Identifying statistical concepts in the University of Victoria's graduate nursing research courses: Exploring a method to evaluate statistics in curriculum.

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Introduction

What is advanced nursing practice and why does a nurse seek it? The Canadian Nurses Association (CNA) state that advanced nursing practice provides in-depth nursing knowledge and expertise to meet "the health needs of individual, families, groups, communities and populations" (CNA, 2008, p.ii). An advanced practice nurse assists with questioning of current nursing practices, creating new knowledge, and improving delivery of nursing and health care services (Patterson & Haddad 1992; Elliott 1995; Sutton 1995; Davies 2002; Bryant-Lukosius 2004). Advance practice nursing (APN) abilities are designed to critically respond to a changing health care system and to play a key role in meeting the health care needs of Canadians (CNA, 2008). Such advanced practice abilities are obtained through a combination of nursing clinical experience, education, leadership skills, and a broad understanding of the nursing clinical and organizational environment (CNA, 2008). Although there is diversity amongst the nursing regulatory bodies in Canada about the kind and amount of nursing experience and education required to meet these advanced practice abilities, all agree that the advanced practice nurse is accountable for meeting and applying CNA competencies. CNA defines competencies as the "integrated knowledge, skills, judgement and personal attributes required of a registered nurse to practise safely and ethically in a designated role and setting" (CNA, 2005). Core competencies for the advanced practice nurse fall under four broad categories; clinical, consultation and collaboration, leadership, and research. The aim and interest of this project falls under the category of research, and is based on why I entered the Master's program in Nursing at the University of Victoria. My need for skills in research analysis led me to further education in order to acquire this knowledge.

Of the four core APN competencies, it seemed to me that the first two (clinical and consultation/collaboration) could be learned and acquired in a clinical setting over time. I also assumed that the competency of leadership could be acquired with experience and mentorship in a health care setting. However, I believed the competency of research, consisting of the ability to generate, synthesize, and use research evidence needed a more sequentially complete learning structure, consisting of statistical knowledge and research techniques, and would be best addressed within a Masters in Nursing (MN) educational program.

CNA and the College of Registered Nurses of British Columbia (CRNBC) have different definitions and educational requirements for advanced nursing practice, but the ability of being able to read, analyze, and undertake research is aligned. CRNBC states that competencies for advanced practice nursing "involves analyzing and synthesizing knowledge; understanding, interpreting and applying nursing theory and research; and developing and advancing nursing knowledge and the profession as a whole" (CRNBC, 2012, para.6; CNA, 2008). CNA defines advanced nursing practice as a combination of graduate education and clinical experience that allows nurses to develop competencies in "analyzing and synthesizing knowledge", and "understanding, interpreting, and applying nursing theory and research" (CNA, 2008, p. 4) to nursing practice. CNA's position is that "generating, synthesizing and using research evidence is central to advanced nursing practice" (CNA, 2008, p. 23). BC Ministry of Advanced Education also takes the position of a generic Master's degree leading to the ability to "have a working comprehension of how established techniques of research and inquiry are used to create and interpret knowledge in the discipline" and "have a capacity to evaluate critically current research and advanced research and scholarship in the discipline or area of professional competence" (Government of British Columbia, 2006, p. 20). Thus it seems a safe observation that while all

Registered Nurses have an expectation to read and understand research, advanced practice nurses should have a broader, more knowledgeable, and deeply developed understanding of the research process.

Research skills acquired during study in an advanced nursing practice degree (MN) program prepares nurses to effectively promote nursing research, generate new knowledge, and interpret and incorporate new knowledge into clinical practice (CNA, 2008). In a MN program, nurses should learn how to critique and interpret evidence based findings (CNA, 2008) through the application of a range of methods, including quantitative approaches to research, an approach to knowledge generation that depends heavily on statistical theory and methods. Therefore, the ability to read and understand statistical concepts is foundational at this level, as the findings of empirical research in the quantitative tradition are generated using statistical approaches to data analysis. If an advanced practice nurse does not understand the concepts that underpin the statistical approaches used to obtain and analyze numerical data, how can this nurse critique research for the appropriateness and rigour of the method used, and how will this nurse generate research that contains these concepts? It stands to reason that by the time a nurse emerges from a MN program, he or she should understand concepts relevant to quantitative research, in particular, those central to statistical analysis. Based on this line of reasoning, the questions forming the basis for this project are as follows: how much statistical knowledge regarding quantitative research does the University of Victoria, School of Nursing's MN programs offer? Is the University of Victoria, School of Nursing providing enough exposure and practice with statistical knowledge within their MN programs to confidently claim that their graduates are able to synthesize, critique, and utilize empirical statistical research? I will attempt to answer these questions by scrutinizing University of Victoria, School of Nursing MN curriculum for statistical

knowledge using a compilation of fundamental statistical concepts, and examining the data through the lens of cognitive learning theory.

Statement of problem

The nursing faculty at the University of Victoria would like to ensure that their MN graduates have developed the knowledge, skills, and attitudes required to critically analyze, interpret, and apply the findings of quantitative research. How much statistical knowledge, both terminology and usage, are University of Victoria MN students being exposed to in their programs, and are the concepts being sufficiently addressed to provide the ability to generate, synthesize, and utilize empirical research upon graduation? One way to address these questions was to evaluate the School of Nursing MN curriculum for statistical concepts, then appraise how statistical knowledge was being defined, presented, discussed, applied, and evaluated. Identifying and formulating a list of fundamental statistical concepts used in quantitative research was an important first step, and then application of this list to existing curriculum with a cognitive learning theory focus was used to advance this curriculum evaluation.

Project goals

1. Prepare a list of statistical concepts foundational to the understanding of quantitative research that can be used to analyze the statistical content in the University of Victoria, School of Nursing Masters program.
2. Using a cognitive learning theory framework, evaluate the University of Victoria, School of Nursing, Masters program course curriculum that contains quantitative research methodology to ascertain student exposure and activities with statistical concepts.
3. Critically examine the amount and usage of statistical conceptual knowledge within the University of Victoria, School of Nursing MN program.

Project assumptions

1. Key assumptions about curriculum: For the purpose of this project, curriculum was defined as the content of quantitative research courses in the University of Victoria, School of Nursing's four MN programs; Advanced Practice Leadership, Nurse Educator, Nurse Practitioner, and Master of Nursing / Master of Science in Health Informatics. The courses offering quantitative content in these programs are *Methodological Knowledge and Advanced Nursing Practice* or NURS 508, *Qualitative and Quantitative Analysis* or NURS 425, and *Applied Statistics in Nursing* or NURA 510. All of these courses were offered through on-line distributed learning. The data reviewed was limited to each course syllabus; any reading packet attached to the course, required readings including research articles and textbook, professor instigated discussion topics, and required assignments. For the purpose of this project, curriculum did not include reviewing individual student work, or student responses in discussion topics within the identified courses. Recognizing that different professors use different pedagogical styles and discussion, I reviewed the most current and available course materials for each course.
2. Key assumptions about statistical concepts: These are essential concepts in graduate nursing school curriculum. An experienced understanding of the concepts is necessary for the MN graduate to be able to generate, synthesize, and utilize quantitative research.
3. Key assumptions about Cognitive Skills Acquisition theory (CSAT): CSAT is a sub-theory of cognitive learning (Van Lehn, 1996; Renkl & Atkinson, 2007) that can be used to evaluate statistical knowledge of students, based on learning activities contained in the curriculum. The ability of students to synthesize, critique, and utilize empirical research containing certain statistical concepts can be estimated, based on CSAT phase placement

(see theoretical framework description below). Students were assumed to be able to synthesize, critique, and utilize empirical research that contained the examined statistical concept when they were at the end of the intermediate phase in CSAT. CSAT phases for a group of students within a course can be determined by isolating each statistical concept, and identifying the learning activities that occurred regarding that concept within a curriculum.

Theoretical framework

Cognitive Skill Acquisition theory (CSAT) is a cognitive sub-learning theory which focuses on how people learn complex skills in well-structured domains such as mathematics, medical diagnostics, computer programming, or physics (Renkl & Atkinson, 2007). When an individual has acquired the ability to solve problems in these well-structured domains, referred to as intellectual tasks, the individual has acquired a cognitive skill (VanLehn, 1996). Statistics can also be considered a well-structured domain, due to its reliance on numeracy and its chronological pathway of collection, organization, analysis, and interpretation of data. CSAT is distinguished by a framework that recognizes three phases of cognitive skill acquisition; early, intermediate, and late (Fitts, 1964; Van Lehn, 1996; Renkl & Atkinson, 2007). Each phase is characterized by learning activities that need to be worked at and completed by the student, in order to successfully develop the cognitive skill (VanLehn, 1996). CSAT appears to be a particularly useful theory to examine progressive cognitive skill development within educational curriculum, as defined learning activities determine student learning phase placement. When the student is at the end of the intermediate phase, the cognitive skill is assumed to be established within the learner, and entering the late phase is characterized by practice, building both speed and accuracy with the skill (Renkl & Atkinson, 2007) and demonstration of error free conceptual

knowledge (Van Lehn, 1996). CSAT can be used as a theoretical lens to examine University of Victoria, School of Nursing MN curriculum to determine the phase of learning achieved at the conclusion of each course, with attention to important knowledge that is needed to synthesize, critique, and utilize current empirical research. As the Canadian Nurses Association expectations for advance practice nurses is the ability to understand, develop, and disseminate evidence-based nursing knowledge (CNA, 2008), providing evidence that statistical research topics have been covered in graduate curriculum to an appropriate learning level would be notable.

Description of methodology

An essential step for this project was identifying conceptual understanding of statistics required to accurately generate, synthesize, and use quantitative research evidence. While performing a comprehensive literature search, it became apparent to me that there was no existing delineation of statistical competencies required for advanced nursing practice, and no list of statistical concepts that were essential to understanding, developing, and applying quantitative research at an advanced practice nursing level. The search was then expanded to include undergraduate nursing statistical requirements. Beitz (1998) attempted to create a list of major statistics and statistical tests needed by all registered nurses, regardless of education level. Beitz's statistical list was echoed by Zellner, Boorst and Tabb (2007), whose research concluded that undergraduate nurses need a working knowledge of commonly used statistics that appear in published nursing research journals. Mantzoukas (2009) discovered many of the same statistical concepts that Zellner, Boorst and Tabb (2007) identified were used commonly in high impact international nursing journals between 2000 and 2006.

Moving the literature search for a definitive statistical concept list beyond the discipline of nursing exposed a multitude of perceived statistical concepts needed to read, critique, and

produce quantitative research. However, I could find no definitive list of statistical concepts that were deemed essential to developing the ability to read, critique, and produce quantitative research. Stone, Allen, Rhoads, Murphy, Shehab, and Saha (2003) developed a Statistical Concept Inventory (SCI), which was intended to measure statistical concept knowledge gained from courses containing introductory statistical concepts. Assessment of the SCI confirmed introductory statistical concept measurement and no statistical tests commonly used in research were identified, except t-tests. This indicated to me that the SCI measurement of statistical concepts needed for reading and understanding quantitative research was incomplete, and the SCI could not be used by itself to measure quantitative research abilities.

Based on this review of the literature, there was no statistical concept arrangement in the nursing literature that could be used singularly and exclusively as a list of important statistical concepts needed in advanced nursing practice to generate, synthesize, and use quantitative research. In order to meet the project goal of preparing a statistical concept list to be used to evaluate the statistical content in the University of Victoria, School of Nursing MN program that is reflective of student's knowledge level regarding quantitative research, I combined two existing lists; one consisting of introductory statistical concepts, and another consisting of research statistics commonly used in published nursing research. The Statistical Concept Inventory (SCI) proposed by Stone et al. (2003), important for its fundamental listing of basic statistical concepts was used, and common research statistics in published nursing research, compiled by Zellner et al. (2007) and echoing important nursing statistical concepts proposed by Beitz (1998) and Mantzoukas (2009) was added.

A check list of all involved statistical concepts was created in combination with the Cognitive Skill Acquisition Theory (see Appendix A). Obvious duplication of statistical concepts

was corrected and the list was divided into five main statistical sections; descriptive, inferential, probability, graphical, and statistical concepts commonly found in nursing research. The compiled check list of the methodology was labelled Nursing: Statistical Knowledge in Master`s Programs (N-SKIMP) for ease of referral during use and discussion.

Table 1

CSAT phase activity

CSAT phase	Characterized	Activities and amount of activity
Early phase	Info acquisition activities	Reading or discussion of concepts. Can be readings or discussions separately or within other concepts. Instructor or peer activities accepted. Unlimited amounts.
Intermediate beginning phase	Examples of problem solving	Readings or discussions of concept use in example. Can be examples of individual concept use, or examples of use within other concepts. Instructor or peer examples accepted. Unlimited amounts.
Intermediate middle phase	Problem solving experience	Problem solving of concept by self or with peers. Can be problem solving with individual concept use, or problem solving within other concepts. Input and correction given during or post activity, by instructor or peers. 5 experiences needed before progression.
Intermediate end phase	Experiential problem solving experience	Problem solving of concept by self or with peers. Can be problem solving with individual concept use, or problem solving within other concepts. Input and correction given during or post activity, by instructor or peers. Unlimited amounts.
Late phase	No errors with problem solving	Major example of error free problem solving of concept by self. Instructor assessed.

In order to make clear measurement levels using CSAT phases, I defined activities and amounts of activities contained within each phase, using VanLehn's (1996) original theorizing as a guide. See Table 1 on page 12.

I also qualified the CSAT levels of measurement with knowledge acquisition labelling, as an attempt to indicate a knowledge level acquired by students that could be characterized by the defined activities. This was also based on VanLehn's (1996) original CSAT theorizing. See Table 2 below.

Table 2

CSAT knowledge acquisition

CSAT phase	Characterized	Knowledge level
Not addressed	No mention	No knowledge
Early phase	Info acquisition activities	Introduction
Intermediate beginning phase	Examples of problem solving	Beginning understanding
Intermediate middle phase	Problem solving experience	Developing understanding
Intermediate end phase	Experiential problem solving experience	Experienced understanding
Late phase	No errors with problem solving	Finalized conceptual understanding

Finally, I added the codicil that if a course curriculum discussed a statistical concept five or more times in a significant manner, it would be considered important and would be added to the N-SKIMP statistical concept check list (See Appendix A for the initial N-SKIMP format). However, this would only be done in non-elective courses, as the aim of the project was to assess the MN students' exposure to statistical concepts, and not all the students would take an elective.

NURS 508 assessment

The first course to be examined with N-SKIMP was *Methodological Knowledge and Advanced Nursing Practice*, also known as NURS 508. It is a required course in all of the MN program options at the University of Victoria. The University of Victoria's calendar entry for the course states:

> [Students will] explore[s] a variety of approaches to research guided by a philosophical framework that includes ontology, epistemology and ethics. Emphasis will be placed on developing student's [*sic*] abilities to critically appraise and synthesize research studies with a view to clarity, consistency and coherence. (University of Victoria, 2011a, para. 1).

The course curriculum from the summer semester of 2011 was assessed for statistical concepts and the CSAT was applied at the same time, using N-SKIMP.

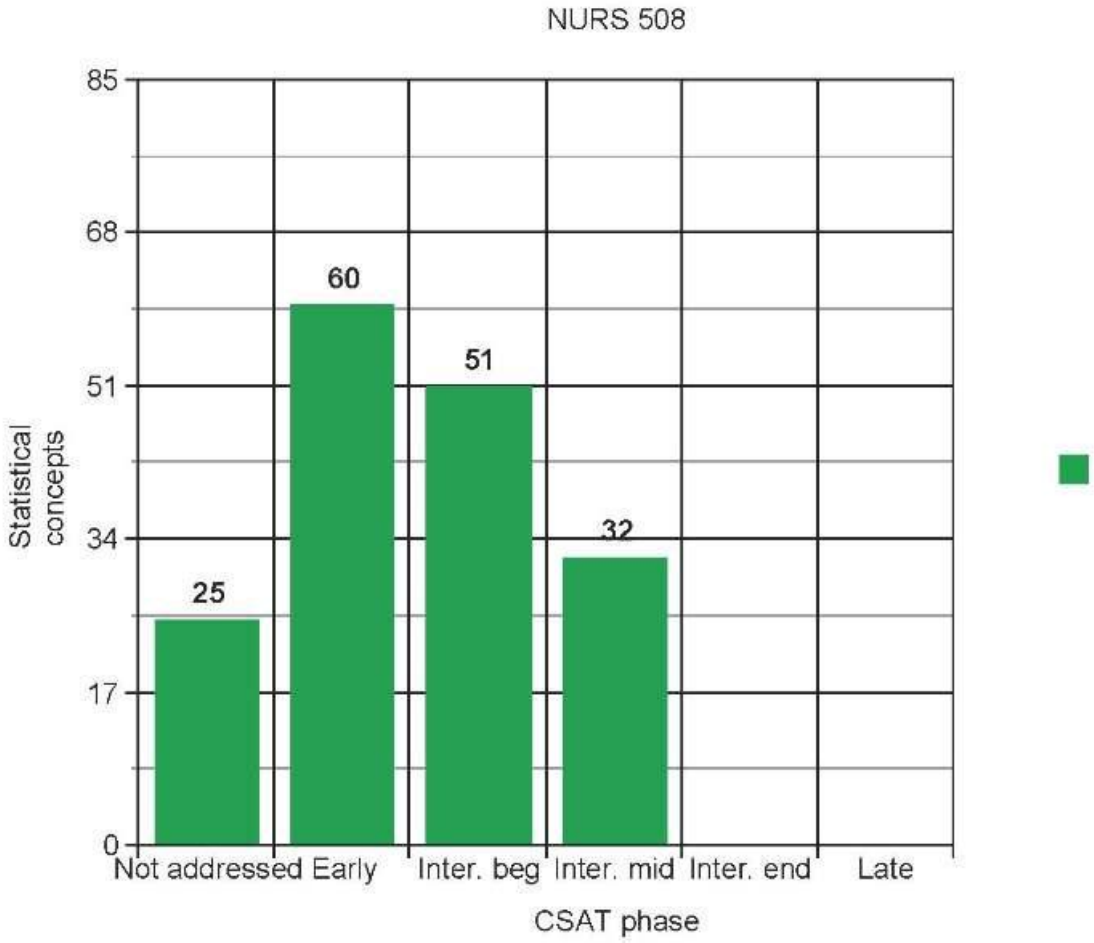
Overall, of the 85 statistical concepts that were identified on the N-SKIMP, 32 reached CSAT Intermediate middle stage, 19 reached CSAT Intermediate beginning state, 9 reached CSAT Early phase, and 25 concepts were not addressed. No concepts were addressed beyond the Intermediate middle stage of CSAT. The obtained data reflected each individual statistical concept at the highest CSAT level that it obtained in the course, and did not reflect any gaps in CSAT phases.

NURS 508 results can be found in Appendix B, in Table B1 within the N-SKIMP format with red text to indicate the additions of statistical concepts addressed five or more times in a significant manner. A concept map format can be found attached in Appendix B, in Figure B1. Table 3 on page 15 indicates the number of statistical concepts addressed within a CSAT level, as some statistical concepts may not have been addressed in a chronological CSAT phase

progression. Overall a total of 60 statistical concepts on N-SKIMP had been addressed to a minimum Early CSAT phase, or approximately 71% of the statistical concept list.

Table 3

Summary of NURS 508 total number of statistical concepts addressed and isolated within each CSAT phase.



NURS 508 did not have any of the statistical concepts in the Intermediate end phase of CSAT, meaning that no statistical concepts were taken to the level where a student could be considered to have an experienced understanding of usage (see Table 2 on page 13 for CSAT knowledge acquisition labels). Approximately 38% of the total list of statistical concepts was at the Intermediate middle phase, indicating developing understanding and less than 6 experiences

with problem solving. The majority of statistical concepts not addressed fell within the N-SKIMP probability section, and reference to Appendix B Table B1, indicates that several of the concepts in the statistical concepts commonly found in nursing research are addressed to an information acquisition level, CSAT Early phase, and therefore only reach an introductory stage.

NURS 425 assessment

The second course to be analyzed was *Qualitative and Quantitative Analysis,* also known as NURS 425. This research course is an elective in University of Victoria`s undergraduate studies, but is a required course in University of Victoria`s MN studies. It can be pre-empted by an approved course as specified by the Nursing Admission Committee (University of Victoria, 2011b), but one could assume that the content of the replacement course would be very similar to NURS 425. The University of Victoria's calendar entry for the course states:

> A grounding [*sic*] in the techniques commonly used in the analysis of both quantitative and qualitative data. Students will engage in the process of qualitative analysis through examining qualitative data, data coding and thematic construction. A range of descriptive and inferential statistical approaches to quantitative analysis are examined using a computer-based system. (University of Victoria, 2011c, para.1).

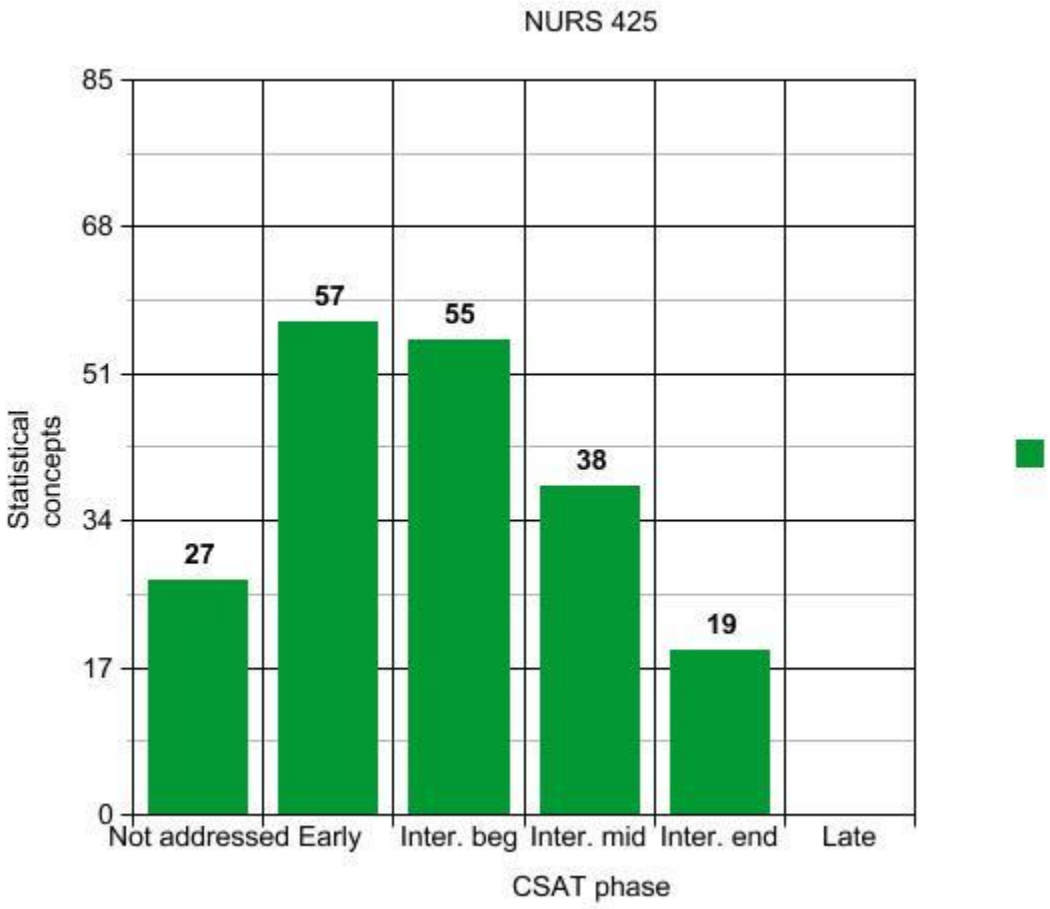
The course curriculum from the spring semester of 2012 was assessed for statistical concepts and the CSAT was applied at the same time, using N-SKIMP. The course was divided into two distinct sections; quantitative and qualitative analyses. The quantitative section of the course was assessed, using the modified N-SKIMP containing additional statistical concepts from NURS 508.

Overall, of the 85 statistical concepts that were identified on the modified N-SKIMP, 19 concepts reached Intermediate end stage, 18 reached CSAT Intermediate middle stage, 18

reached CSAT Intermediate beginning state, 2 reached CSAT Early phase, and 28 concepts were not addressed. The obtained data assessed each individual concept to the highest CSAT level that it obtained in the course, and did not reflect any gaps in CSAT phases.

Table 4

Summary of NURS 425 total number of statistical concepts addressed and isolated within each CSAT phase.



NURS 425 results can be found in Appendix C, in Table C1 within the N-SKIMP format. There were no additional statistical concepts added to the N-SKIMP format from NURS 425. A concept map format can be found attached in Appendix C, in Figure C1. Table 4, found above, indicates the number of statistical concepts addressed within a CSAT level, as some statistical

concepts may not have been addressed in a chronological CSAT phase progression. Overall a total of 58 statistical concepts had been addressed to one or more phases of CSAT or approximately 68% of the statistical concept list.

NURS 425 had 22.4% of the concepts addressed to the level where a student could be considered to have an experienced understanding of usage (see Table 2 on page 13 for CSAT knowledge acquisition labels). Twenty seven of the N-SKIMP concepts were not addressed at all and, referring to Appendix C Table C1, indicates that the gaps were mainly in the sections of probability and statistical concepts commonly found in nursing research. An interesting note regarding NURS 425 that did not present in the N-SKIMP is the length of class time devoted to learning these statistical concepts; approximately half the course, or a seven week section.

NURA 510 assessment

The last course to be analyzed was *Applied Statistics in Nursing*, also known as NURA 510. It is an elective course offered in all of the MN program options at the University of Victoria. The University of Victoria's calendar entry for the course was:

> Students will develop familiarity with advanced statistical methods as they are applied to nursing and health care. These will include multiple linear regression, factor analysis, and multivariate analysis of variance. Students will have the opportunity to use statistical software packages such as SPSS. A brief introduction to structural equation modelling and psychometric methods may be offered (University of Victoria, 2011d, para.1).

The course curriculum from the spring semester of 2012 was assessed for statistical concepts and the CSAT was applied at the same time, using N-SKIMP.

Overall, of the 85 statistical concepts that were identified on the modified N-SKIMP, 18 concepts reached CSAT Intermediate end stage, 30 reached Intermediate middle stage, 17

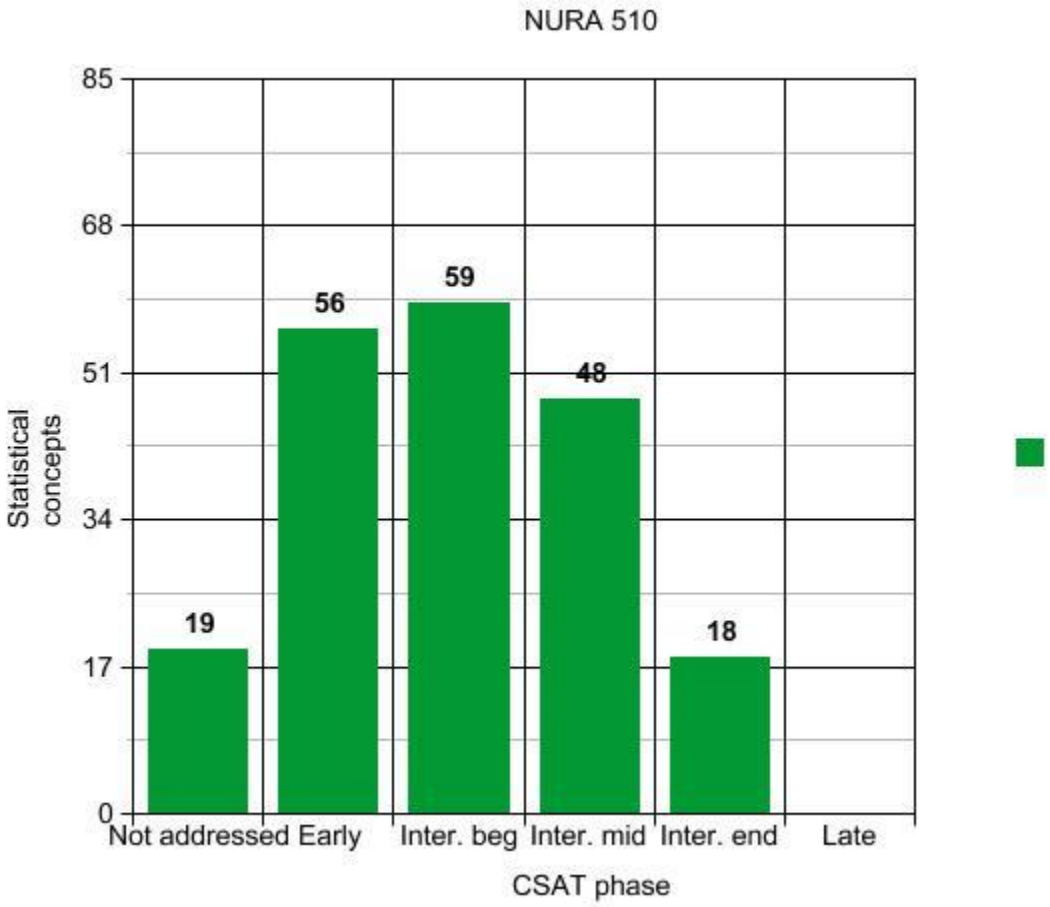
reached Intermediate beginning state, one was addressed at the CSAT Early phase, and 19 concepts were not addressed. The obtained data assessed each individual concept to the highest CSAT level that it obtained in the course, and did not reflect any gaps in CSAT phases.

NURA 510 results can be found in Appendix D, in Table D1 within the revised N-SKIMP format. No additional statistical concepts were added to the N-SKIMP statistical concept list as NURA 510 is an elective, even though there were several additional statistical techniques discussed five or more times in a significant manner. A concept map format can be found attached in Appendix D, in Figure D1. Table 5, found on page 20, indicates the number of statistical concepts addressed within a CSAT level, as some statistical concepts may not have been addressed in a chronological CSAT phase progression. Overall a total of 60 statistical concepts had been addressed to one or more phases of CSAT or approximately 71% of the statistical concept list.

NURA 510 addressed 21.2% of the total statistical concepts to the level where a student could be considered to have an experienced understanding (see Table 2 on page 13 for CSAT knowledge acquisition labels). An interesting finding, when referring to Appendix D Table D1, was in the N-SKIMP section of statistical concepts commonly found in nursing research which showed there were several gaps between the CSAT phases, indicating a missing component in the CSAT progression of learning a cognitive skill. This could possibly be explained by the fact that NURS 508 was a prerequisite to NURA 510, and assumptions could have been made of statistical concepts already covered up to an earlier phase of CSAT. However, when the N-SKIMPs are compared between NURS 508 and NURA 510 (see Appendix Tables B1 and D1) there is no indication that these gaps had been addressed.

Table 5

Summary of NURA 510 total number of statistical concepts addressed and isolated within each CSAT phase.



Background discussion to key findings

When considering the University of Victoria's MN graduates' ability to read, understand, generate, synthesize, and utilize quantitative research, an assumption must be made as to which CSAT phase statistical concepts should be reached during a course in order to achieve this ability. Renkl and Atkinson (2007) suggest that when the student is at the end of the CSAT intermediate phase, the cognitive skill is assumed to be established within the learner. Therefore it seems clear that the CSAT phase of Intermediate end should be achieved with

important statistical concepts in order to have an experienced understanding of quantitative research using those particular concepts. Refer to Table 2 on page 13 for the complete list of qualified CSAT knowledge acquisition labels, based on Van Lehn's (1996) original CSAT theorizing.

At this point, before discussing the data findings of University of Victoria's MN program statistical content, it seems logical to briefly examine the knowledge that undergraduate nurses bring to graduate studies. It is difficult to measure statistical knowledge acquired as a working nurse as it would have to be assessed individually. A review of the University of Victoria, Bachelor of Science in Nursing (BSN) program does not list introductory statistics as a prerequisite to any nursing undergraduate courses (Camosun College, 2011; Selkirk College, 2011; Aurora College, 2011; College of the Rockies, 2012), and British Columbia Grade 11 Mathematics is the minimum course accepted for entry into the undergraduate nursing program. In the British Columbia Institute of Technology's Mathematics 11 competency test there is no statistical content (BCIT, 2009), except for the generic mathematical concepts of percentages and variation, therefore one can assume most statistical concepts are not covered to any CSAT phase in British Columbia Grade 11 Mathematics. University of Victoria, School of Nursing course NURS 360, *Professional Practice VI: Nursing Research,* is a requirement for the BSN, and the intent of the course is to "enhance participants understanding of nursing scholarship and enhance abilities to comprehend, critique and utilize nursing research" (University of Victoria, 2011e, para.1). Although I was not able to assess this course curriculum for statistical content, I was able to access the 2010 NURS 360 syllabus and it did address some statistical conceptual knowledge based on quantitative research methodology. This course covers both quantitative and qualitative research methodology, so it is doubtful that many statistical concepts would be able to

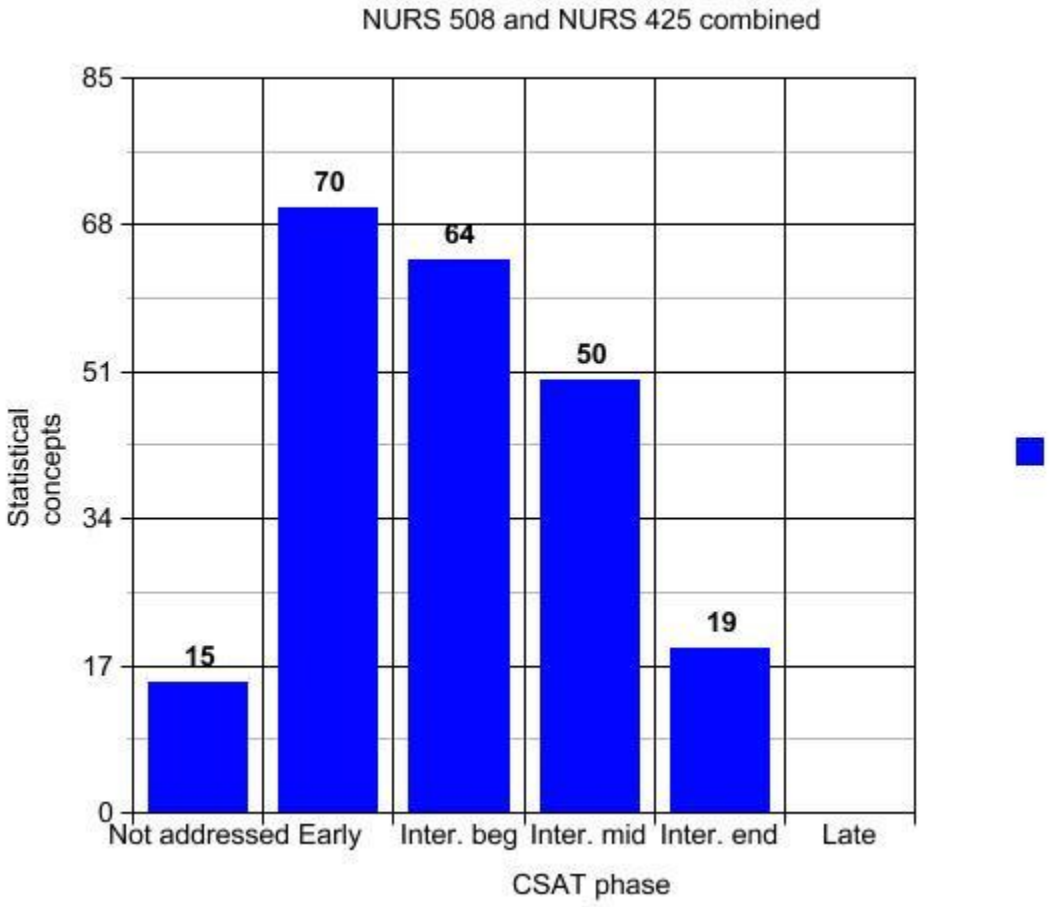
be covered to an experienced understanding in the CSAT level due to time constraints. However, it may address important statistical concepts up to the CSAT intermediate middle level indicating problem solving experience and therefore a developing understanding of addressed concepts (refer to Table 3 on page 13 for knowledge acquisition labels), considering BC nurses with an entry to practice education are required to "analyze and interpret qualitative and quantitative data" (CRNBC, 2008, p.11). A developing understanding of statistical concepts in CSAT's intermediate middle phase may be regarded as the minimum to meet this entry level competency, and I believe that NURS 360 should be assessed for confirmation of this.

When considering the statistical concept content findings of this project, the data has been presented in individual course format and in concept map form, within Appendixes B, C, and D. NURS 508 and NURS 425 are requirements for University of Victoria, MN graduation and therefore these course data were assessed together, to analyze the graduate's overall ability to generate, synthesize and use research evidence, regarded as central by CNA to advanced nursing practice (CNA, 2008). When NURS 508 and NURS 425 data were combined, see Appendix E Table E1, there were more statistical concepts addressed, but no further advancement on any of the concepts to Intermediate end, therefore no significant increase in the experienced understanding any of the addressed statistical concepts. Although the increased exposure to statistical concepts that NURS 508 provided could be viewed as a positive factor for gaining an increased familiarity with statistical terms, it did not increase statistical concept understanding ability beyond what NURS 425 provided independently. Appendix E figure E1, provides a concept mapping of the combined two course data. Table 6, found on page 23, indicates the number of statistical concepts addressed within a CSAT level, as some statistical concepts may not have been addressed in a chronological CSAT phase progression. Overall a

total of 70 statistical concepts on N-SKIMP had been addressed or approximately 82% of the statistical concept list.

Table 6

Summary of NURS 508 and NURS 425 results combined showing total number of statistical concepts addressed and isolated within each CSAT phase.

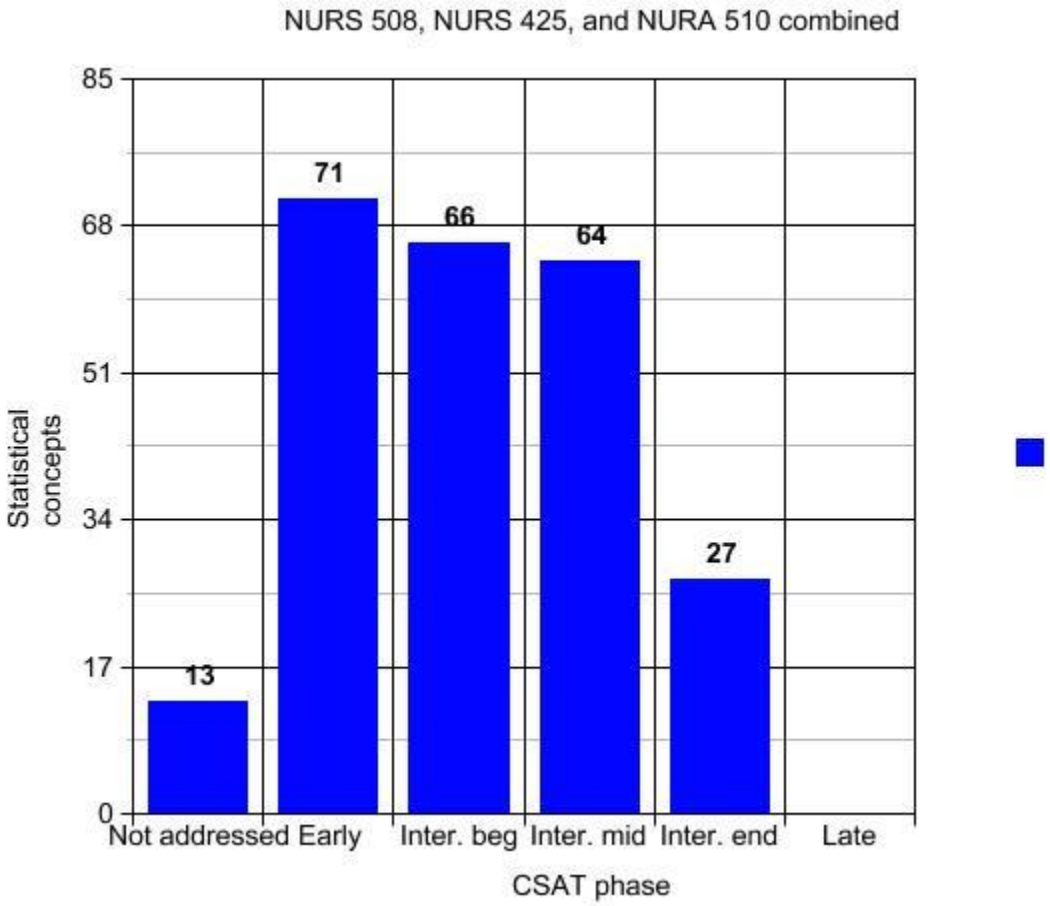


With reference to Appendix E Table E1, one can see that out of 15 statistical concepts not addressed, 9 of them were contained in the N-SKIMP probability section. Approximately 22% of the statistical concepts on N-SKIMP arrive at the knowledge level of experienced understanding, and that seems somewhat low for an advanced nursing ability to read, understand, generate, synthesize, and utilize quantitative research using statistical concepts. In particular, the N-

SKIMP section of statistical concepts commonly found in nursing research has only one concept taken to an experienced understanding state, t-tests. This is particularly troubling as it appears MN students are not getting enough problem-solving experience using statistical concepts in common nursing research. The data of NURS 508, NURS 425, and NURA 510 was then assessed together to ascertain if the number of statistical concepts reaching the experienced understanding level increased when combined.

Table 7

Summary of NURS 508, NURS 425, and NURA 510 results combined showing total number of statistical concepts addressed and isolated within each CSAT phase.



NURA 510 is an elective and not necessary to graduate with a MN degree, but it contained important statistical concepts foundational to quantitative research understanding, with the focus on advanced research methodology. When the data of all three courses was combined, see Appendix F in Table F1, the number of statistical concepts increased in the Intermediate end phase, from 19 concepts to 27. Appendix F, Diagram F1, provides a concept mapping of the combined three courses data. Table 7, found on page 24, indicates the number of statistical concepts addressed within a CSAT level, as some statistical concepts had not been addressed in a chronological CSAT phase progression. Overall a total of 72 statistical concepts on N-SKIMP had been addressed to some degree within CSAT, or approximately 85% of the statistical concept list, a small increase from 82% of the two required courses NURS 508 and NURS 425. However, it is significant to note that the increases in statistical concepts addressed in both the Intermediate middle and Intermediate end CSAT phases. Combining all three courses data brought the number of statistical concepts taught to an experienced understanding level to 31.8%, a significant increase from 22.4% in the combined total of the required MN courses of NURS 508 and NURS 425.

When applying the N-SKIMP for statistical concept assessment, the reader will note that no statistical concepts within any of the assessed courses entered the Late phase of CSAT. This was because there was no way to assess the error level of the assignments within the projects parameters, as there was no access to student's assignments or completed activities. However, the University of Victoria`s School of Nursing online sample library of posted theses and projects was viewed and briefly assessed, with the idea that if they contained statistical concepts from the N-SKIMP, these concepts could be considered taught to the CSAT Late phase, as the theses and projects had been closely followed and critiqued by University of Victoria graduate

faculty. Using the 12 posted theses from 2008 to the present, there was no quantitative research and therefore none were assessed for statistical concepts. Using the same time frame in projects yielded 60 eligible examples, and their assessment became complicated as there were many literature reviews that summarized quantitative research assessment but did not contain or elaborate on statistical concepts utilized, merely that they were quantitative. This complication resulted in the counting of projects that had used some form of quantitative research, and I did not assess them with the N-SKIMP format, as all the references used in the applicable projects literature searches would have to be reviewed, a task that time limitations deemed unmanageable. The assumption with this percentage data was that there would have been CSAT Late phase entry and therefore finalized conceptual understanding of many of the N-SKIMP statistical concepts. Overall, 68% of the eligible projects used some form of evaluation of some type of quantitative research data.

Key findings

1. NURS 425 contained the bulk of the statistical concept development within the MN program.
2. NURS 508 addressed many of the statistical concepts, but none were taken to the Intermediate end phase, or to the experienced understanding level (refer to Table 2 on page 13 for CSAT knowledge acquisition labels).
3. NURS 425 and NURS 508, both required courses for MN studies, combined had 82% of the statistical concepts addressed, however only 22% were at an experienced understanding level, indicating cognitive skill establishment. This was no greater than NURS 425 data by itself.

4. NURS 425 and NURS 508 combined data had significant gaps in the N-SKIMP section of statistical tests found in nursing research.
5. When NURA 510 data was added to NURS 425 and NURS 508 data, 84% of the statistical concepts were addressed, an increase of little more than 2%. However, combining all three courses brought the number of statistical concepts taught to an experienced understanding level of 31.8%, a significant increase from 22.4% in the combined total of the required MN courses of NURS 508 and NURS 425.
6. Based on the CSAT methodology, there appeared to be a lack of statistical concept information sharing between courses, with some information repeated and some CSAT phases missing even when prerequisites were considered.

Recommendations to University of Victoria's, School of Nursing Graduate Committee

I suggest that NURS 360 be assessed with N-SKIMP to greater enhance the overall curriculum picture. It may be that many of the statistical concepts are addressed to a significant level in CSAT, and therefore some of the CSAT Early phase activity could be reduced in the graduate program. This could benefit the MN courses, especially NURS 425 as that particular course appears to contain the majority of the statistical concept development.

It was apparent that NURS 425 contained the bulk of the statistical concept development and took many concepts to the CSAT phase of Intermediate end, indicating experienced understanding of the concepts and establishment of cognitive skills. As mentioned previously, NURS 425 contained two parts, quantitative and qualitative sections, and the entire section of quantitative research was covered in the first seven weeks. Cognitive skill acquisition theory does not stipulate time frames for knowledge development, but it is notable that the majority of statistical conceptual development for University of Victoria's MN nursing students occurred in

an intensive seven week time frame. When reviewing NURS 425 data, see Appendix C, one sees a lack of conceptual development in the section of statistical concepts commonly found in nursing research, with the exceptions of chi-square and t tests, and this perhaps is something that NURS 508 should address.

NURS 508 did not cover any concepts beyond the CSAT Intermediate middle phase and therefore no statistical concepts reached an experienced understanding by the students. The idea that NURS 425 should cover the statistical basics and NURS 508 should cover the statistical tests commonly found in nursing research is, I believe, an important point to the overall statistical conceptual development within the MN programs. NURS 425 and NURS 508 data combined had 82% of the statistical concepts addressed, however only 22% were at an experienced understanding level. This was no greater than NURS 425 data by itself. Both NURS 425 and NURS 508 also covered qualitative research data, an extremely broad focus for a thirteen week term. In order to effectively build on coursework, I suggest NURS 508 should not try to cover statistical basics, but instead focus on the N-SKIMP section of statistical concepts commonly found in nursing research. If MN students do not have a recent undertaking of NURS 425 or equivalent within the last five years before admission to the graduate program then they must be required to take it. If they have taken it but have less than an A standing, then they should be required to audit it. I believe that NURS 425 should be the foundational piece to understanding the basic statistical concepts and NURS 508 should address the gap between understanding of the statistical concepts, and applying their use within the context of quantitative research. If NURS 508 focuses on the statistical concepts commonly found in nursing research it will help to narrow a very broad conceptual field, and perhaps NURA 510, the elective, can

provide additional problem solving experience with the statistical concepts commonly found in nursing research and continue to cover more of the complex statistical concepts.

NURA 510, an elective, had the prerequisite of NURS 508. As NURS 508 is a required course in the University of Victoria, School of Nursing MN programs, the statistical concepts assessed by N-SKIMP should have the expectation to be taken to the Intermediate end CSAT level before a student enters NURA 510. NURA 510 should be able to build on the established cognitive skills laid by NURS 508 and NURS 425, and should provide opportunities of experienced problem solving with the statistical concepts of N-SKIMP. Of course, being an elective, NURA 510 should continue to provide opportunities to explore more advanced statistical concepts used in nursing research to the CSAT phase of Intermediate end. The current NURA 510 offered activities in more advanced statistical concepts but N-SKIMP did not indicate this, as I elected not to add statistical concepts to N-SKIMP that were addressed five or more times in a significant manner in an elective course.

Prerequisites were important to this curriculum picture. I suggest that prerequisites be applied to both NURS 508 and NURA 510. NURS 425 should be a prerequisite for both 508 and 510, as it provides a solid foundation for many of the statistical concepts. This would ensure a progression of courses from NURS 425 to NURS 508, and then finally to NURA 510. I would also suggest that although an introductory statistical course is currently not needed for NURS 425 as many introductory statistical concepts are covered within it, that it be strongly advised. With the intensity of the current NURS 425 seven week quantitative section format, it may become more learner centered and less content driven if statistical concepts have already been addressed to a more advanced CSAT phase.

Finally, we come to recommendations about the statistical concepts taught within the curriculum. Based on the CSAT theory and methodology, there appeared to be a lack of statistical concept sharing between courses, with some information repeated and some CSAT phases missing even when there were prerequisites in place. With the time limitations of each course and the large amount of statistical conceptual knowledge that must be brought to an established cognitive level, there must be clear expectations of certain statistical concepts reaching CSAT phases within each course. NURS 425 is the foundation, needing to develop an experienced understanding of the statistical concepts within the N-SKIMP sections of descriptive, inferential, probability, and graphical. NURS 508 should continue with this conceptual knowledge development, with the emphasis on the N-SKIMP section of statistical concepts commonly found in nursing research. NURA 510, the elective, should continue with this statistical conceptual knowledge, providing more problem solving opportunities with statistical concepts commonly found in nursing research and adding more increasingly complex statistical concepts found in nursing research to an experienced understanding level. Lastly, I believe that more students should be encouraged to do quantitative data analysis in their final thesis or project, in order to consolidate and present their understanding of statistical conceptual data. There were no examples of quantitative research theses in the University of Victoria, School of Nursing sample library of online posted theses and projects, and a review of University of Victoria, graduate School of Nursing tenure track faculty who expressed an interest in research methodology revealed twenty professors whose interest was qualitative methodology, three interested in mixed methods, and three quantitative. This indicates to me that the University of Victoria, School of Nursing faculty have adequate representation and expertise in quantitative methodology, but MN students are not choosing quantitative methodology for major research. Is

this because the MN students do not feel confident in their statistical concept knowledge in relation to quantitative research methodology? Based on data from this project, I believe that the University of Victoria, School of Nursing MN programs are providing an adequate amount of statistical concepts information acquisition and example activities, but needs to increase problem solving with these concepts to support its claim that its MN graduates can generate, synthesize, and use quantitative research evidence immediately upon graduation.

Limitations of this project

A major drawback of this project is my inability to assess the comprehensive statistical literacy of a University of Victoria, MN graduate: through this analysis I can merely estimate their abilities with individual statistical concepts based on their curriculum exposure. This major problem illuminates the difficulty of transferring statistical concept knowledge into a measurement of quantitative research ability. Perhaps this could have been addressed somewhat by involving a sampling of students and assessing their statistical concept and quantitative research abilities before and after each MN research course.

Creating and using the N-SKIMP format as a combined framework with the identified statistical concepts and CSAT phases had positive and negative aspects. One of the main challenges was my personal lack of statistical knowledge and familiarity with multiple statistical concept names. I was unfamiliar with the many different names, partial names, and abbreviations for concepts and I used only the terminology of N-SKIMP, which may have impacted the data collection. My lack of statistical knowledge may also have impacted the inclusion of concepts in the N-SKIMP statistical list whose understanding may not be needed in order to generate, synthesize, and utilize quantitative research. The thirteen statistical concepts not addressed by any of the University of Victoria research courses may have the potential to be removed from the

statistical concept list. There were also problems regarding CSAT. Even with my definitions of activities within the CSAT phases, the distinctions on what constituted a measureable activity was not always clear. For example an information acquisition event could be as simple as mentioning the statistical concept within another concept discussion, or as complex as an entire article of text describing it. There were also concerns about the possibility of counting the same statistical concept more often than was warranted, as it could be referred to several times in an article using different contexts; for example the same statistical concept could be referred to in the data analysis, discussion, and a table. When it was obvious that it was the same statistical concept I assessed it once, and when it was unclear I counted it as many times as it appeared. I believed this was not of major significance because when a statistical concept was found in an article of text, it was always at CSAT Early or Intermediate beginning phase, and these stages could have limitless activities and not progress to the next level of CSAT. This concern revealed the issue that within the N-SKIMP format there was only learning progression from CSAT Intermediate middle to Intermediate end phases. CSAT Early, Intermediate beginning and Late phases contained activities that could be counted, but there was no definitive number of activities to achieve that led to a higher phase of CSAT. Progressive learning was assumed, but it was not clearly defined as to when and how that progression occurred. It was only at the Intermediate middle phase that the number of activities mattered significantly, as progression to Intermediate end phase was dependent on the number of problem solving experiences provided. Within the Early and Intermediate beginning CSAT phases, the N-SKIMP format did not acknowledge if the statistical concept was addressed once or one hundred times, the concept did not advance into a higher CSAT phase, and it did not make a difference to the data outcomes.

Finally, I close with a positive aspect of the N-SKIMP format. It was a serviceable format in which to combine two large concepts; a list of statistical concepts important to generating, synthesizing and using quantitative research evidence, and a cognitive learning theory that could assess these statistical concepts within a body of knowledge. If used again, this format could possibly evolve into a measurement tool, with validity and reliability tests assessing and honing its trustworthiness.

Conclusion

In conclusion I reflect on the original question of the project: Is the University of Victoria, School of Nursing providing Masters students with enough statistical knowledge to have confidence in their abilities to generate, synthesize, and utilize quantitative research evidence in their advanced nursing practices? Based on the obtained data and analysis, I believe that the University of Victoria is providing sufficient exposure to foundational statistical concepts to minimally meet quantitative research needs of advanced practice nurses. However, in order to confidently claim that all MN graduates can generate, synthesize, and utilize quantitative research in their advanced nursing practice, I believe the University of Victoria needs to reach more advanced phases of CSAT in many of the statistical concepts, and definitely in the statistical concepts commonly found in nursing research. Looking closely at statistical prerequisites and statistical content of all the MN graduate research courses will allow adjustment of content and activities to address this progression of CSAT phases. I believe that adding more focused problem solving activities will dramatically increase CSAT scoring, and allow students to reach a confident established skill development with important statistical concepts. It may simply require readjustment of course content with an informed overview of what other research courses contain and to what level of understanding they are addressing

important statistical concepts. Using CSAT as the methodology for assessing students' knowledge level and ability with statistical concepts could provide an excellent framework for progressive, constructivist quantitative research skill development across the University of Victoria MN curriculum. It could also provide some tangible proof that the CNA core competency for quantitative research ability is being met within the University of Victoria, School of Nursing MN programs.

This has been an interesting project for a statistically challenged nurse, interested in curriculum assessment. This project provided the University of Victoria with an admittedly limited overview of statistical concept content within their program and how it fits together to help analyze understanding of statistical knowledge of their graduate students. This project provided me with insight into the difficulties of teaching introductory statistical concepts in a research based course, and a healthy respect for those who teach them. Of interest to note is that when opportunities arose to discuss my project with my MN cohort, all were polite but no one was particularly interested, leading me to wonder about attitudes towards statistics and the role these attitudes may have in achieving quantitative research competency. A future qualitative study about attitudes and feelings regarding statistics in graduate nursing education would be interesting to explore in light of my experiences.

I hope that the University of Victoria, School of Nursing Graduate Committee will be able to use the information generated within this project in some small way, even with the projects sizable limitations. I want to expressly thank the University of Victoria for allowing me this opportunity to investigate a small piece of curriculum assessment, and to be able to appreciate the complexity and depth that statistical knowledge brings to nursing.

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Appendix A

Nursing: Statistical Knowledge in Master`s Programs (N-SKIMP)

CSAT phase:

Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Info acquisition activities	**Examples with solution**	**Problem solving with input and correction**	**Problem solving experience**	**No errors**

Descriptive:					
Data collection					
Frequency distribution					
Impact of outliers					
Measures of central tendency					
Median					
Mode					
Normal distribution					
Percentages/percentiles /quartiles					
Sampling					
Standard deviation					
Random sampling					
Variance					
Weighted mean					
Inferential:					
Alternative hypothesis (research hypothesis)					
Bias					
Choosing appropriate statistical test					
Confidence intervals					
Correlation					
Experimental design					
Hypothesis testing					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Mean					
P value					
Parameter estimation					
Sample					
Sample size effect					
Probability:					
Bayes theorem					
Conditional probability					
Contingency tables					
Exponential distribution					
Geometric distribution					
Independence					
Joint probability					
Law of large numbers					
Marginal probability					
Memoryless property					
Population parameters					
Probability					
Probability rules					
Probabilities of sequences					
Properties of the normal distribution					
Graphical:					
Bar graphs					
Central limit theorem (graphical)					
Correlational coefficient					
Dot plots					
Histograms					
Interpreting graphs					
Line graphs					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Methods of displaying data					
Range					
Sample/parent distributions					
Scatter plots					
Skew					
Uniform distributions					
Variability					
Statistical concepts commonly found in nursing research:					
Analysis of variance (ANOVA); all kinds					
Chi-square					
Cronbach's alpha					
Discriminant analysis					
Fishers exact probability test					
Kruskal-Wallis					
Mann-Whitney					
McNemar test					
Multiple comparison/post-hoc tests					
Odds ratio					
Power analysis					
Regression, all kinds					
t test: paired/two-sample					
Wilcoxon's test					
z score					

Appendix B

NURS 508

Table B1: N-SKIMP of NURS 508

CSAT phase:

Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Info acquisition activities	**Examples with solution**	**Problem solving with input and correction**	**Problem solving experience**	**No errors**

Descriptive:					
Data collection	X	X	X		
Dependent variables	X	X	X		
Frequency distribution	X	X			
Impact of outliers					
Independent variables	X	X	X		
Levels of measurement	X	X	X		
Measures of central tendency	X	X	X		
Median	X	X			
Mode	X	X			
Normal distribution	X	X			
Percentages/percentiles /quartiles	X				
Sampling	X	X	X		
Standard deviation	X	X	X		
Random sampling	X	X			
Variance	X				
Weighted mean					
Inferential:					
Alternative hypothesis (research hypothesis)	X	X	X		
Bias	X	X	X		

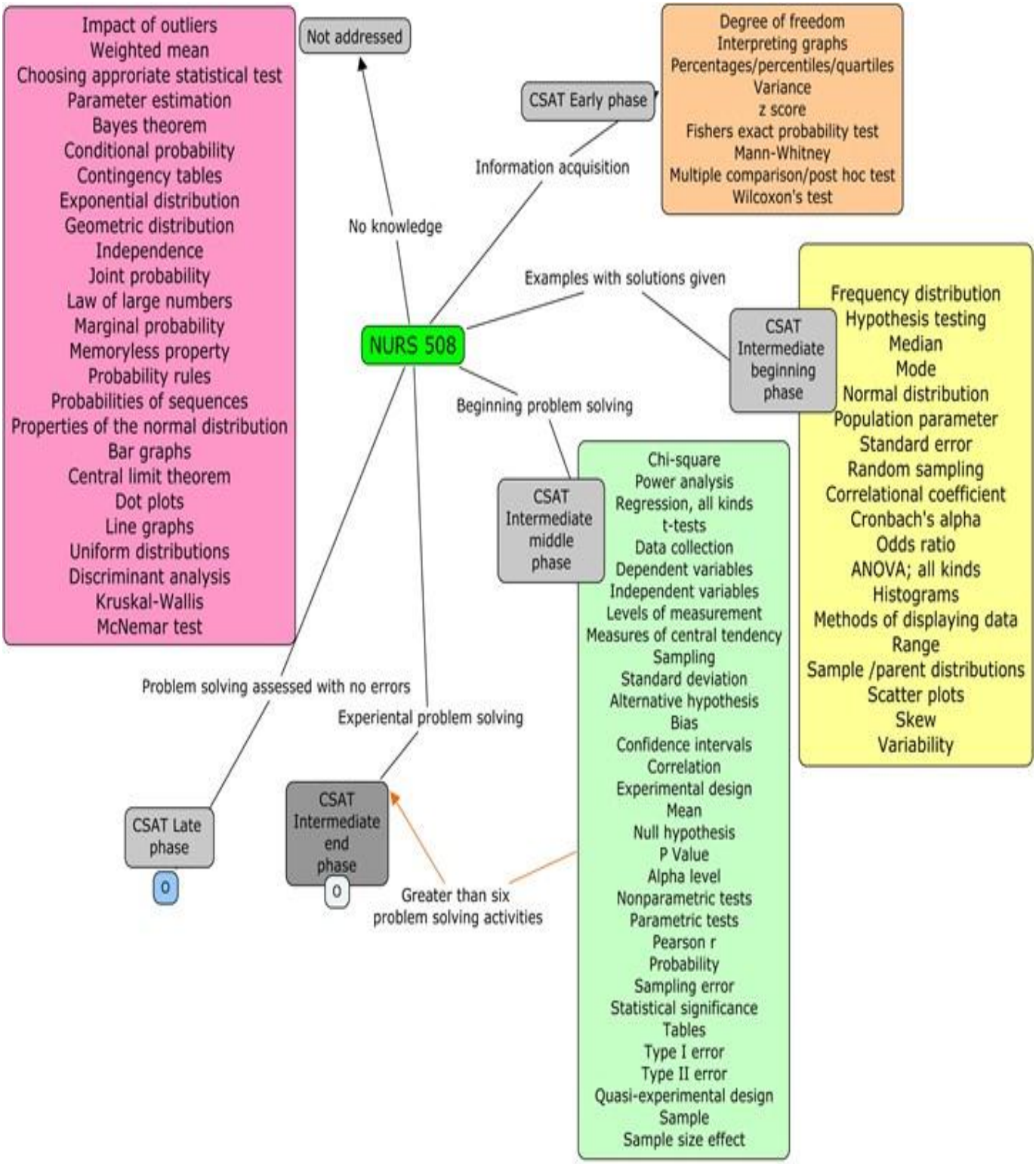
	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Choosing appropriate statistical test					
Confidence intervals	X	X	X		
Correlation	X	X	X		
Experimental design	X	X	X		
Hypothesis testing	X	X			
Mean	X	X	X		
Null hypothesis	X	X	X		
P value	X	X	X		
Parameter estimation					
Quasi-experimental design	X	X	X		
Sample	X	X	X		
Sample size effect	X	X	X		
Probability:					
Alpha level	X	X	X		
Bayes theorem					
Conditional probability					
Contingency tables					
Degree of freedom	X				
Exponential distribution					
Geometric distribution					
Independence					
Joint probability					
Law of large numbers					
Marginal probability					
Memoryless property					
Nonparametric tests	X	X	X		
Parametric tests	X	X	X		
Pearson r	X	X	X		
Population parameters	X	X			
Probability	X	X	X		
Probability rules					
Probabilities of sequences					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Properties of the normal distribution					
Sampling error	X	X	X		
Standard error	X	X			
Statistical significance	X	X	X		
Type 1 error	X	X	X		
Type 2 error	X	X	X		
Graphical:					
Bar graphs					
Central limit theorem (graphical)					
Correlational coefficient	X	X			
Dot plots					
Histograms	X	X			
Interpreting graphs	X				
Line graphs					
Methods of displaying data	X	X			
Range	X	X			
Sample/parent distributions	X	X			
Scatter plots	X	X			
Skew	X	X			
Tables	X	X	X		
Uniform distributions					
Variability	X	X			
Statistical concepts commonly found in nursing research:					
Analysis of variance (ANOVA); all kinds	X	X			
Chi-square	X	X	X		
Cronbach's alpha	X	X			
Discriminant analysis					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Fishers exact probability test	X				
Kruskal-Wallis					
Mann-Whitney	X				
McNemar test					
Multiple comparison/post-hoc tests	X				
Odds ratio	X	X			
Power analysis	X	X	X		
Regression, all kinds	X	X	X		
t test: paired/two-sample	X	X	X		
Wilcoxon's test	X				
z score	X				

Note. Additional statistical concepts that were found in NURS 508 course curriculum that addressed the concept 5 or more times in a significant manner were added to N-SKIMP in red text.

Figure B1: Concept map of NURS 508 statistical concepts



Appendix C

NURS 425

Table C1: N-SKIMP of NURS 425

CSAT phase:

Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Info acquisition activities	**Examples with solution**	**Problem solving with input and correction**	**Problem solving experience**	**No errors**

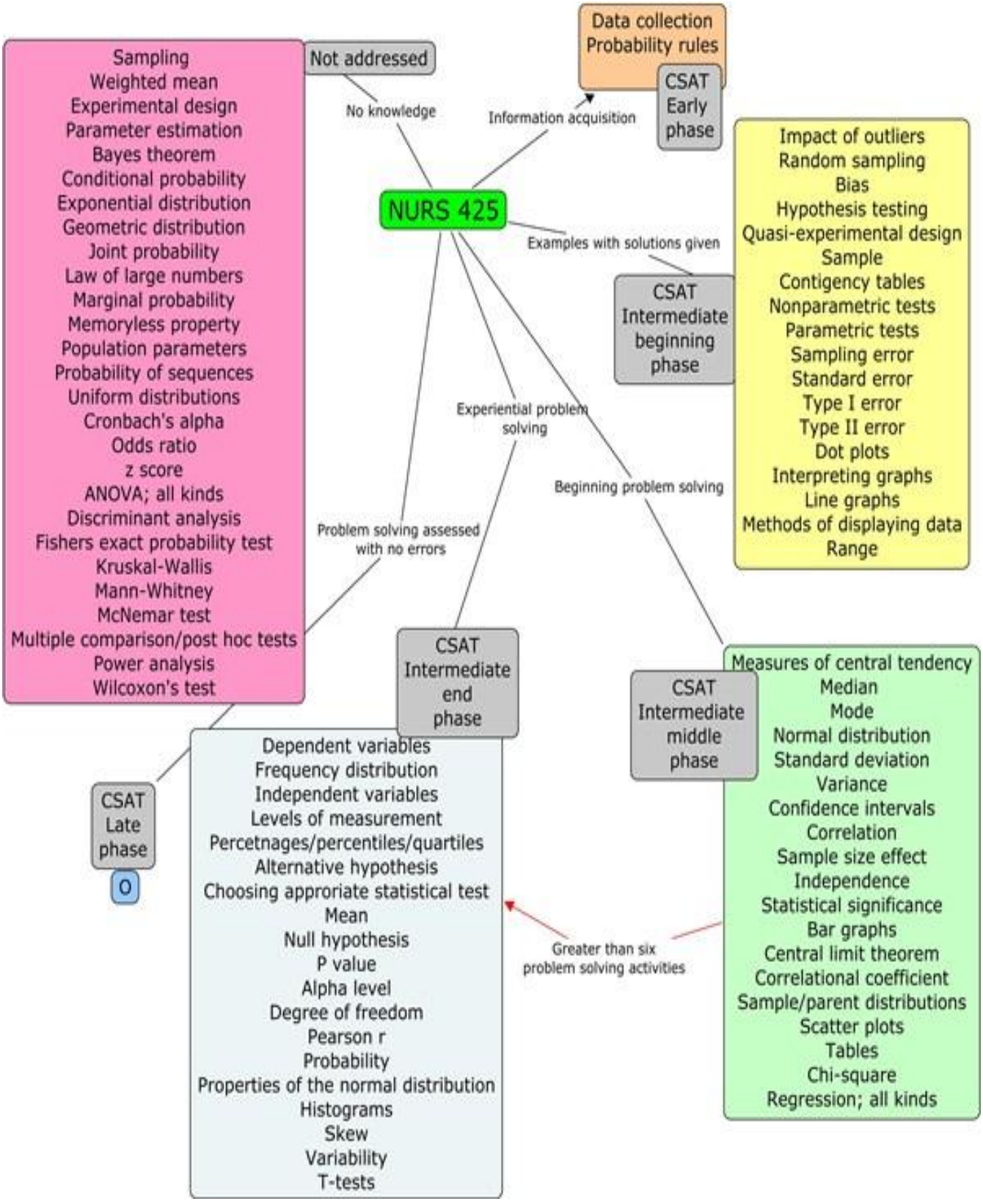
Descriptive:					
Data collection	X				
Dependent variables	X	X	X	X	
Frequency distribution	X	X	X	X	
Impact of outliers	X	X			
Independent variables	X	X	X	X	
Levels of measurement	X	X	X	X	
Measures of central tendency	X	X	X		
Median	X	X	X		
Mode	X	X	X		
Normal distribution	X	X	X		
Percentages/percentiles /quartiles	X	X	X	X	
Sampling					
Standard deviation	X	X	X		
Random sampling	X	X			
Variance	X	X	X		
Weighted mean					
Inferential:					
Alternative hypothesis (research hypothesis)	X	X	X	X	
Bias	X	X			
Choosing appropriate statistical test	X	X	X	X	

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Confidence intervals	X	X	X		
Correlation	X	X	X		
Experimental design					
Hypothesis testing	X	X			
Mean	X	X	X	X	
Null hypothesis	X	X	X	X	
P value	X	X	X	X	
Parameter estimation					
Quasi-experimental design		X			
Sample	X	X			
Sample size effect	X	X	X		
Probability:					
Alpha level	X	X	X	X	
Bayes theorem					
Conditional probability					
Contingency tables	X	X			
Degree of freedom	X	X	X	X	
Exponential distribution					
Geometric distribution					
Independence	X	X	X		
Joint probability					
Law of large numbers					
Marginal probability					
Memoryless property					
Nonparametric tests	X	X			
Parametric tests	X	X			
Pearson r	X	X	X	X	
Population parameters					
Probability	X	X	X	X	
Probability rules	X				
Probabilities of sequences					
Properties of the normal distribution	X	X	X	X	

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Sampling error	X	X			
Standard error	X	X			
Statistical significance	X	X	X		
Type 1 error	X	X			
Type 2 error	X	X			
Graphical:					
Bar graphs	X	X	X		
Central limit theorem (graphical)	X	X	X		
Correlational coefficient	X	X	X		
Dot plots	X	X			
Histograms	X	X	X	X	
Interpreting graphs	X	X			
Line graphs	X	X			
Methods of displaying data	X	X			
Range	X	X			
Sample/parent distributions	X	X	X		
Scatter plots	X	X	X		
Skew	X	X	X	X	
Tables	X	X	X		
Uniform distributions					
Variability	X	X	X	X	
Statistical concepts commonly found in nursing research					
Analysis of variance (ANOVA); all kinds					
Chi-square	X	X	X		
Cronbach's alpha					
Discriminant analysis					
Fishers exact probability test					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Kruskal-Wallis					
Mann-Whitney					
McNemar test					
Multiple comparison/post-hoc tests					
Odds ratio					
Power analysis					
Regression, all kinds	X		X		
t test: paired/two-sample	X	X	X	X	
Wilcoxon's test					
z score					

Figure C1: Concept map of NURS 425 statistical concepts



Appendix D

NURA 510

Table D1: N-SKIMP of NURS 425

CSAT phase:

Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Info acquisition activities	**Examples with solution**	**Problem solving with input and correction**	**Problem solving experience**	**No errors**

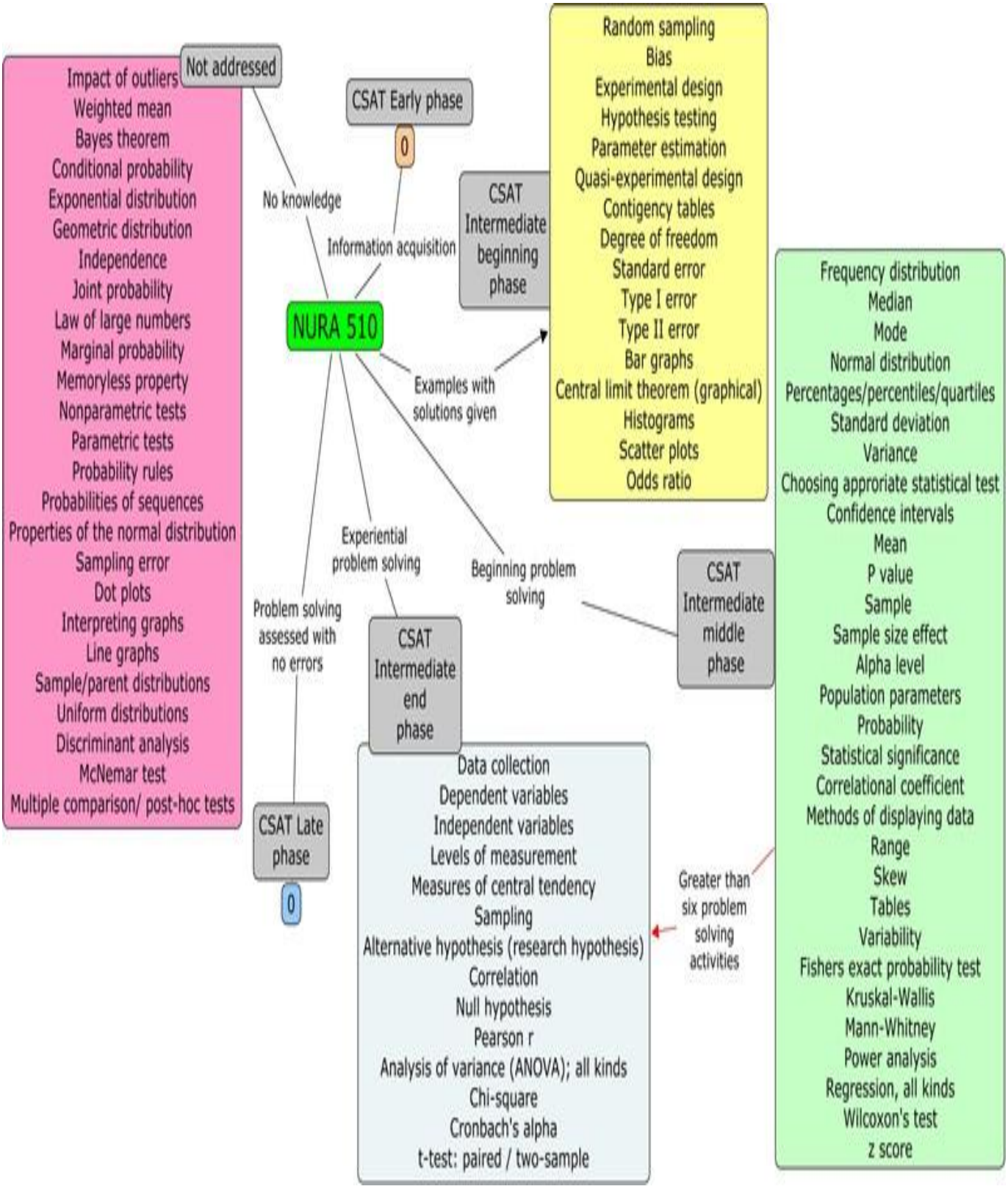
Descriptive:					
Data collection	X	X	X	X	
Dependent variables	X	X	X	X	
Frequency distribution	X	X	X		
Impact of outliers			X		
Independent variables	X	X	X	X	
Levels of measurement	X	X	X	X	
Measures of central tendency	X	X	X	X	
Median	X	X	X		
Mode	X	X	X		
Normal distribution	X	X	X		
Percentages/percentiles /quartiles	X	X	X		
Sampling	X	X	X	X	
Standard deviation	X	X	X		
Random sampling	X	X			
Variance	X	X	X		
Weighted mean					
Inferential:					
Alternative hypothesis (research hypothesis)	X	X	X	X	
Bias	X	X			

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Choosing appropriate statistical test		X	X		
Confidence intervals	X	X	X		
Correlation	X	X	X	X	
Experimental design		X			
Hypothesis testing	X	X			
Mean	X	X	X	X	
Null hypothesis	X	X	X	X	
P value	X	X	X	X	
Parameter estimation	X	X			
Quasi-experimental design		X			
Sample	X	X	X	X	
Sample size effect	X	X	X		
Probability:					
Alpha level	X	X	X		
Bayes theorem					
Conditional probability					
Contingency tables		X			
Degree of freedom	X	X	X		
Exponential distribution					
Geometric distribution					
Independence					
Joint probability					
Law of large numbers					
Marginal probability					
Memoryless property					
Nonparametric tests	X	X			
Parametric tests	X	X			
Pearson r	X	X	X	X	
Population parameters	X	X	X		
Probability	X	X	X		
Probability rules					
Probabilities of sequences					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Properties of the normal distribution					
Sampling error	X	X			
Standard error	X	X	X		
Statistical significance	X	X	X	X	
Type 1 error	X	X			
Type 2 error	X	X			
Graphical:					
Bar graphs		X			
Central limit theorem (graphical)		X			
Correlational coefficient	X	X	X		
Dot plots					
Histograms	X	X			
Interpreting graphs					
Line graphs					
Methods of displaying data	X	X	X		
Range	X	X	X		
Sample/parent distributions	X	X			
Scatter plots		X			
Skew	X	X	X		
Tables	X	X	X		
Uniform distributions					
Variability	X	X	X		
Statistical concepts commonly found in nursing research:					
Analysis of variance (ANOVA); all kinds	X	X	X	X	
Chi-square	X	X	X	X	
Cronbach's alpha	X	X	X	X	
Discriminant analysis					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Fishers exact probability test	X		X		
Kruskal-Wallis			X		
Mann-Whitney	X		X		
McNemar test					
Multiple comparison/post-hoc tests	X				
Odds ratio	X	X	X		
Power analysis			X		
Regression, all kinds	X	X	X		
t test: paired/two-sample	X	X	X	X	
Wilcoxon's test	X		X		
z score	X	X	X		

Figure D1: Concept map of NURA 510 statistical concepts:



Appendix E

NURS 508 and NURS 425 combined

Table E1: N-SKIMP of NURS 508 and NURS 425 combined

CSAT phase:

Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Info acquisition activities	**Examples with solution**	**Problem solving with input and correction**	**Problem solving experience**	**No errors**

Descriptive:					
Data collection	X	X	X		
Dependent variables	X	X	X	X	
Frequency distribution	X	X	X	X	
Impact of outliers	X	X			
Independent variables	X	X	X	X	
Levels of measurement	X	X	X	X	
Measures of central tendency	X	X	X		
Median	X	X	X		
Mode	X	X	X		
Normal distribution	X	X	X		
Percentages/percentiles /quartiles	X	X	X	X	
Sampling	X	X	X		
Standard deviation	X	X	X		
Random sampling	X	X			
Variance	X	X	X		
Weighted mean					
Inferential:					
Alternative hypothesis (research hypothesis)	X	X	X	X	
Bias	X	X	X		

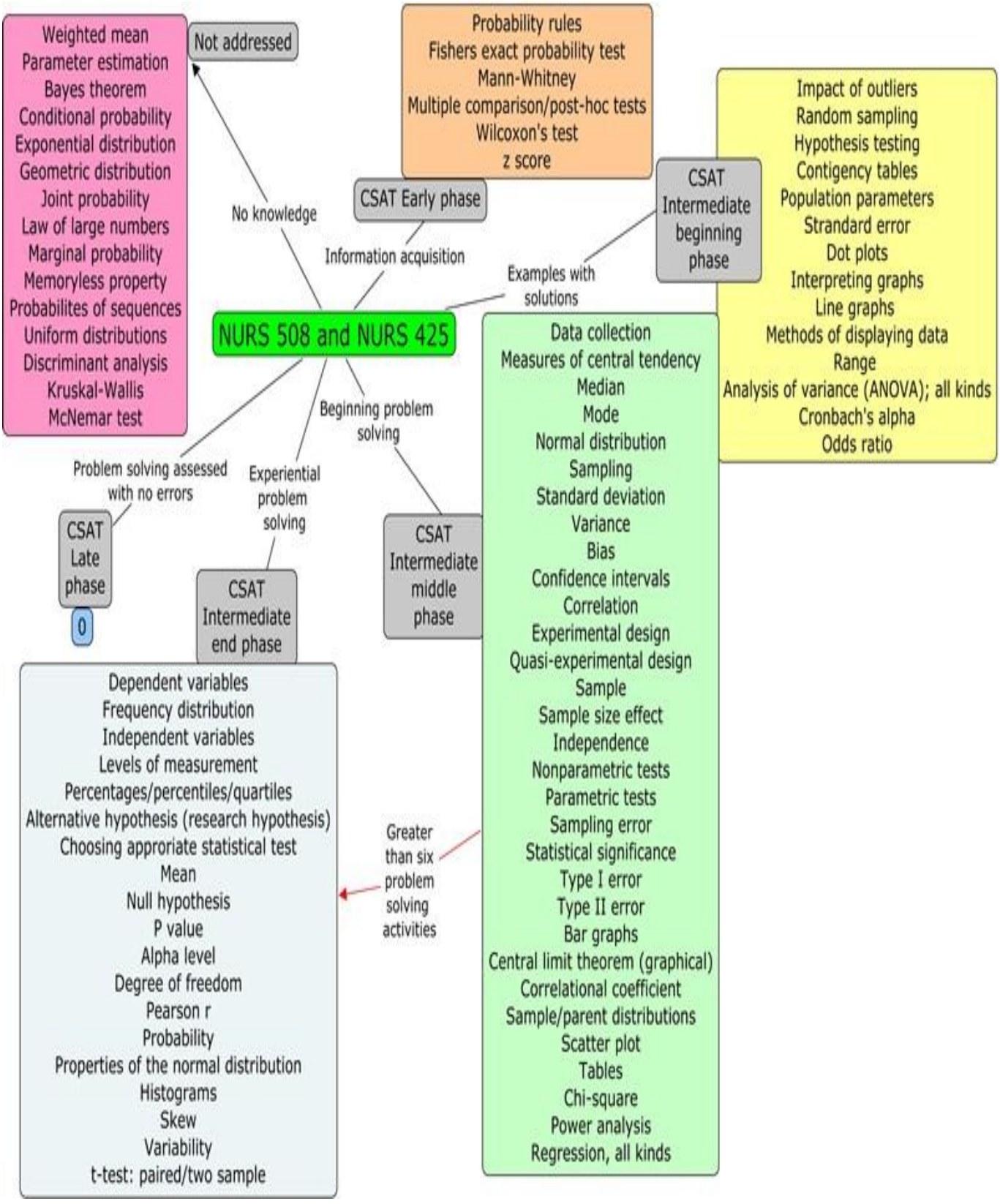
	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Choosing appropriate statistical test	X	X	X	X	
Confidence intervals	X	X	X		
Correlation	X	X	X		
Experimental design	X	X	X		
Hypothesis testing	X	X			
Mean	X	X	X	X	
Null hypothesis	X	X	X	X	
P value	X	X	X	X	
Parameter estimation					
Quasi-experimental design	X	X	X		
Sample	X	X	X		
Sample size effect	X	X	X		
Probability:					
Alpha level	X	X	X	X	
Bayes theorem					
Conditional probability					
Contingency tables	X	X			
Degree of freedom	X	X	X	X	
Exponential distribution					
Geometric distribution					
Independence	X	X	X		
Joint probability					
Law of large numbers					
Marginal probability					
Memoryless property					
Nonparametric tests	X	X	X		
Parametric tests	X	X	X		
Pearson r	X	X	X	X	
Population parameters	X	X			
Probability	X	X	X	X	
Probability rules	X				
Probabilities of sequences					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Properties of the normal distribution	X	X	X	X	
Sampling error	X	X	X		
Standard error	X	X			
Statistical significance	X	X	X		
Type 1 error	X	X	X		
Type 2 error	X	X	X		
Graphical:					
Bar graphs	X	X	X		
Central limit theorem (graphical)	X	X	X		
Correlational coefficient	X	X	X		
Dot plots	X	X			
Histograms	X	X	X	X	
Interpreting graphs	X	X			
Line graphs	X	X			
Methods of displaying data	X	X			
Range	X	X			
Sample/parent distributions	X	X	X		
Scatter plots	X	X	X		
Skew	X	X	X	X	
Tables	X	X	X		
Uniform distributions					
Variability	X	X	X	X	
Statistical concepts commonly found in nursing research					
Analysis of variance (ANOVA); all kinds	X	X			
Chi-square	X	X	X		
Cronbach's alpha	X	X			
Discriminant analysis					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Fishers exact probability test	X				
Kruskal-Wallis					
Mann-Whitney	X				
McNemar test					
Multiple comparison/post-hoc tests	X				
Odds ratio	X	X			
Power analysis	X	X	X		
Regression, all kinds	X	X	X		
t test: paired/two-sample	X	X	X	X	
Wilcoxon's test	X				
z score	X				

Note. Additional statistical concepts that were found in NURS 508 course curriculum that addressed the concept 5 or more times in a significant manner were added to N-SKIMP in red text.
NURS 425 is used as the foundational course, and the data is indicated in black text (X=NURS 425).
NURS 508 overlapping data with NURS 425 is not noted and kept in black text (X= NURS 425 and NURS 508).
Data that NURS 508 adds is indicated in blue text (X=NURS 508).

Figure E1: Concept map of NURS 508 and NURS 425 statistical concepts combined



Appendix F

NURS 425, NURS 508 and NURA 510 combined

Table F1: N-SKIMP of NURS 425, NURS 508 and NURA 510 combined

CSAT phase:

Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Info acquisition activities	**Examples with solution**	**Problem solving with input and correction**	**Problem solving experience**	**No errors**

Descriptive:					
Data collection	X	X	X	X	
Dependent variables	X	X	X	X	
Frequency distribution	X	X	X	X	
Impact of outliers	X	X	X		
Independent variables	X	X	X	X	
Levels of measurement	X	X	X	X	
Measures of central tendency	X	X	X	X	
Median	X	X	X		
Mode	X	X	X		
Normal distribution	X	X	X		
Percentages/percentiles /quartiles	X	X	X	X	
Sampling	X	X	X		
Standard deviation	X	X	X		
Random sampling	X	X			
Variance	X	X	X		
Weighted mean					
Inferential:					
Alternative hypothesis (research hypothesis)	X	X	X	X	
Bias	X	X	X		

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Choosing appropriate statistical test	X	X	X	X	
Confidence intervals	X	X	X		
Correlation	X	X	X	X	
Experimental design	X	X	X		
Hypothesis testing	X	X			
Mean	X	X	X	X	
Null hypothesis	X	X	X	X	
P value	X	X	X	X	
Parameter estimation	X	X			
Quasi-experimental design	X	X	X		
Sample	X	X	X	X	
Sample size effect	X	X	X		
Probability:					
Alpha level	X	X	X	X	
Bayes theorem					
Conditional probability					
Contingency tables	X	X			
Degree of freedom	X	X	X	X	
Exponential distribution					
Geometric distribution					
Independence	X	X	X		
Joint probability					
Law of large numbers					
Marginal probability					
Memoryless property					
Nonparametric tests	X	X	X		
Parametric tests	X	X	X		
Pearson r	X	X	X	X	
Population parameters	X	X	X		
Probability	X	X	X	X	
Probability rules	X				
Probabilities of sequences					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Properties of the normal distribution	X	X	X	X	
Sampling error	X	X	X		
Standard error	X	X	X		
Statistical significance	X	X	X	X	
Type 1 error	X	X	X		
Type 2 error	X	X	X		
Graphical:					
Bar graphs	X	X	X		
Central limit theorem (graphical)	X	X	X		
Correlational coefficient	X	X	X		
Dot plots	X	X			
Histograms	X	X	X	X	
Interpreting graphs	X	X			
Line graphs	X	X			
Methods of displaying data	X	X	X		
Range	X	X	X		
Sample/parent distributions	X	X	X		
Scatter plots	X	X	X		
Skew	X	X	X	X	
Tables	X	X	X		
Uniform distributions					
Variability	X	X	X	X	
Statistical concepts commonly found in nursing research					
Analysis of variance (ANOVA); all kinds	X	X	X	X	
Chi-square	X	X	X	X	
Cronbach's alpha	X	X	X	X	
Discriminant analysis					

	Early	**Intermediate** Beginning	**Intermediate** Middle	**Intermediate** End	**Late**
Fishers exact probability test	X		X		
Kruskal-Wallis			X		
Mann-Whitney	X		X		
McNemar test					
Multiple comparison/post-hoc tests	X		X		
Odds ratio	X	X	X		
Power analysis	X	X	X		
Regression, all kinds	X	X	X		
t test: paired/two-sample	X	X	X	X	
Wilcoxon's test	X		X		
z score	X	X	X		

Note. Additional statistical concepts that were found in NURS 508 course curriculum that addressed the concept 5 or more times in a significant manner were added to N-SKIMP in red text.

NURS 425 is used as the foundational course, and the data is indicated in black text (X=NURS 425).

NURS 508 overlapping data with NURS 425 is not noted separately and kept in black text (X= NURS 425 and NURS 508).

Data that NURS 508 adds is indicated in blue text (X=NURS 508).

NURA 510 overlapping data with NURS 508 and NURS 425 is not noted separately and kept in black text (X= NURS 425, NURS 508, and NURA 510).

Data that NURA 510 adds is indicated in green text (X= NURA 510)

Figure F1: Diagram of NURA 510, NURS 425 and NURA 508 statistical concepts combined