learning environment would: • Be up to the teacher, since she/he knows the material best. • Consist of thoughtful criticism of my work by someone with appropriate expertise.
Motivation to Learn (Pintrich et al., 1991)	Intrinsic Goal Orientation	Student perceptions about why they engage in the learning process based on challenge, curiosity, mastery, etc.	• I prefer challenging class work so I can learn new things. • The most satisfying thing for me is trying to understand course content as thoroughly as possible.
	Extrinsic Goal Orientation	Student perceptions about why they engage in the learning process based on external validation such as grades, rewards, etc.	• If I can, I want to get better grades in my courses than most of the other students. • I want to do well in my courses because it is important to show my ability to my family, friends, employer, or others.
	Task Value	Student perceptions about how interesting, important, and useful the course material is.	• I am very interested in the content area of my courses. • I think I will be able to use what I learn in one course in other courses.
	Control Beliefs	Student perceptions about the relationship between their effort to learn and outcomes.	• It is my own fault if I don't learn course material. • If I try hard enough, then I will understand the course material.
	Self-Efficacy for Learning and Performance	Student beliefs in their own ability to master course material.	• I expect to do well in my courses. • I'm confident I can understand the basic concepts taught in my courses.

NOTE: This table is reprinted from Gauci, M., Perz, A., Purzer, S., Kirkpatrick, J., & McComb, S.A., 2012, "A Comparison of Nursing and Engineering Undergraduate Education," *ASEE Illinois-Indiana Section District Conference Proceedings*, with permission from ASEE.

Variables and Instruments

Cognitive Complexity was assessed using Moore's (1989a) 65-item Learning Environment Preferences (LEP) instrument. The LEP was designed to assess Perry's (1981) levels of intellectual development across five aspects of the learning environment: (1) course content/view of learning, (2) role of instructor, (3) role of student/peers, (4) classroom atmosphere/activities, and (5) evaluation. Definitions and sample items for each cognitive complexity dimension are given in Table 3. As can be seen in Table 3, the referent for each item set was the student's "ideal learning environment." Items are designed to tap progressively increasing levels of cognitive complexity and elicit responses ranging from "not at all significant" to "very significant" across a five-point Likert scale. The LEP has been used in the field with undergraduate students (Granello, 2010; Lavis, 2005; Zygmont & Schaefer, 2006).

Cognitive complexity position ratings are calculated to reflect the level that best represents the student's progression along Levels 2 through 5 of Perry's (1981) continuum (see Appendix A for a table describing all levels). Moore (1989a, page 6) justifies this narrowed focus on Levels 2 through 5 because Level 1 "has never been adequately verified empirically." Levels 6 through 9 are not included because they reflect increasing levels of commitment in a contextually relativistic world rather than structural changes to an individual's cognitive ability to synthesize disparate perspectives. As scores in our sample ranged from 2.61-4.25, this limitation of the LEP instrument did not impact our research.

This instrument's reliability and validity are reported in Moore (1987). The coefficient alpha ranges from .72-.84 for the four levels examined. Construct validity, assessed via factor analysis, was confirmed for Levels 2 and 3. Some overlap existed between Levels 4 and 5; the progression of factor loadings, however, mirrors the anticipated progression of cognitive complexity. Thus, the LEP was deemed valid.

Motivation to Learn was assessed using Pintrich and colleagues' (1991) 26-item Motivated Strategies for Learning Questionnaire (MSLQ) across five dimensions: (1) intrinsic goal orientation, (2)

extrinsic goal orientation, (3) task value, (4) control beliefs, and (5) self-efficacy for learning and performance. Definitions and sample items for each motivation to learn dimension are given in Table 3. All items were scored on a seven-point Likert scale ranging from “not at all true of me” to “very true of me.” These measures have been extensively validated in the field (e.g., Kramarski & Michalsky 2009; Lodewyk & Winne 2005).

Reliability and validity for the MSLQ is reported in Pintrich, Simth, Garcia, and McKeachie (1993). Coefficient alpha ranged from .62-.93. Predictive validity was assessed via correlation between the MSLQ dimensions and respondent academic performance (i.e., final grade for the course in which the respondents completed the MSLQ). All correlations were significant except for the correlation with extrinsic goal orientation, suggesting reasonable validity.

Data Analyses

Analysis of Variance (ANOVA) via the General Linear Models procedure in SAS 9.2 was used to identify differences across years and majors, and any significant interactions between years and majors. The level of significance was set at $p<.05$. Results for cognitive complexity and motivation to learn are presented in Tables 4 and 5, respectively.

Table 4. ANOVA Results for Cognitive Complexity

	Dimensions of Cognitive Complexity														
	Course Content/ View of Learning			**Role of Instructor**			**Role of Student/Peers**			**Classroom Atmosphere/ Activities**			**Evaluation**		
	Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)	Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)	Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)	Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)	Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)
Freshmen	3.27 (0.54) *n*=147	3.17 (0.61) *n*=39	3.25 (0.56) *n*=186	3.21 (0.97) *n*=147	2.79 (0.93) *n*=39	3.12 (0.98) *n*=186	3.56 (0.80) *n*=147	3.46 (0.88) *n*=39	3.54 (0.82) *n*=186	3.10 (1.03) *n*=147	2.94 (1.01) *n*=39	3.07 (1.03) *n*=186	3.84 (1.08) *n*=147	3.38 (1.18) *n*=39	3.74 (1.11) *n*=186
Sophomore	3.25 (0.59) *n*=249	3.08 (0.49) *n*=153	3.19 (0.56) *n*=402	3.01 (0.94) *n*=249	3.01 (1.01) *n*=153	3.01 (0.96) *n*=402	3.52 (0.96) *n*=249	3.63 (0.90) *n*=153	3.57 (0.94) *n*=402	2.86 (1.02) *n*=249	2.64 (1.03) *n*=153	2.77 (1.03) *n*=402	3.37 (1.14) *n*=249	3.77 (1.14) *n*=153	3.52 (1.15) *n*=402
Junior	3.38 (0.69) *n*=187	3.10 (0.41) *n*=111	3.27 (0.61) *n*=298	3.15 (0.98) *n*=187	2.92 (0.94) *n*=111	3.06 (0.97) *n*=298	3.61 (0.92) *n*=187	3.62 (0.95) *n*=111	3.61 (0.93) *n*=298	2.93 (1.04) *n*=187	2.63 (0.93) *n*=111	2.82 (1.01) *n*=298	3.48 (1.13) *n*=187	3.71 (1.17) *n*=111	3.57 (1.15) *n*=298
Senior	3.27 (0.66) *n*=92	3.24 (0.60) *n*=120	3.25 (0.62) *n*=212	3.16 (1.06) *n*=92	3.26 (1.16) *n*=120	3.22 (1.12) *n*=212	3.63 (0.93) *n*=92	3.68 (0.93) *n*=120	3.66 (0.93) *n*=212	3.03 (1.07) *n*=92	2.86 (1.13) *n*=120	2.93 (1.11) *n*=212	3.55 (1.18) *n*=92	3.86 (1.21) *n*=120	3.73 (1.21) *n*=212
Super Senior	3.17 (0.66) *n*=33	3.22 (0.57) *n*=18	3.19 (0.62) *n*=51	3.53 (1.11) *n*=33	2.77 (0.89) *n*=18	3.26 (1.09) *n*=51	3.55 (0.96) *n*=33	3.65 (0.98) *n*=18	3.58 (0.96) *n*=51	2.87 (1.10) *n*=33	2.61 (1.06) *n*=18	2.78 (1.08) *n*=51	3.56 (1.22) *n*=33	4.25 (1.11) *n*=18	3.80 (1.22) *n*=51
	Year *p*=.45			Year *p*=.15			Year *p*=.70			Year *p*=.04			Year *p*=.29		
Total	3.29 (0.62) *n*=708	3.14 (0.52) *n*=441	Year x Major *p*=.14	3.13 (0.99) *n*=708	3.03 (1.03) *n*=441	Year x Major *p*=.02	3.57 (0.92) *n*=708	3.63 (0.92) *n*=441	Year x Major *p*=.86	2.95 (1.04) *n*=708	2.72 (1.04) *n*=441	Year x Major *p*=.95	3.53 (1.15) *n*=708	3.76 (1.17) *n*=441	Year x Major *p*=.004
	Major *p*=.03			Major *p*=.001			Major *p*=.62			Major *p*=.009			Major *p*=.01		

M = mean; *SD* = standard deviation; *n* = sample size; *p* = *p*-value
Black cells indicate significant results at the *p* <.05 level.

Table 5. ANOVA Results for Motivation to Learn

	Dimensions of Motivation to Learn																			
	Intrinsic Goal Orientation				**Extrinsic Goal Orientation**				**Task Value**				**Control Beliefs**				**Self-Efficacy for Learning and Performance**			
	Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)		Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)		Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)		Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)		Eng *M*(*SD*)	Nurse *M*(*SD*)	Total *M*(*SD*)	
Freshmen	5.50 (0.93) *n*=147	5.43 (1.06) *n*=39	5.49 (0.96) *n*=186	Year *p*=.006	5.64 (1.00) *n*=147	5.93 (0.95) *n*=39	5.70 (0.99) *n*=186	Year *p*=.0002	5.93 (0.75) *n*=147	6.27 (0.68) *n*=39	6.01 (0.75) *n*=186	Year *p*=.13	5.45 (0.99) *n*=147	5.56 (0.96) *n*=39	5.48 (0.98) *n*=186	Year *p*=.46	5.55 (0.86) *n*=147	5.66 (0.94) *n*=39	5.58 (0.88) *n*=186	Year *p*=.02
Sophomore	5.08 (1.01) *n*=247	5.22 (0.89) *n*=153	5.13 (0.97) *n*=400		5.77 (0.97) *n*=247	5.52 (0.99) *n*=153	5.67 (0.98) *n*=400		5.62 (0.79) *n*=247	6.30 (0.60) *n*=153	5.88 (0.79) *n*=400		5.21 (0.98) *n*=247	5.50 (0.88) *n*=153	5.32 (0.95) *n*=400		5.26 (0.88) *n*=247	5.48 (0.80) *n*=153	5.34 (0.86) *n*=400	
Junior	5.22 (0.92) *n*=187	5.26 (0.96) *n*=111	5.23 (0.93) *n*=298		5.65 (1.02) *n*=187	5.38 (1.01) *n*=111	5.55 (1.02) *n*=298		5.61 (0.83) *n*=187	6.30 (0.67) *n*=111	5.87 (0.84) *n*=298		5.32 (0.94) *n*=187	5.36 (1.01) *n*=111	5.34 (0.96) *n*=298		5.38 (0.95) *n*=187	5.45 (0.87) *n*=111	5.40 (0.92) *n*=298	
Senior	5.19 (1.03) *n*=89	5.39 (0.85) *n*=120	5.30 (0.94) *n*=209		5.45 (1.15) *n*=89	5.20 (0.96) *n*=120	5.31 (1.05) *n*=209		5.50 (0.80) *n*=89	6.26 (0.65) *n*=120	5.93 (0.81) *n*=209		5.36 (0.96) *n*=89	5.29 (0.99) *n*=120	5.32 (0.98) *n*=209		5.41 (0.91) *n*=89	5.67 (0.70) *n*=120	5.56 (0.81) *n*=209	
Super Senior	5.31 (1.00) *n*=33	5.72 (0.72) *n*=18	5.46 (0.93) *n*=51		5.29 (1.21) *n*=33	5.43 (1.14) *n*=18	5.34 (1.17) *n*=51		5.47 (0.91) *n*=33	6.43 (0.50) *n*=18	5.81 (0.91) *n*=51		5.39 (0.96) *n*=33	5.50 (1.11) *n*=18	5.43 (1.01) *n*=51		5.52 (0.99) *n*=33	5.73 (0.72) *n*=18	5.59 (0.90) *n*=51	
Total	5.23 (0.98) *n*=703	5.31 (0.91) *n*=441	Year x Major *p*=.54		5.65 (1.03) *n*=703	5.43 (1.01) *n*=441	Year x Major *p*=.06		5.66 (0.81) *n*=703	6.29 (0.63) *n*=441	Year x Major *p*=.06		5.32 (0.97) *n*=703	5.41 (0.96) *n*=441	Year x Major *p*=.26		5.38 (0.91) *n*=703	5.55 (0.81) *n*=441	Year x Major *p*=.77	
	Major *p*=.06				Major *p*=.41				Major p<.0001				Major *p*=.22				Major *p*=.01			

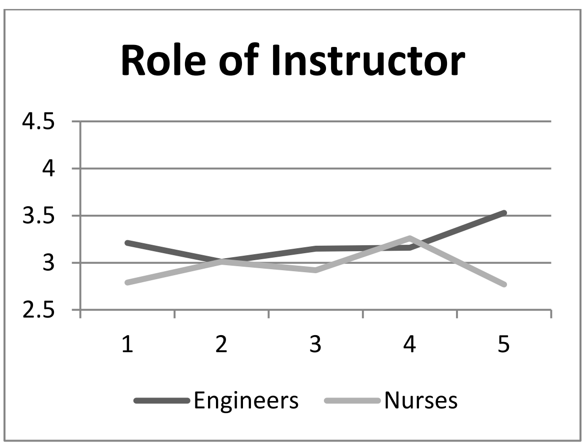
M = mean; *SD* = standard deviation; *n* = sample size; *p* = *p*-value
Shaded cells indicate significant results at the *p* < .05 level.

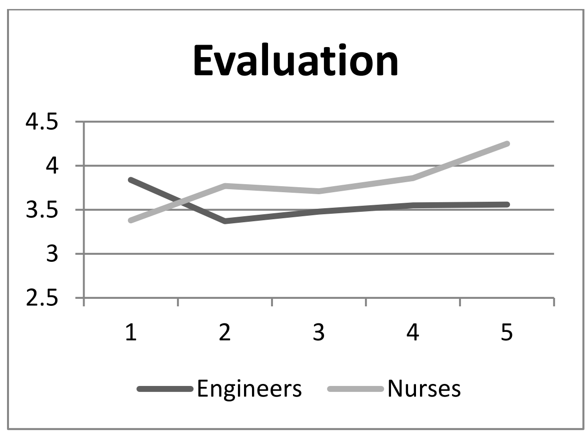
Results

Cognitive Complexity

The interaction between years and majors was significant for the cognitive complexity dimensions of role of instructor (p=.02) and evaluation (p=.004). Graphs depicting the significant changes over time by major are presented in Figure 1. For role of instructor, nursing students fluctuate over grade levels with freshmen and super seniors reporting the lowest levels of cognitive complexity. Engineering students' cognitive complexities relating to the role of the instructor drop from the freshmen to sophomore year and then stabilize or increase, with a sharp increase at the super senior level. With respect to evaluation, nursing students report a steady increase in cognitive complexity across grade levels. Engineering students' cognitive complexities relating to evaluation drop from the freshmen to sophomore year and then stabilize.

Figure 1. Graphs Depicting Significant Interactions





Nursing and engineering students have significantly different cognitive complexity regarding course content/view of learning (p=.03), with engineering students reporting higher cognitive complexity.

Differences across years (p=.04) and majors (p=.009) were significant for cognitive complexity related to classroom atmosphere/activities, but the interaction between years and majors was not significant (p=.95). Freshmen reported the highest cognitive complexity related to classroom

atmosphere/activities and sophomores the lowest. Engineering students reported higher cognitive complexity associated with classroom atmosphere/activities than nursing students.

No significant differences in year ($p=.7$) or major ($p=.62$) were found for cognitive complexity associated with the role of student/peers.

Motivation to Learn

Differences across years were significant for (1) intrinsic goal orientation ($p=.006$), with freshmen and super seniors reporting the highest intrinsic motivation and sophomores reporting the lowest; (2) extrinsic goal orientation ($p=.002$), with freshmen and sophomores reporting the highest extrinsic motivation and seniors and super seniors reporting the lowest; and (3) self-efficacy ($p=.02$), with super seniors reporting the highest self-efficacy and sophomores reporting the lowest. Differences between engineering and nursing students were also identified for task value ($p<.0001$) and self-efficacy ($p=.01$), with nursing students reporting higher levels of motivation than engineering students on both dimensions. No significant interaction terms were found for motivation to learn.

Discussion

In this study, we examined the similarities and differences in the cognitive complexity and motivation to learn of nursing and engineering undergraduate students from the freshmen to the super senior grade level. Several interesting similarities and differences between the professional disciplines emerged. One of the most interesting similarities was the impact of the sophomore year on both cognitive complexity and motivation to learn. Where significant differences across years were uncovered, with the exception of extrinsic goal orientation, the scores were lowest at the sophomore level and then either stabilized or increased through the senior year. This trend may reflect the process of the students adjusting to the academic rigor of college and the advanced complexity of the coursework at the sophomore year. In

essence, the sophomore drop in cognitive complexity and motivation to learn may be a recalibration of students' expectations and learning strategies. At the same time, they may be struggling to understand the relevance of the new material to their practice-oriented profession. Faculty may be able to mitigate some of the reduction in cognitive complexity and motivation to learn at the sophomore level through increased student-centered learning experiences, such as flipped classrooms, or innovative curricular approaches, such as concept-based learning. To promote successful adaptation to the collegiate experience at the freshmen level, an emphasis on helping students build tools for academic success may also be a useful priority. For instance, teaching students about a growth mindset, where they consider intelligence to be learnable and challenges to be part of that learning process (Dweck, 2006; Elliott & Dweck, 1988), may help them understand that the challenges they face are surmountable and part of their expected trajectory.

The significant downward trend of extrinsic goal orientation in both disciplines coupled with the significant increasing intrinsic goal orientation from the sophomores to the super seniors was encouraging. At times, students in both professional disciplines can become overwhelmed by the intensity of the curriculum combined with the sheer volume of graded assignments and projects. The importance of grades as evidence of achievement may influence the choices students make about how they spend their time if they are driven by extrinsic motivators. Our results suggest that students may become less driven by external factors (e.g., grades) over time, and increasingly motivated by an intrinsic desire to learn. Faculty and accreditation expectations for both disciplines promote the development of skills needed to flourish in today's dynamic professional environment, and this finding suggests we are graduating burgeoning life-long learners equipped to maintain currency.

The final similarity between the two professional disciplines we uncovered is in the responses of the super seniors. For two dimensions of cognitive complexity, namely classroom atmosphere/activities for all students and role of instructor for nursing students, the super seniors' scores were lower than the

senior to the super seniors' scores. Super seniors are classified as any student requiring more than four years to graduate. These students may be the best students who have extended their programs to allow for learning experiences to enrich their education (e.g., cooperative learning experiences, study abroad semesters). Alternatively they may be at-risk students who have had to repeat courses during their tenure. The national push towards increasing four-year graduation rates (e.g., Akers & Chingos, 2013) is drawing attention to this cohort of students. More research is needed to untangle their varying needs and how institutions can help them succeed.

Significant differences between the professional disciplines were also uncovered in cognitive complexity and motivation to learn. Nursing students reported lower levels of cognitive complexity associated with classroom atmosphere/activities (i.e., receiving facts in class vs. learning how to apply facts to support reasoning) and course content/view of learning (i.e., structure, specific assignments vs. open-ended papers and projects) than their engineering counterparts. One reason for these lower scores may be attributable to the requisite gateway to practice. Nursing students must pass the National Council Licensure Examination (NCLEX) before they can be employed. This exam may strongly influence nursing students' emphasis on content that will be included on the exam and specific strategies for taking the exam. Faculty may also share this emphasis as program quality is linked to first-time NCLEX pass rates. Alternatively engineering students can seek professional engineering (PE) licensure, but it is rarely a requisite for employment. Thus, engineering students are not as pressured by a licensure exam, and therefore, may be more open to application opportunities in their classes.

A second reason why nursing students' cognitive complexities associated with classroom atmosphere/activities and course content/view of learning are lower than those of engineering students may be explained by program design and instructional process. Nursing education combines didactic classroom instruction with weekly clinical practice, where classroom content is applied via direct nursing care to a selected patient under faculty supervision. Nursing students' lower cognitive complexity scores

may indicate that nursing faculty rely too heavily on the clinical experience as the primary means for students to absorb how didactic material is applied in practice. A positive trend since our data were collected is an increasing use of situated learning in didactic courses (Murray, 2013; Spector & Odom, 2012) as recommended by the Carnegie Foundation report (Benner et al., 2010). This trend may enhance the cognitive complexity development of nursing students and more closely aligns with the classroom experiences of engineering students. Because engineering students are not required to engage in the practice environment until the senior year, their faculty create didactic activities that integrate practical examples (e.g., case studies, behavioral simulations) to facilitate the application of engineering principles to real-world scenarios. This more holistic approach in the classroom may help explain why the engineering students report higher cognitive complexity in classroom atmosphere/activities and course content/view of learning. Interestingly, the difference in pedagogical approaches between nursing and engineering may also explain why nursing students report higher levels of motivation with respect to task value. Through their clinical experiences, nursing students receive firsthand, and repeated, exposure applying the material they learn in the didactic setting.

For two dimensions of cognitive complexity, namely role of instructor and evaluation, significant interactions between majors and time were identified. With respect to instructor roles (i.e., provider of facts vs. critiques), engineering students had relatively consistent cognitive complexity after the drop from the freshmen to sophomore year. Nursing students, however, had more fluctuations over time, with the highest cognitive complexity reported by seniors. This shift may be attributable to the curricular shift in focus from learning clinical skills to considering systematic issues associated with nursing leadership and public health. Before this shift, students may view the instructor role as ensuring nursing students are delivering safe patient care. After this shift, instructors may be seen as experts who can provide critiques about how nurses can make an impact beyond the bedside. An interesting drop in nursing students' cognitive complexity with respect to the role of instructors occurs from the senior to

the super senior level. This drop may be attributable to both the types of students who become super seniors (i.e., at-risk and high achieving students) and the looming pressure of the NCLEX exam. Both types of students will be focused on how they can pass the NCLEX exam, albeit for different reasons, which may explain their desire for instructors to provide them with the facts they need to succeed.

Differences over time and between majors were also identified in the evaluation component of cognitive complexity. Nursing students demonstrated an ongoing upward trend from the freshmen year, moving from an initial view of the evaluation process being instructor led to viewing the evaluation process more as receiving expert critique of their work by the end of the program. One reason for this shift may be the large number of self-reflection assignments nursing students complete. Via these assignments, students are encouraged to become connoisseurs of best practices and increasingly self-aware of their personal impact on the safety of patients. This emphasis on self-reflection may also help explain the significantly higher perceptions of self-efficacy reported by nursing students.

The cognitive complexity differences associated with evaluation also may be explained by how evaluation is performed in nursing and engineering disciplines. In the majority of nursing programs, students progress through clinically-based courses that build on the skills attained in previous courses, culminating in a clinical capstone experience where they are embedded in an organization with a practicing nurse, an aspirational peer. In addition to building nursing skills, this approach may also build a desire to receive critique from a variety of individuals with whom the student is interacting both within and outside academia. Additionally, senior nursing students’ courses emphasize leadership development through self-regulation activities, such as reflection and metacognition, that may help explain their cognitive complexity development with respect to evaluation. In contrast, once engineering students adjusted at the sophomore year to the evaluation process employed, the cognitive complexity scores remained essentially stagnant across the years. This continuity across years may reflect the consistency in grading approaches throughout the engineering curriculum. Students are evaluated in the classroom

setting via structured assignments and exams designed by faculty. In their last year, engineering students complete a senior design project in a real-world setting. This team-based experience requires students to integrate skills learned across a variety of courses to an engineering problem being experienced in a professional organization. Because senior design projects are typically undertaken at the same time as traditionally designed engineering courses (i.e., lecture-based instruction with structured assignments and exams), engineering students may not immediately realize any cognitive complexity development associated with these experiences.

Limitations

As with all studies, ours has limitations. First, our cross-sectional data do not provide a longitudinal perspective over time. Rather, they represent the perceptions of students at their current grade level, which may be indicative of curricular and/or instructor differences over time rather than developmental growth over time. To our knowledge, no substantive changes in teaching occurred over the four years prior to our data collection. Moreover, statistics of admitted admissions were minimally different across the years in each profession, suggesting that the cohorts of students were roughly equivalent. Thus, our results represent a good first step toward rigorous comparisons of pedagogical differences across professional disciplines. Second, three dimensions of motivation to learn were slightly less reliable than recommended. Any significant results involving these constructs should be interpreted with caution. Third, the engineering data were collected primarily from industrial engineering classes. Fourth, the number of nursing freshmen who responded is low (a 35% response rate), which may skew results. The decision was made not to use class time to distribute the survey given that the students only have a single, one-credit nursing course in the fall of their freshmen year. Finally, we compared and contrasted two professional disciplines across two constructs. Many other professional disciplines (e.g., pharmacy, business) and additional constructs (e.g., learning styles, stress, satisfaction) may provide interesting

comparisons. While our efforts provide a valid comparison of disciplines across professional lines, future researchers are encouraged to conduct longitudinal research across a wider array of students that includes additional constructs.

Conclusion

This descriptive study comparing two professional disciplines with quite different pedagogical approaches provides insight into the development of students' cognitive complexity and motivations to learn. Our results suggest that, overall, students in nursing and engineering advance in cognitive complexity while maintaining motivation for learning. Such findings are encouraging, as both disciplines need professionals who are motivated to maintain currency in the dynamic environments in which they practice and are cognitively capable of contextualizing the new knowledge they acquire. Simultaneously, the observed differences between majors and/or across years provide insight about improvements that may be useful to enhance the education process. Possible improvements may include facilitating freshmen's assimilation to college life by developing realistic expectations in anticipation of the sophomore drop in cognitive complexity and motivation to learn; incorporating student-centered learning experiences to clearly demonstrate links between academic learning and practice, particularly for sophomores; and designing strategies that to help nursing students balance cognitive complexity development with their emphasis on didactic content that will be included on the NCLEX exam. Additional research, untangling the varying needs of super seniors, may help faculty in both professions better understand why students more than four years to complete their undergraduate programs.

In addition to the aforementioned recommendations for pedagogical practice, our results also may have utility at a more global level. Historically, nursing has looked to other health-oriented professions as a benchmark. Herein, we demonstrate the benefits of looking beyond healthcare to other practice-based professional disciplines. From this research, nursing and engineering can learn from the

successes of the other. Both have been challenged to provide learning experiences that are contextual (Benner et al., 2010; Committee on the Engineer of 2020, 2005). While engineering embeds practical applications into didactic courses and reserves immersive experiences for the senior design project courses, nursing has students engaged in the practice setting early in the curriculum. Due to the shrinking faculty resources for clinical teaching (AACN, 2015b) and the recent report on the success of high-fidelity simulation (Hayden et al., 2014), nursing is re-thinking the traditional clinical practice model. Thus, the applicability of examining outcomes associated with the engineering pedagogical approach to teaching and learning is salient.

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References

ABET. (2015). *Criteria for accrediting engineering programs, 2015-2016*. Retrieved from http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2015-2016/#outcomes on July 1, 2015.

Akers, B & Chingos, MM. (2013). “Time-to-graduation too often overlooked,” *The Brown Center Chalkboard*, Number 19. Washington, DC: The Brookings Institute. Retrieved from http://www.brookings.edu/research/papers/2013/05/01-college-graduation-rates-akers on July 1, 2015.

American Association of Colleges of Nursing. (2015a). *The essentials of baccalaureate education for professional nursing practice*. Retrieved from http://www.aacn.nche.edu/education-resources/BaccEssentials08.pdf on July 1, 2015.

American Association of Colleges of Nursing. (2015b). *Nursing faculty shortage fact sheet*. Retrieved from http://www.aacn.nche.edu/media-relations/FacultyShortageFS.pdf on July 1, 2015.

Benner, P, Sutphen, M, Leonard, V, & Day, L. (2010). *Educating nurses: A call for radical transformation*. San Francisco, CA: Jossey-Bass.

Broome, ME, Ironside, PM, & McNelis, AM. (2012). Research in nursing education: State of the science. *Journal of Nursing Education,* 51(9), 521- 524.

Bullough Jr, RV, Young, JR, Hall, KM, Draper, RJ, & Smith, LK. (2008). Cognitive complexity, the first year of teaching, and mentoring. *Teaching and Teacher Education,* 24, 1846-1858.

Committee on the Engineer of 2020 Phase II. (2005). *Educating the engineer of 2020: Adapting engineering education to the new century*. Washington, DC: The National Academies Press.

Culver, RS, & Hackos, JT. (1982). Perry’s model of intellectual development. *Engineering Education,* 73, 221-226.

Dweck, CS. (2006). *Mindset: The new psychology of success*. New York: Random House.

Elliott, ES & Dweck, CS. (1988). Goals: An approach to motivation and achievement. *Journal of Personality and Social Psychology,* 54(1), 5-12.

Estepp, CM & Roberts, TG. (2015). Teaching immediacy and professor/student rapport as predictors of motivation and engagement. *NACTA Journal* 59, 155-163.

Gauci, M, Perz, A, Purzer, S, Kirkpatrick, J, and McComb, S. (2012). “A comparison of nursing and engineering undergraduate education,” Proceedings of the 2012 ASEE Illinois-Indiana Section Conference, Valparaiso, IN, (March 17, 2012).

George, JM. (1990). Personality, affect, and behavior in groups. *Journal of Applied Psychology*, 75, 107–116.

Granello, DH. (2010). Cognitive complexity among practicing counselors: How thinking changes with experience. *Journal of Counseling & Development,* 88, 92-100.

Hayden, J, Smiley, R, Alexander, M, Kardong-Edgren, S, & Jeffries, P. (2014). The NCSBN national simulation study: A longitudinal randomized controlled study replacing clinical hours with simulation in prelicensure nursing education. *Journal of Nursing Regulation 5(2)*: S3-S64. Retrieved from https://www.ncsbn.org/JNR_Simulation_Supplement.pdf on July 1, 2015.

Interprofessional Education Collaborative Expert Panel. (2011). *Core competencies for interprofessional collaborative practice: report of an expert panel.* Washington, DC: Interprofessional Education Collaborative.

Kramarski, B & Michalsky, R. (2009). Investigating preservice teachers’ professional growth in self-regulated learning environments. *Journal of Educational Psychology,* 101, 161-175.

Lavis, CC. (2005). *Evaluating intellectual development of horticultural students: The impact of two teaching approaches using Perry’s scheme of intellectual development as measured by the learning environment preference*. Retrieved from ProQuest Dissertations and Theses. (Dissertation/thesis number 3203841; ProQuest Document ID 304991839).

Lodewyk, KR & Winne, PH. (2005). Relations among the structure of learning tasks, achievement, and changes in self-efficacy in secondary students. *Journal of Educational Psychology,* 97, 3-12.

Marra, RM, Palmer, B, & Litzinger, TA. (2000). The effects of a first-year engineering design course on student intellectual development as measured by the Perry scheme. *Journal of Engineering Education,* 89, 39-45.

Moore, WS. (1987). *The learning environment preferences: Establishing preliminary reliability and validity for an objective measure of the Perry scheme of intellectual development*. Retrieved from ProQuest Dissertations and Theses. (Dissertation/thesis number 8808586; ProQuest Document ID 303589116).

Moore, WS. (1989a). *The learning environment preferences: An instrument manual*. Retrieved from reflectivelpo3462.wikispaces.com/file/view/LEP+Manual2.doc on July 1, 2015.

Moore, WS. (1989b). The learning environment preferences: Exploring the construct validity of an objective measure of the Perry scheme on intellectual development, *Journal of College Student Development,* 30, 504-514.

Murray, TA. (2013). Innovations in nursing education: The state of the art. *Journal of Nursing Regulation,* 3, 25-31.

Perry, WG, Jr. (1981). Cognitive and ethical growth: The making of meaning. In Chickering, AW and Associates (Eds), *The modern American college* (pp. 76-116), San Francisco: Jossey-Bass.

Pintrich, PR, Smith, DAF, Garcia, T, & McKeachie, WJ. (1991). “A Manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ),” Technical Report No. 91-B-004, The Regents of The University of Michigan.

Pintrich, PR, Smith, DAF, Garcia, T, & McKeachie, WJ. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement* 53: 801-813.

Pintrich, PR & Zusho, A. (2007). Student motivation and self-regulated learning in the college classroom. In Perry, RP & Smart, JC (Eds), *The scholarship of teaching and learning in higher education: An evidence-based perspective* (pp. 761-810). Dordrecht, Netherlands: Springer.

Schunk, DH & Zimmerman, BJ. (2008). *Motivation and self-regulated learning: Theory, research, and applications.* New York: Lawrence Earlbaum.

Shuman, LJ, Besterfield-Sacre, M, & McGourty, J. (2005). The ABET “Professional Skills” – Can they be taught? Can they be assessed? *Journal of Engineering Education,* 94, 41-55.

Spector, N & Odom, S. (2012). The initiative to advance innovations in nursing education: Three years later. *Journal of Nursing Regulation,* 3, 40-44.

Wankat, PC & Oreovicz, FS. (1993). *Teaching engineering*. New York: McGraw-Hill.

Weimer, M. (2002). *Learner-centered teaching: Five key changes to practice*. San Francisco, CA: Jossey-Bass.

Winne, P & Hadwin, A. (2008). The weave of motivation and self-regulated learning. In Schunk, S & Zimmerman, B (Eds), *Motivation and self-regulated learning: Theory, research, and applications* (pp. 297-314). New York: Lawrence Erlbaum.

Wright, G. (2011). Student-centered learning in higher education. *International Journal of Teaching and Learning in Higher Education,* 23(3), 92-97.

Zygmont, DM & Schaefer, KM. (2006). Assessing the critical thinking skills of faculty: What do the findings mean for nursing education? *Nursing Education Perspectives,* 27, 260-268.

Appendix A: Perry's Framework of Cognitive Complexity

Perry Position		Learning
1	Basic Duality	World is right or wrong; teacher is authority who provides correct answers
2	Dualism: Multiplicity Prelegitimate	Worldview remains dualistic; multiple views are acknowledged, but perceived as wrong or teaching tools
3	Multiplicity Legitimate but Subordinate	Worldview remains dualistic, but multiplicity is unavoidable; authority may not know the one right answer
4	Complex Dualism/Advanced Multiplicity	Dualistic worldview still comfortable, but acknowledge that legitimate uncertainty and opinion diversity exist; authority provides information about ways to think
5	Contextual Relativism	Everything in the world is relative; authority provides discipline-specific methods and criteria to guide decision making
6	Relativism: Commitment Foreseen	Commitment to a position is needed based on values and judgments; students own the responsibility for committing but may not be ready to commit
7, 8, 9	Levels of Commitment	Commitment occurs at varying levels of abstraction and requires an integration of procedural and subjective knowledge

Sources: Culver & Hackos (1982); Marra, Palmer, & Litzinger (2000); Wankat & Oreovicz (1993)