Title page

What indicators predict numeracy performance in undergraduate nursing students?

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Impact of COVID-19 Statement

This thesis was completed during the COVID pandemic phase, as a registered nurse with the Nursing and Midwifery Council and a lecturer within the School of Nursing and Midwifery. This was an extremely challenging time, that involved a significant volume of time, effort, and emotional investment towards curriculum redesign, supporting students, colleagues, and practice areas to implement emergency standards and care delivery. This substantially affected the amount of dedicated time to this thesis creation and limited some areas of development. Having colleagues and close family members significantly affected by COVID and my Nan dying during the pandemic in a residential home, where we were unable to visit her, plus working from home with my two children, impacted on my emotional well-being and productivity. I required significant periods of extension to complete this work, as well as an intermission for 6 months.

Whilst I appreciate the significant challenges of completing a professional doctorate in everyday circumstances, attempting to do this during a pandemic, has significantly increased the complexities and challenges I have experienced with its completion.

Dedication

This thesis is dedication to my beautiful babies Ruby and Jack, thank you for your patience with me whilst I pursued this dream, always and forever the terrible trio!

To my parents Kate and Paul for your unwavering support, despite all my crazy ideas and dreams, I know your forever be there supporting me. I promise this will be the last thing (well maybe ☺)

To two of the most influential women in my life, my Nan Violet Carpenter, I really hope you are watching and feeling proud of me. I kept going Nan, despite everything.

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“She dared to believe, that she might possibly achieve………….”

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Abstract

Abstract

Aim: To identify indicators that predict numeracy performance in undergraduate nursing students

Method: The cohort study looked to identify indicators that predict nursing numeracy performance collecting data on variables gender, age, field of nursing, Mathematics anxiety, mathematics qualification, current ability with general numeracy and performance in a nursing numeracy testing. Participants involved a cohort of first year Adult, Child, and Mental Health pre-registration nursing students (n=286). Who completed a demographic data sheet, MAS-UK mathematics anxiety screening tool, Basic and Key Skill Builder (BKSB) initial and diagnostic self-marking assessment tool, and a nursing numeracy test.

Results: No significant contribution to the prediction of nursing numeracy was made by gender, age, nursing field and mathematics qualification with small beta values (β=-.029, .076, -.040, -.057 respectively).

However overall BKSB score makes a 11.9% partial correlation (.345) with an 11.9% (.345 squared) total contribution to R squared contribution to the predictor of numeracy performance. The study identified that achieving higher marks in the BKSB screening led to higher achievement in the nursing numeracy exam (p value (β=.361), (t(228)=5.96, p=.000) (β=.361), (t(228)=5.96, p=.000)

Mathematics anxiety Beta coefficient score of (β=-.254) suggests that Mathematics anxiety has a negative impact on the exam total (t(288)=-4.17, p=.000) with anxious students attaining a lower marks in the nursing numeracy exam, each point higher in the anxiety score, resulting in a decrease of .203 mark in the total exam score (B=-.203, 95%CI=-.299 to -.107). Maths anxiety contributed 5.8% (-.241) to R squared and unique contribution to the explanation of variance in total exams scores. Identifying as female affected mathematics anxiety scores with males scoring lower on the MAS-UK scale (M=44.37, SD 13.64), females (M=54.65, SD 18.27) (ANOVA .017) F value of (5.77).

Conclusion: Current numeracy ability, as measured by a diagnostic tool, and mathematics anxiety score provide effective indicators that predict nursing students' numeracy performance. Incorporating these diagnostic tools into admissions and/or induction periods early in the nursing programme may enable targeting of numeracy support strategies that may improve students' numeracy attainment in their programme.

CHAPTER 1: INTRODUCTION

1.1 Researcher's Perspective

"You're in the bottom set for maths Clare, that means your only able to get a C grade for GCSE, don't get your hopes up too high, will you now……" I really needed that C grade to pursue my desired career, it was so important to me. The anxiety I experienced when studying maths at school, has been something that has been a reoccurring apprehension through my educational and professional career. In my clinical career, I remember checking, double checking and triple checking calculations when administering drugs, fearing the implications of getting any calculation wrong. When stepping into nurse education I remember marking numeracy entrance examples and thinking, I am not sure I could do these. I decided to sit in on sessions run by a newly employed literacy and numeracy advisor, to see if I could make sense of anything. I had some light bulb moments about basic numeracy processes that I had never understood before. I could see other participants understanding these processes and anxieties being relieved. From this point, I became more involved in the teaching of numeracy in context, helping to write and deliver sessions to students. This escalated further when I started my professional doctorate and was thinking about the subject areas I might want to research and focus my thesis on. I have been employed in higher education since 2010 and have always had a keen interest in the predictors of nursing numeracy and what factors influence these predictors.

Anecdotally, applicants to nursing programmes appear to have struggled significantly during my 11 years in higher education, with one of the significant reasons for not progressing to the interview stage being failure of the nursing numeracy test at interview. Places withdrawn, when students did not achieve the mathematics qualification required to enter the pre-registration courses, with applicants often returning year after year to try to obtain a place. It made me think significantly about if the numeracy qualification was fit for purpose and a true reflection of an individual's numeracy ability. Could some individuals be being denied a place on a pre-registration nursing programme who were more than capable of the required elements for numeracy? Nevertheless, they did not have the ability to attain the appropriate certification to prove this. What if the individuals attained places because of them having the appropriate qualifications, but they could then not perform at the desired standard in a practical context? What were the factors affecting this? Were qualifications completed a significantly long time ago? Did this equate to someone not currently attaining the desired grade today?

The research in this study will help me to identify the possible and most influential predictors of nursing numeracy performance. While being involved in pre-registration nursing recruitment, I noted the number of rejections and individuals serially applying each year for a place, due to nonattainment of grades in numeracy. I recall many conversations with students saying that they "hate maths", they "cannot do it", that thinking about maths makes them feel sick. Witnessing students having panic attacks prior to nursing numeracy calculations exams, significantly sparked my empathy and interest.

Taking the time to speak to these individuals, calm them, and pass on my knowledge, tips, and ideas on how to manage this; seeing moments of clarity, receiving emails thanking me for my patience and understanding, made me feel proud. Seeing students pass numeracy exams that they feared with such passion, only drove me on to explore this subject area further and work towards identifying the main factors that affected numeracy performance, with the intention to change curricula and teaching, adapting approaches and recruitment in the future, to ensure a more satisfactory experience for students whilst maintaining public safety. Ensuring there is equity of access for all students to pre-registration programmes; improve teaching strategies and changing curriculums to ensure that nursing meet the desired numeracy ability to be a registrant on the Nursing and Midwifery Council (NMC).

We, as educators, have a responsibility to prepare students for their future, not for our past. Students need to be better prepared in nursing numeracy skills and numeracy ability. Students should view this learning as a positive experience and a development of their skills and not a tiresome and terrifying experience that is part of their training.

Through this research, I examined several hypotheses around predictors of nursing numeracy performance. I hope to begin the conversation at my university and nationally, exploring potential changes with processes and approaches to nursing numeracy. This information could be vital in helping universities in their recruitment processes and teaching of nursing numeracy in the future. With the focus on aiding students to become more proficient in nursing numeracy and numeracy skills, building their confidence and ability for future practice.

1.2 Chapter plan:

This thesis is composed of five chapters. Chapter One is the Introduction where the aims and the structure of the thesis are identified. Chapter Two the Literature Review identifies gaps in the literature providing a rationale of how the proposed study will contribute to the original body of knowledge on the topic of predictors of nursing numeracy. Chapter Three is the Methodology Chapter where the research methodology, research questions, methods, ontology, and epistemology are discussed.

Chapter Four is the data presentation and analysis, discussing the data collected offering analysis and discussion.

Chapter Five concludes the thesis and is the discussion, conclusion, and recommendations chapter. Research findings are explored and identification of the contributions to the body of knowledge are made, along with some recommendations for future practice.

1.3 Background and Setting

Stolic (2014) suggests that mathematical skills are vital for medication calculations, implying that the understanding of these skills are critical for the ability to apply these to nursing numeracy. Brown (2002) highlights concerns with nursing students appearing to be unprepared for the mathematical content of nursing programmes, especially struggling with demonstrating and applying numeracy skills such as fractions. With many degree programmes containing a substantial numeracy component, even if the primary focus of the degree is not mathematics. Students appear to dislike this numeracy component, displaying anxiety behaviours about these elements, ultimately leading to an influence on the student's success and satisfaction with their courses (Thompson et al 2015). Maths anxiety was identified as the strongest affective predictor for nursing students with the Math anxiety commonly defined as a “feeling of tension, apprehension, or fear that interferes with math performance” (Ashcraft 2002, p.181, Thompson et al 2015).

Affective predictors are modulations of manifestations of things such as anxiety disorders and social phobias, which contribute towards creating an anxiety state surrounding a particular activity or practice (Trapp and Koltz 2016). Thompson et al (2015) emphasise the importance of ensuring the predictor is explored, researched and its impact measured, in correlation to the students’ ability to complete nursing numeracy tests.

1.4 Why is this study so important?

Being numerate means having the confidence and skill to use numbers and mathematical approaches in all aspects of life (National Numeracy 2017) with poor numeracy skills being linked to mistakes in drug administration amongst students and registered nurses, adversely affecting patient and public safety (McMullan et al 2010). Fleming et al (2013) describe the serious nature of these errors for patients and although student nurses recognise the importance of mathematics and its links to patient safety, some still struggle to undertake accurate mathematical calculations and conceptual measurements. The new national curriculum for mathematics 2021, suggests that mathematics is an interconnected subject that pupils need to have the ability to move fluently between interconnected subject areas, applying their mathematical knowledge across subject areas. Developing mathematical reasoning and competence to aid the completion and solving of increasingly sophisticated problems (DfE 2021). Numeracy-related tasks are common in the healthcare setting and need to include the understanding of numbers in the assessment of nutritional status and information, the interpretation of numbers and their relevance such as interpreting blood sugar readings and other clinical data, when and how to adjust and complete medications and dose calculations, and understanding the probability in risk communication (Rothman et al 2008)

Nursing pre-registration courses place particular importance on robustly assessing students as being safe and competent on their numeracy ability, with this being a direct requirement for registration on the NMC's nursing register (NMC 2018). The NMC require education providers to ensure that selection and admission criteria provide evidence of the potential to develop sufficient numeracy skills by the end of their programmes (NMC 2018). An ability to predict success for applicants based upon their previous qualifications, identified anxieties, motivations and experiences could significantly influence the success of applicants and assist education providers in implementing specific student-centred interventions to increase proficiency. Interventions could include mathematics revision sessions and engagement in pre course and early intervention teaching after screening. Barra (2013) work identifies that student accessing such interventions and engaging in them at regular intervals, increases successful attainment of numerical content in pre-registration nursing programmes. With a 25% pass rate in a control non-intervention groups, up to those consistently attending and engaging in intervention groups eliciting a 75% pass rate.

41,222 applicants applied to pre-registration nursing programmes to commence in September 2022, (UCAS 2022), with 12,440 being school leavers aged 18. With many young people leaving school with inadequate numeracy and mathematical skills that they need to function within life, work and higher education, a number of these applicants would benefit from studying applied maths at a greater depth (Advisory Committee on Mathematics Education 2011). The Children's Commissioners report in 2019 suggests this has not improved, with 99,799 (18%) of all school leavers in 2018 leaving without substantive qualifications at level 2. This equates to a reversal of the trend from the previous decade, where a reduction in the number of children leaving full time education without substantive qualifications was continually falling year on year (Children's commissioner 2019). The new national curriculum for mathematics (2021) aims to ensure that pupils develop a conceptual understanding of mathematics with an ability to recall and apply knowledge to a variety of routine and non-routine problems with increasing sophistication, this includes the ability to break down problems into a series of simpler steps and persevere to seek solutions (DfE 2021).

Identifying the prevalence of this as an issue on application to pre-registration programmes is pertinent, with poor mathematical ability contributing on average, to one-third of applicants failing a pre-entry numeracy test and then not proceeding to interview (Robert and Campbell 2017). Education providers have been encouraged by regulators and others, that there should be an emphasis on university programmes to address this through screening and support of pre-registration learners (Byatt 2014).

The previous iteration of the NMC's educational standards for pre-registration nursing numeracy ability was part of the entry requirement:

"AEI'S (Approved Education Institutions) must ensure that selection and admission criteria provide evidence of basic numeracy skill, such as the ability to use numbers accurately in respect of volume, weight, and length. These skills must include addition, subtraction, division, and multiplication; use of decimals, fractions, and percentages; and the use of a calculator" (NMC 2010)

The publication of the new pre-registration standards for education in nursing in 2018, shifts the accountability from the applicant to the education provider, stipulating those programmes must ensure that the pre-registration nursing student has the capability to develop their numeracy skills, required to meet the programme outcomes (NMC 2018). They also dictate that all programmes include a health numeracy assessment related to nursing proficiencies and calculation of medicines assessment, with this element requiring a pass mark of 100%. To gain entry to a pre-registration nursing programme, the education provider sets the academic qualification for numeracy for entry, i.e., GCSE Mathematics at grade C/4 or above.

With medication errors occurring in approximately one in every five doses in a typical hospitals and concerns that 11-14% of medication errors are directly related to mathematical skills (Barker 2002), it is an extremely important area for development and understanding. National Patient Safety Agency (2009) identify that medication errors account for around 750 million pounds a year, with drug errors accounting for the cause of 25% of all legal proceedings. With the most common issues for these errors, being identified as a poor application of mathematical ability to nursing numeracy tasks. Including fluid balance calculations, understanding, and interpreting of health care research (Flemming et al 2014). This has since risen to 1.6 billion a year, with around 22,303 lives affected, including a direct loss of life of 1708 individuals (BMJ 2020).

More than 237 million estimated drug administration errors occur in the United Kingdom every year, 38.4% occurring in primary care; 72% (3 out of 4 medication errors) have little/no potential for harm, whilst just under 26% around 1 in 4, has the potential to cause moderate harm; leaving just 2% potentially resulting in serious harm (BMJ 2020). 54% of these errors were made at the administrative phase. This phase can include a calculation element, so understanding why pre-registration nurses may struggle with this and being able to predict that struggle, introduce measures to help with these; will help immensely towards trying to decrease these errors and their impact on patient safety (Elliot et al 2021)

With nursing post vacancies being at an all-time high in the United Kingdom, in excess of 36,000 (9-10%) in the first quarter of 2021 (NHS digital statistics 2021), and with places on pre-registration nursing programmes in Higher Educational Institutions (HEI's) applications dropping by 20,000 this year (UCAS 2021) There needs to be a development and much better understanding of how we can select and then support students with apparent poor numeracy skills onto and continuing on, these programmes to optimise their success.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

The purpose of this chapter is to review the current literature on predictors of nursing numeracy performance and gain an insight into the significance and contribution of each individual predictor.

This literature review synthesises the evidence related to numeracy in nursing and the predictors of nursing numeracy performance. A thematic analysis of the evidence is presented. As a significant proportion of the current literature focuses on the concept of “mathematics anxiety”, a section is devoted to discussing this predictor in detail, whilst realising the potential power this has when understanding numeracy performance and future educational impact.

2.1 Search strategy and its development

What indicators predict numeracy performance in undergraduate nursing students?

The literature search began with a scoping exercise searching for current peer reviewed articles, via online library Databases: EBSCO host, Cinahl (Cumulative Index of Nursing and Allied Health Literature) ultimate, e book collection (EBSCO Host), E Journals, Medline Complete, Medline with Full text, PsycArticles and Psyc INFO and Joanna Briggs Institute (JBI). Articles selected for inclusion across all searches were quantitative, qualitative, mixed methods research, systematic reviews, and a meta-analysis.

Key search terms included:

This initial scoping exercise carried out in 2018 (then at yearly intervals to check for new publications) searched for Predictor or indicator or factors or determinants) AND Nurs* Numeracy AND performance, inclusion criteria of peer reviewed articles, written in English, full text, dated between 2014-2023 which was (determined by publication dates and not restriction of date range) were retrieved.

Search Term	Boolean operator
Predictor OR indicator OR factors OR determinants	AND
Nurs* Numeracy	AND
Performance	
Retrieved articles	5 all relevant

This evidently identified that predictor evidence as a collective measurement of nursing numeracy was negligeable, with only 5 articles being identified. These focused on striving for a good standard of maths for potential student nurses (Roberts and Campbell 2017); Predictors of numeracy performance in undergraduate psychology, nursing and medical students (Thompson et al 2015); and Identifying strategies to assist final semester nursing students to develop numeracy skills, a mixed methods study Ramjan et al (2014), Pettigrew et al (2020) Contextualising numeracy skill development and assessment in a first year undergraduate nursing subject: A mixed methods research and Gregory et al. (2019) The influence of mathematics self-efficacy on numeracy performance in first-year nursing students: A quasi-experimental study.

A further search was conducted using the same search terms but widening the search strategy to include “All Text” and date range 1997-2023 with no other filters applied.

Search Term	Boolean operator
Predictor OR indicator OR factors OR determinants (all text)	AND
Nurs* Numeracy (all text)	AND
Performance (all text)	
Retrieved articles	122
Duplicated articles within new search	22
Duplicates from previous search	5
Not suitable due to not matching topic	56
Suitable articles for critical appraisal	39

Due to this lack of specific evidence related to the research question a narrative review approach was utilised, thus attempting to seek out new study areas not previously addressed or having very limited evidence published. Identifying and summarising previously published identified issues with nursing numeracy. Avoiding duplications, the narrative approach allowed the sensitisation to existing evidence and concepts around predictor and indicators of numeracy performance in nursing students, even if these were singular predictors or indicators (Ferrari 2015).

Taking this approach allowed the project design to add and create new knowledge of this topic area, allowing sensitisation to concepts and identification of all current singular concepts, allowing synthesis into potential predictors of numeracy performance in pre-registration nurses.

The search continued with a systematic approach, expanding the search by the exploring the current literature and identifying reoccurring themes. On reading the articles, a clear theme for predictors of numeracy performance included numerical ability, academic examination requirements for a preregistration courses and maths anxiety. Therefore, the literature search extended to

Search Term or Exclusion / inclusion criteria	Boolean operator
“Numeracy or numer* or calcula* or math*” (all text)	AND
“nursing education” (all text)	AND
“GCSE” OR “Numeracy qualification”	
Date range (according to article publication range)	1997-2023
Retrieved articles	283
Exact duplications within search excluded	100
Full text and Written in English, Peer reviewed journals	61 excluded 122 remaining
Duplicates from previous searching	33
Not relevant to the topic area	70
Books	4
Articles selected for appraisal	15

The final search explored:

Search Term or Exclusion / inclusion criteria	Boolean operator
“student nurse” or “nursing student” or “undergraduate nurse”	AND
Math* or numer* anxiety	AND
“GCSE” OR “Numeracy qualification”	
Articles identified	3839
Date range (according to article publication range)	2000-2023
Article total	478 excluded Total now 3361
Full text	624 articles excluded Total now 2737
Peer reviewed journals	102 excluded Total now 2635
Exact replications within search excluded	329 excluded Total now 2306
Duplicates from previous searching	36 excluded Total now 2270
Not relevant to the topic area	2203 excluded Total now 67
Articles selected for appraisal	67

Searches one to 4 were crossed searched again and no new articles were identified.

NICE and the Cochrane Library were both searched with one article identified in the in the Cochrane library, however the article was not relevant to the topic. No results were found in Joanna Briggs Institute database. When seeking clarification or support of discussions that involved affirmation of information around practices or processes, The Department of Education, NMC, national office of statistics was utilised. This allowed benchmarking and quality standard comparison of the national picture and its comparability to the study site. See Appendix 1 for PRISMA flow diagram that combines all the searches together in totality (Moher et al., 2009).

The final 126 peer reviewed articles were critically appraised through the appropriate Critical Appraisal Skills Programme (CASP) (2018) Research Checklists. Allowing the principles of narrative searching to be followed (Ferrari 2015). Key results, limitations, suitability of the methods used to test the initial hypothesis, quality of results obtained, interpretation of results, and impact of the conclusions in the field were extracted and synthesised using a narrative approach. Identifying inconsistencies amongst the results and taking the opportunity to integrate new articles in the case of missing evidence. 87 articles were selected for the final literature discussion.

A table reflecting this analysis can be found in appendix 9.

2.2 Numeracy:

First described in the Crowther report in 1959, the word numeracy identified a mirroring for the word literacy in the educational discourse, enabling the identification and description of an individual that is innumerate. Looking to establish an understanding and description of an individual that is innumerate, he suggests that these individuals have a poor understanding of what scientists or mathematicians are talking about (Crowther, 1959). Ultimately, Crowther suggested that a good Sixth Form should be able to send out into the world, men and women who are both literate and numerate. (Crowther, 1959). Khasawneh et al (2020) suggests numeracy includes addition, subtraction, multiplication, and division, with the ability to reason and apply simple numerical concepts to everyday life and practice, allowing development and understanding of its significant importance in so many aspects. Barroso et al (2021) identify that this included concepts such as fluid charts, nutritional scoring, and assessment, risk calculation and many other practical based concepts required for effective, efficient, and safe care delivery. People need an understanding of numbers and basic mathematical skills to use numerical information presented in text, tables, or charts. A basic understanding of numerical concepts is important for informed decisions to be made, however, numeracy and the ability to understand and use numbers, has not received the same attention as literacy in the research literature (Reyna et al 2009).

However, the concept began to shift in mid-1960's from the everyday functionality of numeracy in life, to a more interpretive approach to data and the connections that this has, in allowing us to understand a variety of concepts.

In the 1970's an amplified recognition for the need to introduce numeracy concepts to preschool children and an increased public attention to the centrality of numeracy, as an essential life skill, became evident. This led to Sir Wilfred Cockcroft being commissioned by the British Government of the time, to lead an inquiry into the teaching of mathematics in schools in England and Wales (Cockcroft, 1982).

The report clearly outlined and identified problems with mathematics education, with inconsistent teaching methods, poor adaptation to individual need, leading to students not being able to possess reliable methods for carrying out calculations (however unconventional) without the use of a calculator, even when the numbers were small. A lack of intuitive methods for both written and mental calculations and a fluency in computation of numbers, that was consistently used in short and frequent spells of practice. The utilisation of words within calculations such as 'of" e.g., ¼ of £5.00 needed to be included within curriculum development. The report went on to devise a national improve curricula, teaching, and assessment strategy.

The urgent point at the time was to simply improve and ensure that students achieved mathematical literacy. With the introduction of calculators, computers and mobile phones, the focus of numeracy education changed away from computational skills towards a greater depth of academic ability (Cockcroft 1982).

With this change in focus the definition of being numerate was shifting. No longer was it believed to be "extension of mathematics into other subjects" but rather the "key to understanding our data-drenched society" (Nygaard & Hughes-Hallett, 2001, p. 2). An emphasis on practical and contextualised application was encouraged focusing on being able to build on the interconnectedness of the different types of knowledge encountered in everyday lives. Numeracy also includes the ability to figure out what math skills to apply to a given situation (i.e., contextual, or application-oriented numeracy) (Golbeck et al 2005).

Montori & Rothman (2005) highlights the importance of grasping the concept of functional numeracy and having the ability to apply this skill to nursing tasks appropriately. However, this is not just about reading numbers in everyday life, it involves a significant range of other skills including calculations, fractions, algebra, and geometry, whilst also understanding time, money, measurement, graphs, probability, and an ability to perform multistep maths (Montori & Rothman, 2005).

Xu et al (2023) discusses the hierarchy of mathematical competence and that this is built through integration of number relations. Connections between number concepts are established by learners, allowing them to construct a more advanced system of number recognition and application. This level of integration of mathematical competence occurs when the acquired knowledge becomes fully accessible within their already established knowledge system, only then can the individual utilise this flexibly to solve problems. Being comfortable, confident, and competent in one's judgements on whether to use mathematics within situations or exposures, knowing how to do these mathematic processes and to what degree of accuracy is important, along with what that answer means in relations to the context it is applied, is clearly important in the unique settings and requirements of nursing practice (Coben 2000)

2.2.1 Previous math competency ability

Wright (2006) suggests mathematical ability appears to increase with an increase in student's maths qualifications, a statistically significant difference is noted between different students who attained higher scores in drug calculation numeracy. These students all had a GCSE maths A-C grade in comparison to students with an access or NVQ level 3 qualification, who did not score so highly. This contrasts with Hutton (1998) findings, who identified no statistically significant impact or effect of qualifications on entry to pre-registration nursing programmes, or if those individuals achieved higher scores on drug calculation test scores. Khasawneh et al (2020) discuss their multiply regression analysis, identifying that numerical ability and previous mathematics education were the main direct predictors of the students' drug calculation ability.

When considering numeracy ability, one way to measure this is through examinations and qualifications, the impact of maths anxiety on this achievement is also important. Maloney et al (2011) investigated the processing of symbolic magnitude, the abstract representation of numerical magnitude, normally associated with humans, by high and low maths anxious individuals. The study concludes that highly maths anxious individuals have less precise representations of numerical magnitude, represented by the individual mentally using an internal number line, that allows the recognition of “number sense” and a fundamental ability to process numerical magnitude information automatically and efficiently, than their lower maths anxious peers do. The impact of these low-level numerical deficits is the compromise and non-development of higher-level mathematical skills.

Interestingly however, Furner and Gonzalez-DeHass (2011) suggest that mathematics anxiety is not the sole reason for low math achievement, ensuring that educators are informed of its nature and are aware of the critical academic problem, whilst working towards solutions, will only help individuals manage that anxiety and identify other competing factors to improve the mathematical relationship for the individual.

Hilton (1999) studied 103 pre-registration students who had attained places on a diploma of nursing course suggesting that a mathematics grade C GCSE and above, would lead to competence in performing mathematical based tasks above those without those qualifications. This was assessed by a 20-part question test over 30 minutes with a pass mark of 70% or 14/20 correctly answered questions, with no allowance of calculators. Hilton (1999) discovered that GCSE B grade students consistently performed better at the mathematical tasks, in comparison to students with lower grades. A large proportion of the students in the study entered the programme with a grade C (39.8%); interestingly the range of values for these students within the 20-part question test, demonstrated a wide variety of abilities across the mark spectrum. Ultimately suggesting that had there been mandatory grade C minimum entry criteria at this time, 28 students (27.18%) would have been refused entry to the programme, purely because of this qualification. Fifty-five (53.4%) of the total participants did not achieve the overall pass mark for the exam, with thirty-five of these students possessing a Grade C or higher.

Hutton (1998) concurs with Hilton (1999) discussing the relevance of mathematics qualifications, placing students into three categories for their study:

1) Mathematics at a higher level than GCSE grade C
2) Mathematics at Grade C or equivalent
3) Mathematics at a level below Grade C or no formally recognised mathematics qualification

Students entering the course in category one, performed significantly better (mean score 34.8 (69.6% SD 9.4) than those in categories two (24.9 (49.8% SD 8.3) and three (22.9 (43.8% SD 9.9) (t-test, $p<.005$), no statistical significance is noted between groups two and three. Students in category 1 also performed better in sections involving problem solving. ANOVA suggested a highly significant difference between groups ($p=.0002$), unrelated t-tests defined the statistically significant result was between groups one and two ($p=.001$) but not two and three ($p=.165$).

2.2.2 Numeracy ability and its measurement

Lord Lucas' review suggests there is no distinction between an education for a few mathematicians and a mathematical education for all. The review explains that contemporary assessments of mathematical competence do not provide fair and equitable assessment of ability (Westminster Education Forum April 2017).

How we assess numerical ability is important, several diagnostic assessments can achieve this. Looney (2005) defines diagnostic assessment as the frequent and interactive assessment of student's progression through testing, enabling an identification of their learning needs and current numeracy ability. Black (1998) and Ecclestone (2002) argue that diagnostic assessment activity also helps to inform practice and student progress, providing an assessment of learning not an assessment for learning.

Currently in England, ability is traditionally assessed via national examinations in mathematics, called General Certificates in Secondary Education (GCSEs). Within mathematics, this requires the students to have skills and understanding of mathematical methods and concepts to a deep and fluent level, to apply these and select the appropriate mathematical techniques to solve problems (DoE 2013).

Making reasonable mathematical deductions and inferences with the ability to draw conclusions about mathematical problems, communicating, interpreting, and comprehending mathematical information in a variety of forms, which are directly appropriate to the information and context of the question asked (DoE 2013)

The subject content covers six main areas with numbers, algebra, ratio, proportion and rates of change, geometry and measures, probability and finally statistics assessed. With all these areas significantly linked to parts of nursing numeracy and calculations, this subject content is sufficient to cover what is required for the pre-registration nurse to do well in nursing numeracy exams.

It is however noteworthy from a review by the UK National Numeracy organisation (2017), that the current GCSE system dictates that the bottom 1/3 of students will fail irrespective of their overall absolute performance in tests. This appears to be a specific problem in the GCSE system, as marks are generally cohort referenced rather than absolute, with criterion-referenced scores to determine if the student passes or fails. As a result, grades are determined by the overall averages of the whole cohort, with boundaries set so that a third of a cohort falls below the grade C/4, the level required to enter degree-level courses. This can lead to the student perceiving that they ‘can’t do maths’ perpetuating the self-concept of non-achievement. With this assessment system, not being an absolute measure of ability, but a reflection you can scrape though by rote learning and limited conceptual understanding.

The national numeracy organisation “a new approach to making the UK numerate” (2017) goes onto imply that the UK has become adept at generating qualifications without actually securing the implied underlying improvement in the mathematical skills assessed.

Additionally, some students in the UK enter nurse education through alternative routes other than mainstream secondary education. Alternative routes include access courses, where students who may have few or no higher education qualifications, have the opportunity to take a year to gain appropriate qualification levels to access higher education. Harvey et al (2010) suggests there is limited research into the impact this has on individual's mathematical ability and overall performance in nursing numeracy, but what research there is, suggests that there is no effect on overall performance in nursing courses if the individuals possess an access course qualification (Wilson 2003 and Ofori 2000). Equally, Ofori (2000) study identifies that there were no significant differences in performance among students with an 'O' level GCSE access type qualification and those without any type of entry qualification in main subjects, required for higher educational study. Supporting work from Jeffrey's (1998) and Hutton (1998) identifies that paper qualifications and domain specific knowledge and qualifications, such as mathematics, should not be relied upon as predictors of academic performance in the selection process of potential of pre-registration nurses.

Rhodes-Martin and Munro (2010) descriptive qualitative study highlights alternative approaches to assessing numerical competence if the individual does not have a standard entry qualification to demonstrate their skills in numeracy and literacy. The study location offered a 'Portfolio of Evidence for Entry to Level 1 Study' module, that allows access to adult, children, and mental health nursing courses by completing the 15 level 0 credits module. These students had left school with few formal qualifications but had gained a variety of skills and knowledge from work experiences and life. The students accessed the course without any recourse to alternative lengthy education programmes. Rhodes-Martin and Munro (2010) recognise that the module was very intensive and required lots of one-to-one tutorial support and flexibility. A final assessment involved a half hour viva examination overseen and assessed by the student's personal tutor. Although there was no formal examination assessment, such as doing drug calculations, the student was expected to engage in in-depth questioning on the sources they had provided as evidence. Individuals were expected to discuss these examples in detail to demonstrate understanding. 113 students applied to complete this module over a three-course entry, 83 individuals started the courses with 65 completing them, 5 failed the course, 31 started the adult diploma of nursing course and 30 started the mental health course. Four assignment results recorded, demonstrated no statistically significant difference in referral or resubmission rates for either group. With withdrawal from the course with an intention to return to the programme being similar.

Higher education institutions themselves set entry requirements for pre-registration nursing courses. Interestingly HEIs appear to be setting the requirements for numeracy at a GCSE C/4 to meet the NMC standards on selection, admission, and progression (NMC 2018). However, within this document there is no set standard mathematics exam grade for proficiency in numeracy, to become a registrant on the NMC register. Nursing students are required to have a capability to develop numeracy skills to meet programme outcomes, whilst the HEI must ensure that their programmes include a health numeracy assessment related to nursing proficiencies and calculation of medicines, with this assessment requiring a 100% pass mark. Ensuring that there is a balance between setting the adequate standard to attain proficiency and not setting up individuals to fail, requires a very balanced and locally recognised set of entry requirements (Office for Students 2021)

Other alternatives to GCSE based around functional skills qualifications are often used as forms of assessment in further education establishments. Students are normally screened on entry to these establishments to allow an accurate understanding of their current ability and level of attainment. One such programme is Basic and Key Skill Builder (BKSB) initial and diagnostic self-marking assessment tool, which allows reliable identification of numeracy performance. This categorises performance in relation to educational level from pre-entry levels up to level two in mathematics. The assessment tool is directly connected to the Functional Skills maths and English standards and the Core Curriculum in English and maths.

Schools of nursing stipulating academic grades as a minimum requirement for entry onto their programmes and with GCSE C grades used as a general standard of education. Colleges and HEI'S should be careful not to assume that students are competent in arithmetic, nor does it have the predictive power of lack of competence. Complacency needs to be avoided, that these qualifications imply the individual will have the ability to complete nursing numeracy related tasks, with the potential exclusion of pre-registration students based purely on these qualifications alone would be an unwise move, there is a need for nurse education providers to work to address these important gaps and establish entry-level benchmark requirements (Ramjan 2011, Hutton 1998, McKenna 2022)

2.2.3 Mathematical ability and nursing calculations:

The NMC (2018) outlines the procedural competencies required for best practice. In annexe B. 11.4 of this section, the registrant will need to be able to undertake accurate drug calculations for a range of medications, whilst also ensuring professional accountability with the safe administration of medicines to those receiving care. Dilles et al (2011) identifying that poor calculation skills are demonstrated amongst many student nurses, with some even identifying significant issues directly prior to graduation. Barker et al. (2002) suggests one in every five doses administered in a typical hospital, contains a medication error. Whilst appreciating that not all these errors will be calculation errors, there is a strong link between mathematical skill and proficiency, which is contributing significantly to the possibility of making a medication error. With these being a prerequisite to attaining accurate medication calculations and with many medications requiring complex calculations, the importance of understanding the links between mathematical ability and drug calculations is extremely important.

It is important to support and identify students at the earliest opportunity, who may struggle with drug calculations. McMullan et al (2012) suggests it is particularly important to determine if, and how strongly, the participants' drug calculation ability scores, could be predicted by individual factors such as anxiety, self-efficacy, and numerical ability. McMullan et al (2012) study suggests that drug calculations and numeracy ability of UK nursing students were poor, with a significant reliance on using calculators or inadequate maths education in the past, contributing to poor numeracy results.

Wright (2004) identifies that it is also not just about calculations, general numerical ability is important in health care. The ability to measure blood pressure, weights, times, and heart rates, all require an ability to compute numbers and appropriately chart and calculate where they need to be recorded and how they are interpreted.

Understanding the conceptual framework, the individual uses to visually attaining the correct process of calculations is important (Wright 2004). Conceptual errors are more likely to lead to drug calculation errors, especially with intravenous fluid administration and drip rate calculations. Individuals tend to struggle to extract the exact information that is required to complete the calculation, and it is not actually their mathematical ability that is the issue, leading to errors in calculations. Fleming et al (2014) study also acknowledged this, with participants achieving significantly better scores in tablet calculations and metric conversions, than drip rates. With intravenous therapies being recognised as a particularly high-risk area for errors (Fleming et al 2014), ensuring that students and registered nurses understand the need to extract all the required information to make a correct calculation is paramount.

Gunes et al (2016) descriptive and cross-sectional design study, recruited 128 four-year pre-registration students in Turkey. Collecting three forms of data that included a demographic data sheet, mathematical skill test and a drug calculation skill test, aiming to study the mathematical and drug calculation skills of student nurses.

The mathematical skills test comprised of 10 open-ended questions about division addition, subtraction, metric-system conversions, decimal and fractional numbers. With a pass mark of 60% set, correct answers, awarded one point each with scores converted to percentages out of 100. The median score for the mathematical skills test was 50% with a range of between 0 and 100%. 52% of students did not attain the pass mark. No statistically significant results were identified between mathematical skill and the gender of students (t=0.15, df=125, p=0.87 and t=0.68, df=125, p=0.49), respectively.

Again, consisting of 10 questions, the Dose calculation test score identified a range between 10 and 100% and a median of 60%. 36.4% scored below 60%. Injection and solid-liquid dose calculations and intravenous fluid and infusion rate calculations assessed with scores varying between 0 and 100% and a median of 74.6%. Lowest scores from students were recorded for the intravenous fluid and infusion rate calculations with 73% of students scoring below the 60% pass mark. Strong correlations were identified between dose calculation skills and mathematical skills (r=0.47, n=128, p<0.001). This contrasts with Elonen et al (2021) study that identified the majority (71%) of students were able to answer fluid calculation questions correctly, with older students that a had previous degree in health care and greater satisfaction with their current degree programme, achieving the highest scores. Nearly all the students were able to perform the tablet calculations correctly with 99% passing this element of the test. Elonen et al (2021) conclude that the students in the study appear to have the appropriate skills to perform single medication calculations, however, a significant number of these students have difficulties when the question required multiple calculation operations or a higher level of conceptual knowledge and understanding. Alteren J, Nerdal L (2015) suggest that there is no basis for the conclusion that a statistical relationship existed between high school mathematics grade and number of attempts required to pass the medication calculation test. Identifying in their exploratory study that participants 43% of the time, regardless of their grades in mathematics, passed the medication calculation test on the first attempt, with all students passing by the third attempt. Identifying that high grades in mathematics were not always crucial to passing the medication calculation test, but added an air of caution recognising however that the grade may be important in ensuring a passing medication calculation test within fewer attempts, and therefore reducing the anxiety the student experiences when being placed in a high-stake test.

2.2.4 Nursing Numeracy

The ability of healthcare professionals to perform basic numeracy and relate this to dose calculations competently, is without question one of the most important roles (Arkell and Rutter 2012).

Numerical skills and the ability to the use this knowledge for formulas, rules of rounding and conversion to perform mechanical calculations, refers to the basic functions and rules of calculations. This includes the ability to select the numbers required for the task and the methods, to obtain the correct result in numerical calculations (Elonen 2021, Fleming et al 2014).

Methods include the ability to perform ratio proportion, formula methods and dimensional analysis. Successful completion of these is not achieved with just numerical calculations skills, but also requires conceptual skills to recognise the desired strength and amount of medication supplied to allow the calculation of the doses needed (Toney-Butler & Wilcox, 2020). Wright (2006) highlights these concerns when she suggests that drug dosage calculations require the use of mathematical skills and having poor mathematical skills is highly correlated with a poor performance in drug calculations.

Bagnasco et al (2016) discusses the difficulties that nursing students can have with performing basic arithmetic operations without a calculator, as well as interpreting the information provided to them, including the lack of conceptual skills required to place the information appropriately. With medication calculation errors, occurring due to a lack of proficiency in basic mathematical skills and functions or conceptual understanding of how to interpret clinical data to perform medication calculations, patients are exposed to unintentional harm throughout their journeys in the health care settings, avoiding these episodes of error is extremely important. One particular area of error is dosage calculations being incorrectly performed. The implications for this are vast; with over 6000, cases of error reported in the United Kingdom every month (National Patient Safety Agency 2009). With one of the main contributory factors being miscalculation, with 11-14% of medication errors being associated with mathematical errors (National Medicines Information Centre 2001). The reality of this is worrying, the regular reporting of errors in the wider press and their association with a discourse around falling standards of numeracy within the profession ever present. Mathematical skills, numeracy skills and proficiency are prerequisites to accurate calculations, with some administrative processes for medications requiring complex calculations, often in multiple levels (Beaney 2010). However, student nurses have been found to be inadequate regarding mathematical calculation deficiencies, mathematical skill, conceptual and measurement abilities (Gladstone 1995, Jukes and Gilchrist, 2006) with these still being evident when assessed prior to graduation (Dilles et al 2011).

Common errors include the misplacement of decimal places, as well as ratios and fractions errors and a misunderstanding of how these directly relate to drug administration. Student nurses reported confidence in performing addition, subtraction, and division, but had lower confidence levels in performing multiplication. With the consideration, that many nursing calculations will involve both division and multiplication there is concern about the impact of this (Andrew et al 2009)

Wennberg-Capellades et al (2022) recognises that poor drug calculation skills are directly related to difficulties with understanding mathematical principles. An ability to perform simple calculations does not allude to individuals being able to complete tasks that involve multiple steps and a higher level of conceptual knowledge of numeracy. The individual's ability to recognise errors within their calculations was identified as another risk factor. With the potential of high-risk drug administration errors occurring in practice and simulation, it is of concern when students who provide incorrect answers to test questions, but rate these as likely to be highly correct, creates additional concerns, as to the extent nursing students are aware of their errors and the implications of these errors in practice. In this regard, a recent study in which students were asked to indicate their level of certainty about answers given to a pharmacology knowledge questionnaire, concluded that there was a high risk of medication administration error in 14% of the students who rated incorrect answers with high certainty (Johnson et al 2020)

Ramjan (2011) project, investigated nursing students' perceptions of and performance in, a de-contextualised diagnostic maths paper involving just the use of questions only, verses a contextualised diagnostic maths paper, with questions alongside visual pictures. Of the 119 students approached for participation, 99 participated in a pre-test screening tool and 50-question arithmetic exam, allowing 1 hour for completion. 25.5

or 51% of the students could only answer half the questions on the paper correctly, most problems occurred in the division section, with 24 of the 99 students not attempting the long division section, with a further 7 more not attempting the short division either. There was a distinct inability to divide and multiply fractions and decimals of 10, with students commonly omitting questions that involved calculations requiring expression of fractions as decimals and division of decimals. With dosage calculations often based around decimal values and with the incorrect placement of the decimal causing calculations potentially ten times erroneous, this creates an exceptional dangerous position. Weeks et al (2013), Wright (2005) comment that a lack of basic maths skills can impact on this ability to appreciate basic decimal placement, and further training on dosage calculations will ultimately be ineffective in managing this. Failure to have an ability to understand insufficiently the four operational skills, division of the numerator and denominator, failure to calculate percentages, ratio-proportion or use of a calculator and failure to convert doses from milligram to micrograms. Özyazıcıoğlu (2018) study of nursing students in drug dosage calculation also comments on this area identifying basic numeric skills, errors in arithmetical operations, or placement of decimals or unit conversions (ml, dzy,mg, g, etc.) in drug dosage calculation practices, as the main issues of errors. Wennberg-Capellades et al. (2022) suggests that most common errors noted in relation to calculation were unit conversions, a failure to contextualise the answer they came to, to clinical cases and the need and increase in knowledge to solve more complex concepts, such as maximum concentration and minimum dilution. The extraction of key information from the question or using strategies to achieve this, and simple errors such as not including the units when giving their answer. Basak et al (2016) and Savage (2015) also identify these errors with conversions in their quasi-experimental study and audit respectively, establishing the reason for calculation errors as, not knowing the conversion unit, recording them incorrectly and a lack of attention to detail, common sense, carelessness, and arithmetic errors. The importance of supporting, developing, and constructing an accurate schemata and internal cognitive representation of the world the person is in, that accurately reflects the individual's ability to understand, use symbols, arithmetical operations, and computations, to competently solve authentic medication dosage problems. Requires HEI's to bridge the knowledge-performance and theory-practice gap by embracing new taxonomies of learning. This includes the identification of the taxonomy of essential skills for numeracy and the essential skills clusters dictated by the NMC (2010).

Examples of this taxonomy include numeracy skills and their application to all areas of nursing practice e.g., estimation numeracy skills, with medication dosages and IV infusions rates calculations or the multiplication of numbers, when completing conversions of units or drip rate calculations (Young et al 2013)

With the NMC (2018) now stipulating a compulsory element to join the register being evidence of passing a drug calculations/ numeracy test at 100%, it is considerably worrying that these issues are arising with arithmetical operations. So, are these assessment papers fit for purpose? Do they assess the reality of administration in practice? Is there a replicable requirement across other countries? Wenberg-Cappellades et al (2022) suggest this is not the case in Spain, where the key focus is around safe medication management across a spectrum of medication administration knowledge and not a key focus on calculations (ANECA 2004)

Hutton (1998) suggests that these do not reflect the realities of practice and the individual's ability to perform the appropriate calculations in practice. Supporting these concerns is Ramjans (2011) work assessing decontextualised question exam paper (questions only) and the other contextualised (visual pictures with the questions). A substantial improvement in scores between tests was noted, with contextualised questions being answered better, with 80% of students preferring the visual images, suggesting this enabled a deeper level of learning of numeracy skills, reduced stress and anxiety levels and allowed for a better application and simulation of 'real life' whilst adding an element of realism to the assessment.

This is also discussed in Gregory et al (2019) paper who concurs that their three-step approach to numeracy instruction involving the use of a blended visual learning model, led to a statistically significant increase in student's self-efficacy, increasing confidence and competence in medication calculations. Interestingly the survey data revealed that 386 students reported they felt confident in doing maths calculations and maths tests, although this may not be representative of performance. 138 students reported no confidence, 9 reported some confidence and 7 did not respond to this item. Therefore, it appears important to understand the student's perspective on their confidence and ensure that this is equitable with performance in numeracy testing, as this is not always reflective of ability. Having statistical data on current numerical performance i.e., assessment on entry to programmes, may help to predict and adapt programmes to meet the individual need.

2.2.5 Predictors of nursing numeracy:

So, what if we could predict how an individual would perform in these skills and then implement changes to curricula, recruitment strategies and teaching strategies to help manage and support these students?

With many academic degrees containing a substantial numeracy component and expectation, it is worrying to read that many students dislike the component of their degree and that this potentially leads to poor numeracy performance (Phoenix 1999).

This is particularly evident within the pathway of pre-registration Nursing programmes, Arkell and Rutter's (2012) study demonstrating students strongly disagreed that they found number work easy (n=98, 48%), with these nursing students not enjoying early schooling mathematics teaching. These students then went on to achieve average scores in a 14-item numeracy test of around 30%. Suggesting a translation into poor performance in calculating drug doses in undergraduate nursing students (Wright 2005). Wright (2006) goes on to publicise that there was a statistically significant difference between those that enjoyed mathematics at school and those that never enjoyed maths ($U=38.5$, $p=0.025$) with those enjoying maths more likely to gain higher scores in maths tests.

Wolkowitz and Kelley (2010) identify mathematics ability as the second strongest predictor of academic success in nursing programmes with a 6.13% contribution to the effect on the dependent variable of predicting success on the nursing programme (t4104) $=5.58$ $p<0.00001$). Gregory et al (2019) suggests that there are only two statistically significant predictors of maths achievement within their quasi-experimental cohort study, which used a pre and post-test survey, to look at the impact on the Nursing Self-Efficacy for Mathematics Scale (NSE-Math). The scale consisting of mathematical concepts of arithmetic and skills for medication calculations. The two emerging predictors included a high-Grade Point Average (GPA) measured at the beginning of the semester with a range from 0-7. Students scored a mean of 4.7 and median of 5. The participants with higher NSE-Math scores at the 6-week period of assessment, were more than twice as likely to achieve better grades in the first numeracy test (OR 2.03, 95% CI: 1.06–3.90). However higher academic achievers were over three times more likely to achieve these good grades (OR 3.16, 95%CI: 1.47-6.78)

When establishing what predictors impacted on the NSE median scores at baseline, (scores were measured at baseline and 6 week follow up), mathematical education and gender emerged as significant predictors of better scores in the NSE scores. With males having 2.5 times higher odds of above median NSE-maths scores at baseline (OR 2.65, 95% CI: 1.66–4.23) as were students with a mathematics qualification that demonstrated advanced academic achievement, who also score 2.5 times higher in the NSE-Maths score (OR 2.61, 95% CI: 1.78–3.83). This was also the case in Khasawneh et al (2020) study where significant differences in the mean drug calculation ability test scores were noted between males and females (DCAT) (t (106) = 2.13, p = 0.035 and Cohen's d = 0.43 between males (5.05 (2.32)) and females (4.03 (2.43). Equally there was a significant effect from underline numerical ability being one of the main factors that was contributing to the low drug calculation ability scores noted within their study. However, Hosmer-Lemeshow demonstrated a good fit (χ^2: 4.583, *df = 7, p* = 0.711) but Nagelkerke's pseudo R^2 value of 0.111, suggested a low percentage of explained variance towards these predictors. Barra (2013) suggests

that this numerical ability and its measurement in a Nursing Fundamentals test was found to be a strong predictor of success and had a correlative effect on the overall graduation rate of students, especially those in ethnic minority groups.
Roykenes et al (2016) discusses the notion of self-concept and its impact on an individual's evaluation and description of themselves. Suggesting this is multi-dimensional and differs from academic achievement, consequently a person's actions can be predicted and explained by these self-concepts, individual's perceptions of themselves and the way they act having a reciprocal relationship. Within the domain of mathematics, there is a high correlation between self-confidence and achievement within numeracy and drug calculations tests, suggesting that low self-confidence might be a suggestive factor in the anxiety individuals experience when taking these tests, this is in addition to emotionality and worry.

Ofori (2000) study identified that age was a better predictor of performance in numeracy modules than access type qualifications or GCSE or 'O' level qualifications. Older students performed far better than their younger counterparts did with very mature students outperforming them all. Ofori (2000) identifies that their research is limited regarding drawing inferences from a simple bivariate relationship between a single factor and achievement outcome but offers an interesting discussion on an area that in relevant to pre-registration nursing recruitment. Hutton (1998) does however offer an opinion on why more mature students have less errors and apparent less difficulty on completing numeracy and drug calculations exams, citing a less reliance on calculators and a better recoil of their multiplication timetables from their childhood education.

Wennberg-Capellades et al (2022) identifies that there are several other factors that contribute to nursing students experiencing difficulties with dose calculations aside form arithmetic skills. One contributory factor affecting this is mathematics anxiety, impacting on the student's ability to complete and understand tasks involving mathematics. This fear of the mathematical process and the student's ability to understand, often results in a resistance to learn the mathematic content for the completion of medication administration calculations (Johnson et al 2020). Other key factors identified included a lack of confidence and a feeling of resentment towards the mathematics being too complicated to complete, and an overarching fear that resides when considering the implications of error in the clinical placement/practice setting.

Cross-national differences in medication education regulations and practices and the competences that graduating nurses are expected to have acquired are another key area for discussion. With the Nursing & Midwifery Council (2018) recommending that nurse education institutions, need to provide testing opportunities and educate students to achieve a 100% pass on a health numeracy assessment, this assessment needs to include calculations. This is not the case for many parts of Europe that tend to rely on alternative testing mechanisms, such as safe medication management as a holistic concept rather than just the calculations element (Wennberg-Capellades 2022)

The aim of undergraduate programmes is to develop these skills and ensure that these students gain a level of competency to ensure they can correctly calculate and safely administer prescribed drugs. So, to understand what predicts and impacts these students' ability would be invaluable.

2.3 Anxiety

"Anxiety is a mind-body reaction that occurs instantaneously, and its effects are felt physiologically, behaviourally, and psychologically all at the same time" (Peters-Mayer 2008, p. 4). With a state of intense agitation, tension, or dread occurring from a perceived threat of danger.   Anxiety can cause stress, and an emotional experience that takes over our mind and body, causing unpleasant and stressful situations, of which we feel we have no control (Tyrer 1999)

Remes et al.'s (2016) systematic review of anxiety and anxiety disorders in adult populations suggests that despite high heterogeneity, the prevalence of anxiety across population subgroups and settings suggests an emerging and compelling amount of evidence of anxiety and anxiety disorders in the general population. With general recognition that 3.8–25% of the population, experience anxiety or an anxiety disorder, which is particularly identified in women (5.2–8.7%) and young adults (2.5–9.1%); people with chronic diseases (1.4–70%); and individuals from Euro/Anglo cultures (3.8–10.4%). As opposed to individuals from Indo/Asian (2.8%), African (4.4%), Central/Eastern European (3.2%), North African/Middle Eastern (4.9%), and Ibero/Latin cultures (6.2%).

With women being almost twice as likely to be affected as men are (female: male ratio of 1.9:1), Irrespective of culture, individuals under the age of 35 years are disproportionately affected by anxiety and anxiety disorders (Baxter et al 2013, 2014).

With an average age of 29 across nursing pre-registration nursing programmes, this area needs consider understanding and exploration.

2.3.1 Mathematics anxiety.

Mathematics anxiety is generally defined as a feeling of tension, fear or dread that happens when a person is required to undertake a task involving the assessment of their mathematics performance (Ashcraft 2002, Hembree 1990). Math anxiety is a detrimental attribution to success in mathematics: “An obvious but unfortunate consequence of the avoidance tendency is that compared with people who do not have math anxiety, highly math-anxious individuals end up with lower math competence and achievement” (Ashcroft, 2002, p. 182). Resulting in students avoiding courses and modules that have a high maths content and post-graduation taking a less than optimal career pathway to avoid further exposures (Durrani and Tariq 2009, Barroso et al 2021)

Maths anxiety is considered a dimensional construct with evidence from factor analyses in Liebert and Morris (1967) work, indicating math anxiety can be made up of a variety of components. Specific distinctions made between an individual worrying and their cognitive dimension of anxiety and emotionality or physiological dimension of anxiety.

Interestingly Durrani and Tariq (2009), suggests that nursing students often lacked confidence in and the motivation to develop numeracy skills, expressing little enjoyment of working in numeracy classes. They note a strong correlation between high levels of negative attitudes and maths anxiety towards developing numeracy skills, linking with low levels of competency in students' self-evaluation of their numeracy skills, this is of concern when considering the impact of these elements on the completion of nursing numeracy tests. Furthermore, Durrani and Tariq (2009) surmise that students with higher pre university, mathematics qualifications, tended to exhibit lower levels of maths anxiety along with a greater degree of confidence, enjoyment, motivation, and competence in mathematics.

Barroso et al (2021) supports this previous work whilst also discussing their own study, indicating a significant relationship between mathematics anxiety and mathematics achievement, with this relationship existing across a wide range of educational periods and sectors. Significant differences between grade level achievements and the magnitude of association with mathematics anxiety and mathematics achievement varies as the individual develops, with early education demonstrating a significantly stronger relationship between the two, than in higher education settings. Weaker relationships driven by the relationship between math anxiety and basic knowledge for students in lower years in comparison to upper years. Barroso et al (2021) recognises however, there is limited consideration of generalised anxiety and its impact on young children, as to if actually; this is the overriding impact predictor.
Their analysis of the research conducted between 1992 and 2018 with a 0.747 effect size, finding a small-to-moderate negative, yet statistically significant correlation (*r*-.28 95% CI -.29, -.26), between mathematics anxiety and mathematics achievement. Inequities were however noted between certain groups, including people of racial and ethnic minorities, female students, and students with learning disabilities.

2.3.2 Reasons for Math Anxiety and its impact

The development of math anxiety has been traced back to individuals' negative classroom experiences, of feeling humiliated and embarrassed in front of peers (Weeks et al 2013, Jackson and Leffingwell 1999). With anxiety rooted in emotional factors, but needing differentiated from dyscalculia, normally characterised by a specific cognitive deficit in mathematics (Mammarella et al 2015). This anxiety can exist in people who have mathematics capability, even if they have a distain for mathematics overall, often this also has an emotional component with individuals associating this with past experiences as well (Helal et al 2013)

Many factors contribute to math anxiety, with negative experiences from classroom settings or home contributing significantly. Good math teachers play a vital role in creating a good learning environment by making maths more attractive and reducing anxieties and fears around poor performance (McNaught and Grouws 2007). Interestingly peers also play a significant role often having a negative impact on their colleagues, this significantly affects the individual's learning development, often leaving them behind in subject areas that they do have the ability to progress and excel in (Mutodi and Ngirande 2014). Significantly, this impacts on math anxiety, translating into drug dosage test scores. Through the student's direct avoidance of this subject area, they practise less and therefore do not have the enhanced level of education and understanding associated with this increased exposure, leading to less improvement in test scores (McMullan et al 2012, Fulton and O' Neil 1989). Preis and Biggs (2001) described a process of a Math Anxiety Cycle, a perpetual continuum during which negative experiences with math lead to an avoidance of completing mathematical tasks. This often then leads to poor preparation for any mandatory testing and an overall poor performance in the actual tests. Without correcting this cycle, the implications for nursing practice are that these individuals with poor mathematical performances then go onto incorrectly calculate drug dosages with these errors then translating into incorrect drug administrations to patients and ultimately affect their wellbeing (Kohn et al 2000).

Interestingly however, Ashcraft and Kirk (2001) note, maths anxiety causes adverse effects on the areas of the brain that are associated with working memory, therefore experiencing maths anxiety at a time of testing, can affect overall performance, leading to poor results. Ashcraft and Krause (2007) continue to expand upon this theory, suggesting there are several consequences of maths anxiety on working memory capacity, Eysenck and Calvo (1992) work supports this theory, suggesting anxiety impairs cognition and stops individuals achieving. To decipher maths problems requires a working memory capability of storing, updating intermediate results and performing calculations. Hoffman et al (2012) suggest that individuals, who have less working memory capacity, will demonstrate deficits in emotional responses to challenges such as mathematics. With these dynamic changes occurring, there is an insight into the potential of temporal fluctuation in math solving problems, induced under high stress interactions with mathematical encounters (Trezise and Reeve 2014).

It is therefore very important to recognise that not all math anxiety is related to just long-term arithmetic skill or personality traits but can also impair an individual's short-term functioning and ability in a mathematical or numeracy exam. These may of course differ between individuals, but consideration of this sudden inability appearing in a one-off test, need not necessarily be treated as a long-standing inability in mathematics, but a potential episode of maths anxiety (Cipora 2015). However, Alexander and Cobb (1987) assert that a fear of maths test can potentially extend beyond formal testing, and that all situations the individuals perceive their maths skills are being evaluated or tested in some way, could potentially expose their vulnerabilities or inabilities to correctly answer any question. Within nursing, this could include calculating therapeutic dosages in clinical practice where the need to "get it right" is essential.

McMullan (2012) discusses the potential impact of maths anxiety on a student's ability to pass numerical and calculation exams, setting a 60% pass mark for both employed tests. Only 45% of the students passed the Numerical Ability Test (NAT) and only 8% passed the Drug Calculation Ability Test (DCAT). On examination of the data, it appears that 10% of students demonstrated low levels of math anxiety, (score 0–24%) 70% of students demonstrated medium levels of math anxiety (score 25–74%); the final 20% demonstrated high levels of math anxiety (score 75%). Significant correlations between all the variables are identified in the data suggesting that the strongest correlation being between, math anxiety and self-efficacy, math and drug calculation self-efficacy, math anxiety and drug calculation ability and numerical and drug calculation abilities.
93% of the students who failed the numeracy test demonstrated anxiety, with 83% of the students who failed the drug calculation test demonstrating signs of math anxiety (score 25%). Comparatively, the students that passed the numeracy test (63%) and the 32% who passed the drug calculations test demonstrated maths anxiety signs.

2.3.3 Gender and maths anxiety

The literature indicates mixed results when looking at the association between gender and maths anxiety. Literature suggesting that females suffer more with maths anxiety than males include Paechter (2017), work with psychology students highlights female students reporting a higher level of maths anxiety (β=− 0.660). As opposed to Hembree (1990) meta-analysis suggesting a stronger negative correlation for male students, compared to female students in Grades 5 through to 12, but this did not include students in postsecondary school, whilst Hopko et al.'s (2003) study, again with psychology students, indicating females reported more maths anxiety than males (t (812) =5.53, $p<0.001$). Khasawneh et al (2021) suggests that the development of mathematics anxiety could be affected by gender, with females being more prone to the development of maths anxiety than males.

Hunt et al (2015) suggest that there is little effect associated with gender and maths anxiety, with a statically insignificant result in correlation exploration r (67) =0.13, p=0.26. Alves et al (2015) supports this suggestion with their Mann–Whitney test, showing no significant differences in anxiety toward maths between male and female students (U=2270.5, p=0.541). Equally, Ma (1999) found the correlations to be similar for girls and boys as well,

There is limited understanding as to why females frequently report higher maths anxiety than males. One explanation comes from the theory of sex role socialisation hypothesis. This argues that traditionally mathematics is viewed as a male dominated competence and domain, therefore females tend to socialise themselves to believing that they are mathematically incompetent, leading to avoidance of mathematical tasks and roles (Devine et al 2012)

2.4 Instruments to Measure Math Anxiety

Mathematics anxiety has been assessed with various instruments throughout the last 50 years. Most prominent is the 98-item Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn (1972). Adapted by Betz in 1978, the anxiety subscale of the Fennema–Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976) was developed into the Mathematics Anxiety Score (MAS). This scale consists of 10 items using a 5-point Likert-type scale with MAS being found to have strong internal consistency and stability. Correlations between the MAS and the full-scale MARS suggesting concurrent validity being reported at 0.70 (Cooper & Robinson, 1991) indicating concurrent validity of the scale. Cronbach alpha values ranging from 0.86 to 0.90 suggested by Hackett & Betz (1989).

The measurement of maths anxiety accelerated with the publication of the Mathematics Anxiety Rating Scale (MARS) by Richardson & Suinn (1972). However, issues and concerns were raised around the cumbersome nature of the lengthy completion of the scale and several attempts were made to shorten this original MARS-R scale (Alexander & Martray, 1989; Hopko et al, 2003a). To alleviate these concerns the Abbreviated Math Anxiety scale (AMAS) was created (Hopko et al 2003a). This scale contained just nine items and focused on two main factors, learning Maths Anxiety, the suggestion that anxiety towards maths develops, due to the process of how this was learnt/taught and Math Evaluation Anxiety, closely associated with the relationship of anxiety feelings towards situations such as upcoming tests. These two components were found to make up a shortened 24-item version of the 98-item MARS (Richardson & Suinn, 1972), developed by Plake and Parker (1982).

Good internal consistency estimates were reported for both subscales (*Learning*: Cronbach's α = .78; *Evaluation*: Cronbach's α = .79) as well as for the total scale (Cronbach's α = .83) (Hopko et al 2003). There have been further adaptions of this model for both children (Carey et al 2017) and other countries including Poland, Italy, and the United Kingdom (Caviola et al 2017, Cipora 2015, Hunt 2011)

In recognition of these publications, the AMAS scale presents a concise and valid scale to measure Maths anxiety, with the scale appearing to be adaptable to a range of ages and student demographics, with the added attraction that it is one of the most employed short instruments used in the measurement of maths anxiety (Primi et al 2014).

Through this literature search, most of the published literature around maths anxiety scales was conducted on the American student population. Therefore, this places limitations of the applicability to the British and British pre-graduate populations. Hunt et al (2011) recognises this, suggesting that there are issues with the terminology of the MARS and AMAS scale systems, where British participants were seeking clarification on wording, to gain an understanding of what the question meant. Having these issues with interpretation, lead to concerns around the validity of their use in the British student population.

Hunt et al (2011) subsequently devised a new Mathematics Anxiety Scale for the United Kingdom (Appendix 2). This consisted of a series of statements about situations that may cause concern, involving maths. Initially 38 items, 10 being completely original were created. Items were based around previously validated scales and included student opinions from informed discussions with British undergraduates (Sheffield & Hunt, 2007). Rewording of some of the items including the use of popular UK based games and direct comparison to classroom-based activities.

Participants were asked to respond to the questions, giving an indication of how anxious they would feel about the scenario/statement, again based on a 5-point Likert scale. Scoring 1-5, yielding a scoring range between 38-190.
After initial piloting of the 38 items, all items were correlated with the overall scale, with a minimum (r=.48) recorded. Strong discriminatory power was established through t tests between subjects (p<0.001), allowing comparison between the bottom and top quartiles of the total scale scores with a Cronbach's Alpha of .96.

Of the 38 items included in the pilot study, only 23 were taken forward for inclusion in the final scale, after two were excluded immediately on noting skewness greater than +3 and or kurtosis of +/- 8 and extremes departures from normality (Field 2016). So, of the 36 items left, 27 had factor loadings of at least 0.45, with 4 items also loaded on to more than one factor. Factors 1(Maths evaluation anxiety) and 2 (Everyday social maths anxiety) and items 27,31 and 35 loaded onto factors 1 and 3 (Maths evaluation and math observation anxiety). This led to the retention of 23 items in making up the MAS-UK scale. Cronbach's alpha for the overall scale was excellent (α = .96), as well as for subscales 1 to 3 (α = .92, α = .85, & α = .89, respectively). Test–retest reliability was also excellent for the overall scale, $r(129) = .89$, $p < .001$; Subscale 1 maths evaluation anxiety, $r(129) = .90$, $p < .001$; Subscale 2 everyday social maths anxiety, $r(129) = .73$, $p < .001$; and Subscale 3 maths observation anxiety, $r(129) = .80$, $p < .001$. Therefore, this would suggest this was an accurate and credible tool to use within the United Kingdom education population, to assess mathematics anxiety.

2.5 Self-concept and self-awareness

Math self-concept refers to a person's perceptions of themselves (Shavelson et al 1976). Self-concept also has other constructs that are used interchangeably such as self-esteem, self-worth, and self-evaluation (Shunk and Pajares 2002)
This is most often based upon interactions within their environment and previous experiences. Within the realm of mathematics, value is placed on significant others, such as teachers, parents, or siblings, who have a great influence over the individual's self-esteem and behaviour, with these individuals playing an important role in the environmental factors that can lead to the development of self-concept. Within mathematics, this affects how a person then evaluates and assesses his or her ability in maths.

Appraisal by significant others at important times within the individual's life, such as exam times or leading up to evaluations or presentations, plays a significantly larger role in the success of the individual, than if the activity has a low stake (Abston-Coleman and Levy, 2010). The reaction of the person to this appraisal is strongly influenced by the significant other, and needs considerable understanding and appreciation of the affect, as strong reciprocal relationships between the individuals' actions and people perceptions of themselves, leads to significant effects on their behaviours (Shavelson et al 1976)

Shunk and Pajares (2005) suggests there is a high correlation between self-confidence, an interchangeable construct within self-concept, and test/maths anxiety. Having self-awareness enables individuals to manage themselves as well as affecting their overall performances. Although it is equally recognised that lacking self-awareness can have an equitable impact on individuals, making them make the same mistakes repeatedly (Rasheed 2015). Having the ability to be self-aware enables the individual to identify areas that could be improved and areas that are strengths. Maths confidence and values, Self-efficacy, maths barriers and performance are all factors that related to self-awareness. Understanding these factors and assessing their impact could help determine the methods of improving self-awareness, which may ultimately contribute to overcoming maths anxiety.

Johnson et al (2020) identified in their focus groups discussions, that students offer the recognition that they need to be more self-directed in developing their math skills; taking the time and effort to develop these, along with an increased need for clinical instructors to be more consistent in giving these students the opportunity to practice calculations in the clinical setting and in simulated practice settings.

2.6 Self-efficacy

Self-efficacy, according to Bandura (1977), is the belief that one is capable of successfully performing a task. A person's self-efficacy level is not as much prejudiced by the presence of the anxiety response, as by the elucidation of the presence of this response from the person experiencing it. For example, “having butterflies in the stomach” can be interpreted as a normal physiological response to a new or unfamiliar situation or process and unrelated to their actual ability to complete the task. Whereas individuals with low self-efficacy will see these butterflies as a sign of their own inability to complete the task or managed the situation they are in, this in turn decrease their self-efficacy further. Therefore, it would be reasonable to suggest that this could be a reliable predictor of if the individual will be able to complete a task or not or even attempt it in the first place, or if they will persevere and expend the energy required to complete the task, especially in the face of unforeseen difficulties (McMullan et al 2012). Interestingly within academic institutions self-efficacy has been used as a major focus to evaluate performance in mathematical skills (Kranzler and Pajares, 1997)

Grandell-Niemi et al (2003) suggests that undergraduate nursing students have limited and variable potential when dealing with mathematical concepts, with previous failures or poor experience in mathematics during the primary and secondary education, causing low mathematics self-efficacy when presented with medication calculations in HEI'S (Maag, 2004).

However, the usefulness of mathematics self-efficacy and its ability to predict future academic performances is somewhat questioned, with limited research in this area and a potential lack of reliable and valid instruments to measure this, suggests the need for more research in this area (Kranzler and Pajares, 1997). However more recently, O'Reilly et al (2020) study demonstrated that a structured pedagogical approach to nursing numeracy in undergraduate programmes, allowed development and improvement of students' self-reported self-efficacy with mathematics, permitting, and assisting students in realising the importance of learning and applying these skills as nursing clinicians.

2.7 Summary and Conclusion

In chapter two, the literature reviewed discussed the predictors of nursing numeracy, identifying that math anxiety and the reasons for this, math achievement at school education level, gender, and its influence on math anxiety, all impacted on and influence nursing numeracy (McMullan 2012). There was evidence of students lacking confidence and feeling embarrassed about their ability, highlighting previous experiences of maths as a key factor for their maths anxiety (McNaught and Grouws 2007). There was a clear importance for ensuring students were prepared appropriately for numeracy in the curriculum and why these skills are so important in nursing practice. The increase incidence of medication errors and the importance of mathematical ability in achieving success in calculations was significantly identified. There was some reference towards the implications of what types of qualification made the most impact, but there was equal competing evidence that this was not significant, therefore further exploration and research into this area is required. There was little evidence of the correlation between these pre-entry qualifications required for entry into pre-registration programmes, and the actual current levels of ability of the students on entry to the pre-registration nursing programmes, and their relationship towards nursing numeracy proficiency. Only one paper identified on the predictors of numeracy performance (Thompson et al 2015) however, this focused on three disciplines and did not offer any insight into current levels of numeracy verses qualifications.

A significant deficit in literature appears to be around the impact and link between the pre-registration student nurses' type of numeracy qualification, their numeracy experiences, and the effects on the individual's ability to perform nursing numeracy tasks. Gaining an insight and understanding into the relationship between the individual's numeracy qualification and other influencing factors, such as Maths anxiety and mathematics exposure, could help HEI's to tailor programmes much more specifically to the individual student's needs. Increasing the scope for participation across nursing courses.

The potential to identify the applicants to either increase the probability that they will succeed in their nursing numeracy or allow a greater degree of accuracy in identifying those that need further support, could potentially lead to an increase in successful completion of pre-registration nursing courses and further create a greater understanding of the links between qualifications and outcomes.

2.8 Focus of this study:

This led to the identification of four main areas that required further exploration and the focus of this study:

- The impact of maths anxiety on nursing numeracy performance
- The entry qualification of the student nurses, into a pre-registration programme and its impact on nursing numeracy performance
- The current numeracy level of the pre-registration nursing students and its impact on nursing numeracy performance.
- Identifying predictors of numeracy performance in nursing students

2.9 Research Question:

This study aims to answer the following question.

What indicators predict numeracy performance in undergraduate nursing students?

The outcome of interest is numeracy performance in nursing numeracy exams. As a direct requirement for NMC registration and a significant link to medication error and decrease in patient safety, the performance and ability of pre registrants is imperative.

This study will measure this performance with the use of a nursing numeracy test (Scale) identified as the dependent variable in this study.

The study assumes that numeracy performance is contingent on predictive indicators. Several predictors of numeracy performance are assumed in pre-registration nursing recruitment, including mathematics anxiety levels, mathematical qualification gained prior to entry, reflecting the current mathematical ability of the student and the sustained mathematical ability of the pre registrant student.

The following independent variables may predict numeracy performance:

Predictors at programme entry: These are considered the independent variables.

1. **Age (ordinal)** Ofori (2000) study identified that age was a better predictor of performance in numeracy modules than access type qualifications, GCSE's, or 'O' level qualifications. Older students performed far better than their younger counterparts did, with very mature students outperforming them all.

2. **Gender (nominal)** Males have 2.5 times higher odds of above median NSE-maths scores at baseline, compared to females. Tariq et al (2013) identify that males outperform females in mathematics, developing an understanding of this and seeing the correlation and relationship between qualifications and gender, will enable the adaptation and greater understanding of both teaching delivery and admissions processes. Gregory et al (2019) suggesting that the exploration and continued monitoring of the impact of gender in mathematical attainment and its influence on nursing numeracy success, requires further research and data collection.

3. **Type of maths qualification and associated grade (ordinal)** Wolkowitz and Kelley (2010) identify mathematics ability as the second strongest predictor of academic success in nursing programmes with a 6.13% contribution to the effect on the dependent variable of predicting success on the nursing programmes. However, it is unclear as to if this is directly associated to the qualification itself or the current ability of the pre registrant student nurse.
4. **BKSB screening tool category (ordinal)** Understanding of the individual's numerical ability on entry to nursing programmes by screening them, could allow an understanding of individuals current mathematical ability and its impact on nursing numeracy success. Having the ability to use diagnostic assessments to allow the prediction and identification of a student's ability, is fast becoming a key tool to assist with the diagnosis, identification, and development of assessments for learning strategies. Engagement from students in this feedback and assessment process will lead to better outcomes for students (Ecclestone et al 2010) Therefore to use of diagnostic assessments, including initial screening assessment tools has been a pedagogic initiative to ensure accurate recording of ability, as opposed to historical qualifications holding the weighting of proof for many years. Identifying this as an independent variable alongside the participants original qualification will allow comparison and exploration of impact (Looney, 2005; 2007; 2008; Ecclestone et al, 2010; Torrance, 2012).
5. Mathematical Anxiety measured using the **Mathematical Attitudes Scale (MAS-UK) (scale)**

- Maths anxiety
- Motivation

- Usefulness

Outcome measure at endpoint:

Performance in final nursing numeracy test (Scale)

Data related to all indicators and outcomes was collected from all participants in year one of the BSc Nursing programme to include Child, Mental Health, and Adult pre-registration nursing students.

2.9.1 Objectives:

Using all data as a single sample:

1. To investigate the relationship between each indicator (age, gender, qualification/grade, BKSB score, MAS-UK scores) at programme entry, with performance in nursing numeracy test. Using Parametric and non-parametric testing according to the indicator being explored.

2. To investigate the relationship between the participants mathematical qualification and grade, with MAS-UK anxiety scores. Aiming to discover if there is any relationship with the grade an applicant achieves prior to admission to the university, and the MAS-UK score, with the use of Spearman's Rho.

3. To investigate the relationship between the participants, mathematical qualification/grade and BKSB screening tool category. Enabling the exploration

of the relationship between the candidates' previous achievement and their current level of attainment.

2.9.2 Hypothesis

Test the following hypotheses:

(i) There will be a positive correlation between the participant's original numeracy qualification and the result they achieve in the numeracy-screening assessment tool (BKSB). Attainment of a grade of a qualification leads to an assumption that ability will continue. Exploration of the longevity of qualification validity tested and explored.

(ii) There will be a positive correlation between Males and numeracy test outcomes. With males outperforming females in the nursing numeracy test.

(iii) There will be a positive correlation between mathematical qualifications at the start of the pre-registration programme and anxiety score on the Mathematical Attitude Scale. With individuals who hold a higher mathematical qualification attainment, experiencing less anxiety.

(iv) A positive correlation will be noted between mathematical qualification on entry to the programme and nursing numeracy test

(v) A positive correlation between current numeracy performance (BKSB) on total exam score

(vi) A negative correlation between the MAS-UK and nursing numeracy exam. With individuals experiencing high levels of anxiety not performing well in the nursing numeracy test

2.9.3 Anticipated contributions of this study

It is anticipated that this study will enable identification of correlations between the indicators that predict numeracy performance in nursing numeracy tests. Enabling nursing students and educators to identify strategies that target specific predictors, allowing proportionate student-centred learning support to be offered within nursing curricula.

It is also likely that the study will contribute to areas of nursing education such as recruitment, student support and skills development, as well as identifying areas for further research.

CHAPTER 3: METHODOLOGY

3.0 Research Rationale

The primary purpose of this study was to identify the predictors of nursing numeracy performance. Through investigation and the use of inferential statistics to test the identified hypotheses.

3.1 Study setting:

Based in the Southwest of the United Kingdom, the selected university plays host to over 18,000 students a year. The focus of this study was the Faculty of Health consisting of biomedical sciences, medicine, dentistry, health professions, nursing, midwifery, and psychology. Participants for this research study were accessed through the Nursing and Midwifery school. This school has three sites across Devon and Cornwall with 85% of its applicants coming from Cornwall, Devon, and Somerset area, with an average age being 26. Applicants tend to be from lower social economic groups, with areas scoring less than 1000 on the deprivation scale, representing the 10% most deprived areas in the UK (MoHCLG 2019). Considering the links between poor economic status, deprivation, and education. It is extremely important to understand this and its impact, preparing an appropriate curriculum delivery for pre-registration nursing programmes. Children's commission report suggested that individuals from areas of social deprivation, receiving free school meals, had a 19% increased chance compared to those children that didn't receive free meals of leaving education without reaching level 2 attainment in their assessments (Children's commission 2019)

3.2 Research Design: Methodology

A positivist, cohort study design was conducted, to test six hypotheses in relation to the predictors of nursing numeracy performance. Exploring relationships and correlations between the identified independent variables and the outcome/dependent variable.

The approach implemented a deductive top-down method analysing hypothesised relationships working from a general abstract level, towards a more specific concrete approach. The aim of the research was to establish a reliable and valid body of knowledge on predictors of numeracy performance, to allow Universities to understand the predictors. (Bowling 2009).

Appreciating the theory generated from the literature review and having personal exposure, insight and understanding of the subject area, allowed exploration of the social phenomena of mathematics and specifically its relationship to nursing numeracy (Burns and Grove 2003).

The cohort design explored the potential predictors of numeracy performance in undergraduate Nursing students, by collecting data around gender, age, field of nursing, Mathematics anxiety, mathematics qualification, current ability with general numeracy and performance in a nursing numeracy testing.

3.3 Engagement of staff:

Staff who taught year 1 pre-registration nursing at the selected University, were invited to a face-to-face meeting to discuss the content of the planned research project. Leads were encouraged to have an open discussion about the research study, along with the planned schedule of implementation into their module timetables.

Recruitment sessions were discussed, as well as sessional requirements for completion of all elements of the research process. One module lead was particularly keen and eager to incorporate this within their module time, so this module was selected for the research to be embedded in.

3.4 Population sample:

The population studied were 1st year undergraduate pre-registration nursing students, across the fields of Adult, Child, and Mental health nursing. Two campus sites selected to collect data, with recruitment sessions built into the first taught module of the nursing curriculum. The rationale being, to eliminate any potential bias towards participants gaining substantial input from the nursing programme itself and influencing their knowledge base prior to testing.

Inclusion criteria:

- The participant was aged over 18 years old at the time of enrolment in the study.
- The participant was registered on a pre-registration nursing programme (Adult, child, or mental health) at the University of Plymouth
- The participant had given signed informed consent.

Exclusion criteria:

Participants who met one or more of the following criteria were not included in the study.

- The participant was not over 18 years of age
- The participant was registered on an alternative pre-registration programme in the faculty of health
- The participant had not completed a consent form

3.5 Sampling

The study employed non-probability purposive sampling strategies, my expert knowledge of the sample and a requirement for participants to represent the typical factors of the sample, ensured that each participant met the inclusion and exclusion criteria (Parahoo 2006). This potentially exposes the study to bias, so external objective methods of assessing the typicalness of the selected participants were employed, achieved through comparative sampling to the national averages of participants within similar programmes across the United Kingdom. The sample met these national averages.

A power analysis/calculation completed demonstrated a best approximation of the required participant numbers for this research project (Rudestam and Newton 2014). Recognising that as the sample size increases, the probability of getting a deviant sample diminishes. Recruiting a large sample to the study would provide the opportunity to counterbalance atypical values (Polit and Beck 2006).

Three factors were included in the power calculation, the p level, N (sample size) and r or effect size. With the p value (alpha) set at 0.05 for all the statistical analysis of the data and using Cohen (1988) work around effect size (small effect size of 0.20 to a power of 0.90 large effect) demonstrated an increase from 5 to 95% success rate of detection of statistical significance. This study required 260 participants to meet this success rate (Cohen 1988). 286 participants were recruited to the study out of a potential 348 recruits. Therefore, the ability to detect a true difference between results and allow the ranking and indication of relative importance of individual independent variables is exposed. Gauging the size of the effect, be that small or large allowed the evaluation of the overall importance of the result and the ability to capture both statistically significant results with a small effect, as well as non-statistically significant results with a large effect (Burns 2000).

3.6 Original Instrument use, Validity, and Reliability

3.6.1 Measurement tools:

Several instruments are available to measure maths anxiety (Hunt et al 2011); American writers Richardson and Suinn (1972) led the way with the Mathematics Anxiety Rating Scale (MARS). This scale provides 98 questions, using a five-point

Likert scale to assess maths anxiety; the tool has the flexibility to be used across a range of settings. A 7-week test-retest reliability of .85 and Cronbachs alpha of .97 suggests this tool has a very good to excellent proficiency at measuring maths anxiety. Carpraro, Capraro and Henson (2001) added a further yield mean alpha of .915 and a test retest of .841, when testing the tool in 28 other studies. Suggesting a strong support of the MARS, as a reliable scale tool for measuring Maths anxiety.

There is, however, a scarcity of information and tools available to the British undergraduate to assess maths anxiety, leading to a lack of accuracy of assessment and understanding of questions when using American based tools to assess British students. Hunt et al (2011) believes that this is due to the differing population demographics in the UK and the terminology utilised within the scoring tools. Therefore, Hunt et al (2011) created the MAS-UK screening tool, an easily administrable, reliable, and valid tool used for the assessment of Maths anxiety in the British and European undergraduate student population.

The MAS-UK screening tool was adapted and created from the original United States based assessment tool MARS. It went from the original 98 items to a 23-item Maths Anxiety Screening tool. It measures three factorial elements of maths anxiety, maths evaluation anxiety, everyday social maths anxiety and Maths observation anxiety. Tested on 1,153 British undergraduate students in a typical post 1992 UK based university, a 5-point Likert scale from *not at all* to *very much* was developed. The results of administrating this tool and the descriptive power analysis between subjects measured via t tests, demonstrated all the selected items significantly had the ability to distinguish between the bottom and top quartiles of the overall scale ($p<.001$). Further subsamples established a high level of discriminatory power ($p<.001$), with a Cronbach's alpha for the overall scale being excellent ($a=.96$). Furthermore test-retest reliability was measured at excellent levels for the overall scale $r(129)=.89$ $p<.001$

Written permission was sought from the original authors to use this scale within this research project.

3.6.2 BKSB

Basic and Key Skill Builder (BKSB) functional skills criteria initial and diagnostic assessment tool was used as a screening tool to assess the current levels of numeracy ability of participants.

The BKSB Initial and diagnostic assessment is a computer-based interactive, self-marking assessment tool, it aids with the identification of the learner needs from pre-entry to level 2 in mathematics. This assessment directly correlates to the Functional Skills maths and English standards and the Core Curriculum in English and maths. This tool is widely used across the United Kingdom, mostly within Further Education (FE) settings, often used as part of an assessment for suitability for vocational and access courses (Ecclestone 2013)

The students completed the BKSB diagnostic assessment calculating a current level of ability. All students were also encouraged to complete the diagnostic assessment where the strengths and weaknesses of the student were identified within the level they are working at (BKSB, 2010). This was to encourage the student to go away and do some independent learning in these areas to improve. This data was correlated with the reported academic standard achieved by the students, prior to joining the pre-registration Nursing course.

3.6.3 Nursing numeracy test:

The Nursing numeracy test utilised a set of mental arithmetic problems that aimed to capture the four main mathematical problem-solving areas, addition, multiplication, subtraction, and division. A range of questions from simple fractions and decimal conversions; to basic drug calculations including metric conversions, (conversion tables were provided to assist the participant) and general numeracy and technical measurement. The numeracy test had two sections A and B, which equated to 100 marks being available.

Section A totalling 64 marks:

Section A	**Assessment method**	**Marks awarded**
Section one: Metric unit conversions	6 calculations worth 2 points each	12 marks in total
Section 2: Equivalent fractions, decimals, fractions, and percentages	6 boxes to complete as part of a matrix	12 Marks
Section 3: General numeracy and technical measurement	Questions on decimal places, weight and length additions and subtractions, visual pictures of measurements requiring interpretation i.e., syringes containing coloured liquid	26 marks
Section 4:	Medication Dosage Calculations	14 Marks

	Pictorial representations	

Section B:

Section 1	Transfer of numerical data to a clinical observation chart	18 Marks
Section 2	Transfer of numerical data to a fluid chart	18 Marks

The papers written in consultation with a literacy and numeracy advisor and the mathematics department at the University of Plymouth, adhering to current government and educational curriculum, as well as examination standard based, and written style questions allowed credibility and currency.

Checking the reliability and internal consistency of this exam through SPSS, achieved by testing the Cronbach's alpha coefficient, aiming for a value over .7 (DeVellis 2012). No negative values identified on checking the Inter-Item correlation matrix, indicating items are measuring the same underlying characteristics. Cronbach's Alpha is (.844) demonstrating very good internal consistency reliability for the exam assessment tool. Correlation degree with total score, suggests that all items are measuring the same things, with no low values noted. Mean inter item correlation (.679) suggests items are correlated to a greater extent and that some items may be repetitive in measuring the intended construct. Items are correlated to a greater extent and the items may be repetitive in measuring the intended construct. The paper can be found in appendix 3

A participant data sheet was compiled (appendix 4) gathering data on student identification numbers, full name, email address, age bracket, starting from 18-24 (minimum age entry into a pre-registration nursing programme is 18 years old) going up in 9-year age gaps increments to 55+. Gender identification was recorded, with exemplar answers, with field of nursing also being requested. Participants listed their mathematics qualification, along with the grade achieved prior to entry to the programme. Exemplars again provided, to ensure that the participant identified consistent methods for recording.

3.7 Ethical approval and consent

Ethical approval gained from the University of Essex and the University of Plymouth research ethics committees, ensured that the research was ethical in its approach. A participation information leaflet provided to all participants prior to them deciding if they wish to partake in the research project, this contained an outline of the project, aims and objectives, whilst clearly identifying that the participant had the right to withdraw at any time during the study which included all their data being removed from the study (see appendix 5). Participants had the consent process explained to them with a clear outline of the options to participate or not, this included the right to withdraw at any point in the research process. Participants choosing to take part in the research project signed a consent form in front of the principal researcher, which I countersigned See appendix 5. All participants were anonymised, using the student identification numbering system and through the allocation of participant numbers for completed sets of data. Only the principal researcher had access to the corresponding numbers.

Support networks with both universities occupational health departments, ensured that if required, appropriate access to support systems was in place, for any participant that identified issues related to the project.

A locked filing device secured all data collected as part of the research study, with only the principal researcher having access to this. Electronic files were password protected and destroyed in line with the data management plan submitted for ethical approval.

3.8 Data collection

Once participants had completed their consent forms, a distribution date for the Mathematics anxiety-screening tool was set.

Participants at both university sites received the screening tool as part of a teaching session. A one-hour session was allocated for this, within normal timetabled activities, ensuring no disadvantage to participant's time.

The participants received a hardcopy of the nursing numeracy exam (see appendix 3), allowing 1 hour for completion. Completion of the numeracy exam with only mental arithmetic skills and no electronic calculator allowed. Papers were personally collected and marked by principal researcher, securing these in a locked filing cabinet only accessible by the principal researcher.

3.8.1 Data entry and cleaning

Hard copies were used to record data, and then transferred to SPSS (Statistical Package for Social Sciences), version 25. Utilising a logical systematic approach to data entry and allow data cleaning and preparation, this approach reduced the risk of errors on data entry (Burns and Grove 2003). To enable accurate tracking of data sets uploaded, sets of data were stored alphabetically and all participants assigned a participation number. No identifying features of the participant were included in the data sheet. Only the principal investigator had access to the correlating assigned participant numbers to participant name. Each set of participant's results included a generic data sheet, BKSB score, MAS-UK score, and Nursing numeracy test result.

Data cleansing occurred with rigorous crosschecking of data sets to original documents, attempting to identify any errors. Missing variable results within these sets were highlighted, investigated, and corrected where necessary with final incomplete sets placed at the end of the data input sheet, so they could be easily identifiable. There were no data sets missing significantly large amounts of data and all original data was utilised in the final analysis. Appropriate coding for any missing identified data enlisted in data analysis actions.

A codebook of data prepared prior to entry of all participants' data into SPSS, helped to ensure that missing values and variable labels assigned to identify each individual variable. Each variable label then underwent group coding to allow a logical discussion and analysis of the variable's findings (Bowling 2009).

Sex was coded as binary (1 or 2) 1 male and 2 female, as no participants rated themselves as non-binary. Age into categories starting from 18-24 years (labelled 1), up in 9-year increments to the 55 plus group (labelled 5).

The participant's field of nursing identified, with value labels added from one to three for adult, child, and mental health respectively. Maths qualification and BKSB scores coded from the lowest graded qualification, to the highest, ensuring consistency of analysis.

Anxiety, exam result section A and exam result section B and exam total coded as scale variables, as all followed a numerate scale with no defined categories. All coding was checked with an independent support, discussions held in regard to ensuring all data coding being identified in the same way i.e., smallest to largest, or lowest to highest, providing equity within analysis (see appendix 7)

An edit programme within SPSS allowed identification of missing values, skips, range checks and checks for inconsistencies; this enabled the system to draw attention to any record that appeared to have an error, only identified once acceptable value boundaries were set. Identified dirty items were checked against original data collection sheets and corrected where necessary (Bowling 2009). Once the data upload was complete, visually checking for normality ensued.

Checking of ranges, means, medians and standard deviations for all numerical data occurred, including the use of bar charts and frequencies for categorical data. Histograms and distributions for each plot, allowed recognition of outliers and any skewed data. Once the data upload was complete, visual checking for normality occurred (all histograms for the study can be found in appendix 8)

3.8.2 Data analysis:

The priority was to first establish the normality of the data achieved through the inspection of histograms, looking at frequency distribution of the data and assessing the properties of the distribution of scores (Field 2016). Idealistically distributed symmetrically around the centre of all scores, identifying normal distribution characterised by the presence of a bell-shaped curve, ensuring skew and symmetry of pointiness is observed (Bowling 2009).

After visual inspection, some areas of skew and kurtosis were identified. Therefore, the variables required further testing for normality. This was achieved through statistical testing via SPSS, using Shapiro-Wilks and Kolmogorov-Smirnov tests to examine this data further. These are both non-parametric goodness to fit tests, allow a comparison of scores in the obtained sample, to a theoretically normally distributed set of data, with the same mean and standard deviation.

An insight into if a sample is normally distributed can be found by utilising the null hypothesis, that all data is normally distributed, with an alpha $p>0.05$ set.

Part of the testing process of Kolmogorov-Smirnov is the production of plots. Normality plots with tests on SPSS through descriptive statistics analysis. Normal quantile to quantile tests (Q-Q) plots, similar in nature to PP plots, but with a focus on the plotting of quantiles instead of individual data points. Allowed identification of deviations from diagonal line of normality, with kurtosis and skew monitored as well (Field 2016). The Q-Q plots had minimal data above and below the line, suggesting a level of kurtosis originally identified on visual inspection. Partial evidence of snaking around the central diagonal line offered an appreciation of slight skew.

Although tests for normality using Kolmogorov-Smirnov suggest that a sig. value of .000 a violation of the assumption of normality. Pallant (2016) suggests this is quite common within larger samples of +200. Looking at the actual distribution on the histograms and the normal probability plots (Q-Q), suggested reasonably straight lines and that the data was closely normally distributed. Any significant skews identified were accounted for, with application of national standards and appreciation of normal distributions of the variable within the current literature.

Differential analysis methods analysed the correlation between the independent and dependent variable, including the strength of these correlations. Parametric numerical data analysed with the use of unpaired and paired t tests or single/two-way ANOVA as the data dictated. Non-parametric data utilising Mann-Whitney U test, Wilcoxon's rank sum test or Kruskall-Wallis ANOVA. Categorical data will be analysed for differences with Chi-square test and fisher exact (Bowling 2009). Bivariate tests of association performed to establish the empirical relationship between variables, with the type of data being analysed defining the type of test. Focusing on Spearman's rho or Pearson's r as participate numbers are large, with partial correlations formulated, to allow testing between two variables for association with the dependent variable (Field 2016).

Regression modelling allowed development of established correlations, allowing a greater depth of analysis. Simple one-layer multiple regression allowed the assessment of the contribution of the independent variables on the dependent variable. Checking collinearity, multi collinearity and outliers with the use of Cook's distance and PP plots or QQ plots, dependent on the distribution of the data as variables within the models (Burns and Grove 2003). The establishment of the best-fit model with re-runs to refine and improve the model further (Field 2016). It was established what the contribution of each independent variable was on the dependent variable and the statistical significance of this impact. Adjusted R square value, reported F value, the degrees of freedom, p-values and standardised coefficients allowed the significance of each factor as a predictor (Burns 2000). Part correlation on how the variable uniquely correlates with the outcome variable, including how much the model would lose if you excluded this predictor, is explored (Lang and Secic 1997).

Hypothesis testing:

3.8.3 Table 1 identification of variable, type of analysis and test used.

Variables tested	**Type of analysis**	**Test used**
Maths qualification and BKSB score	Parametric, Ordinal data, bivariate correlation	Spearman's rho

Sex and Exam total	Parametric, Nominal with Scale data Compare means	Independent t test
Maths qualification and anxiety	Parametric, Ordinal and scale data Bivariate correlation	Spearman's rho
Maths qualification and Exam total	Parametric, ordinal and scale Bivariate correlation	Spearman's rho
Nursing Field and Exam Total	Parametric, nominal and scale Comparing means	ANOVA Bonferroni
Sex and Exam A, section B and total exam score all tested individually.	Parametric, Nominal with Scale data Compare means	Independent t test
Age and Exam A, Exam B, and total Exam	Parametric Ordinal and Scale Bivariate correlation	Spearman's rho
Field of Nursing and Exam A, B, and total exam	Parametric, Nominal and Scale	ANOVA Bonferroni

3.8.4 Summary and Conclusion:

The process of chapter 3 was to explain and establish the process for this research study. Allowing understanding of the data collection tools with a clear plan for data analysis.

The distribution of all the data collection tools went well, albeit from some issues with logging on to electronic platforms for completion of BKSB screening, all participants were able to complete the elements they were present at. Chapter 4 will examine the results of this study and Chapter 5 will discuss these findings and offer conclusions and recommendations for future practice.

CHAPTER 4: DATA PRESENTATION AND ANALYSIS

4.0 Introduction

The purpose of this study was to determine the predictors of numeracy performance among nursing students at a higher education institution. Data collected measured the participant's current numeracy ability, using a Numeracy diagnostic programme BKSB, Maths anxiety levels measured with a 23-item MAS-UK Mathematics anxiety-screening tool, measuring three factorial elements of maths anxiety maths evaluation anxiety, everyday/social maths anxiety and maths observation anxiety (Hunt et al 2011). A two-section nursing numeracy exam, examining a range of questions from simple fractions and decimal conversions to basic drug calculations, including metric conversions, general numeracy, and technical measurements, to assess nursing numeracy.

Chapter four presents the results of these investigations, testing the six-hypothesis stated in Chapter 3. Identifying which predictors have the strongest relationship with numeracy performance in the nursing numeracy exam.

4.1 Presentation of data

Throughout this results chapter and discussion chapter, all numerical data are rounded to two decimal places, representing a reasonable level of precision, given the variables measured. For the standardised beta values there will be no zero before the decimal point, being that beta should not exceed one, but for all other values, the Zero will be present. Exact P values will be reported, with footnotes presented by asterisk to denote the significance of the variable.

4.2 Sample Characteristics

The pre-registration nursing population of 2018/19 HEI in the Southwest of England consisted of 348 individuals. Of the 348 students enrolled, 286 participants completed an approved consent form, overall response rate of 82%.

Table 2 includes total participants by gender, 266 females (93%) and 20 males (7%). Although on initial visual inspection and analysis of distribution of this variable, there may be concerns regarding negative skew and leptokurtic kurtosis, it is typical of the national picture of recruitment on pre-registration programmes in the United Kingdom.

Nationally around 8-10% of applicants into nursing identify as male, so 90-92% identifying as female (RCN 2020). Demonstrating an appropriate equity in proportional representation of this sample group.

4.2.1 Table 2: Participants gender identification

Gender	N=	%
Male	20	7
Female	266	93

The age distribution of the participants displayed in table 3, identified most participants were aged between 18-24(n=180 (62.9%). Participants in the 45 to 54 years old category were least well represented (n=7 (2.4%). Again, on inspection of data, an apparent positive skew towards the younger categories is evident (platykurtic distribution sk1.433, Kurtosis 1.372), however the average age of the pre-registration nursing population is 29 years (RCN 2020), this correlates with the mean age of 29 across this study, offering a good representation of the national average and normal expected distribution of the variable.

4.2.2 Table 3: Age of participants in categories

Age category	**N=**	**%**
18-24	**180**	**63.2**
25-34	**72**	**25.3**
35-44	**26**	**9.1**
45-54	**7**	**2.5**
Missing	**1**	**.3**
Total	**286**	**100**

The participant numbers for each field of nursing displayed in table 4 are comparative to national and normal distribution of uptakes for each field of the University in question. The HEI in the Southwest offers around 393 places every year, approximately 282 places in Adult nursing (72%) of the overall total places, with 71 mental health (18%) and 40 child health places (10%). Nationally 77.1% of pre-registration places allocated to adult nurses, 7.4% children's and 13% mental health, the remainder are learning disabilities places (RCN 2018).

4.2.3 Table 4: Field of nursing

Field of Nursing	N=	%
Adult	210	73.4
Child	51	17.8
Mental Health	25	8.7
Total	286	100

Some positive skew was identified on inspection of the distribution for field of nursing (1.356) along with some leptokurtic kurtosis (1.259). Distribution towards the adult field of nursing it noted, but this is representational with the national picture.

284 of the participants completed their Maths qualifications on the participant data sheet (see table 5). With an entry requirement set by the HEI of a GCSE C/4 in mathematics, it was not unexpected that the largest percentage of qualifications were at this grade (147, 51.4%)

Evidence of some positive skew towards the lower end of the qualification range, with a mean of (2.84 SD 1.183), code 2 being GCSE grade D/E (2/3) and code 3 being GCSE C/4. Kurtosis (2.920), again within range, suggests some positive leptokurtic distribution, spiking at code 3, GCSE C/4. This is in line with the national average mathematics qualification entry required for pre-registration nursing. Only 13 of the 284 participants had an AS or A level mathematics qualification accounting for just 4.5% of this studies total sample.

4.2.4 Table 5: Mathematics qualifications of participants

Qualification	N=	%
Functional skills	25	8.7
GCSE D/E	76	26.6
GCSE C	147	51.4
GCSE B	14	4.9

GCSE A	4	1.4
AS/A LEVEL	13	4.5
Other outside of England or the UK	5	1.7
Missing data	2	.7
Total	286	100

BKSB screening tool results (table 6) were slightly positively skewed (.164) with a negative platykurtic kurtosis (-.893); however, these were within acceptable ranges (-0.8 to 0.8 for skewness and -3.0 to 3.0 for kurtosis (Field 2016). A mean score of 2.78 suggesting that candidates attained the lower end of the range of marks of academic accreditations for the numeracy grade, in comparison to their substantiated qualification on entry to the programme. Most attained the equivalent of a GCSE D/E (2/3), N=116 out of a possible 257 results, 72% of participants attaining these grades.

4.2.5 Table 6: Participants BKSB screening tool results

Assessed BKSB level	N=	%
Pre-Entry/Entry level 2	5	1.7
Entry level 3	98	34.3
Level 1	103	36.0
Level 2	51	17.8
Missing	29	10.1
Total	286	100

An inspection of the histogram distribution for Maths anxiety screening tool scores again suggested a slight positive skew and kurtosis (sk .628 kurtosis .231) with a mean 53.6 and median of 53. Participants could score between 23 and 115, so a mid-point scale would be around 57.5. The mean is very near that mid-point, but scores were widely distributed and varied.

Exam results section A (covering section A of the numeracy exam measuring numerical ability), offers a bimodal model with negligible negative skewness and kurtosis (sk -.364 kurtosis -.837). Section A exam mean score 45.921 and a median of 46 from a possible 64 marks (SD 18.166), offering a wide distribution of marks that migrated towards the upper range of marks available. However, Section B exam results offer a negative skew (-1.679), with positive leptokurtic distribution (3.60). Some outliers identified could possibly be an anomaly due to students not completing this section of the exam adequately, or not at all, avoidance strategies are common within high pressure exam conditions, and this could have been the probable cause for non-completion (Preis and Biggs 2001). To account for this, case wise within three standard deviations of the mean, were utilised during analysis. Allowing the capture of 99.7% of data, meeting the empirical rules of statistical analysis for normal distribution. A mean of 28.36 out of a possible 34 marks suggests again that students did well in attaining high scores.

Total score offers a negative skew in acceptable range (-.656) and positive kurtosis of (.135) suggesting overall results were towards the higher end of the mark range, marks were clustered around a central point however, with mean scores of 74.28 and a median of 75 out of a possible 100 marks.

4.3 Presentation of Results: Hypothesis 1

There will be a positive relationship between the participants' mathematical qualification and the result achieved in the numeracy-screening assessment tool (BKSB).

A Spearman's rank-order correlation ran to determine the relationship between mathematics qualification and BKSB screening score (table 7). Preliminary analyses performed ensured no violation of assumptions of normality, linearity, and homoscedasticity. There was a very small *rho* positive non-significant correlation between the variables, with a negligible strength to this relationship noted,13% coefficient of determination-shared variance (rho=.036 n=256) p=.569. Therefore, the hypothesis is rejected, and participants original numeracy qualification had no significant effect on numeracy screening tool results (BKSB).

4.3.1 Table 7: Spearman's Rho statistic correlation between mathematics qualification and BKSB screening tool N=256

Correlations

	Mathematics qualification	**BKSB Screening score**

Mathematics qualification	Correlation Coefficient	1	.036
	Sig (2-tailed		.569
BKSB screening score	Correlation Coefficient	.036	1
	Sig (2-tailed)	.569	

However, exploration of the relationship between mathematical grade on entry to the programme by individual group data, identified GCSE C/4 group scored the lowest mean at (2.59 CI 2.46 to 2.71) with students only attaining a level entry 3 or level 1, equivalent of a GCSE D-E or below. A level students achieved the highest mean score of (3.62 CI 3.31 to 3.92) moving very close to the level 2 BKSB score GCSE A-C. A and B grade students scored equitably, at (3.07 and 3.00) respectively, level 1 GCSE mathematics ability grade D to E.

ANOVA demonstrated a significant p value at (P=.000) with a large F value (4.858), eta squared 0.10 medium to large effect (Table 8)

4.3.2 Table 8: One-Way Analysis of Variance Summary Table Comparing individual grade categories with Total numeracy grade.

Total Grade

	SS	DF	MS	F	Sig.
Between groups	16.38	6	2.73	4.858	.000

Within Groups	**139.93**	**249**	**.562**
Total	**156.31**	**255**	

So, whilst there was no significant effect of maths qualification on over all BKSB assessment score, there were significant relationships between the entry mathematical qualification and the current level of numeracy ability. These were noted to be lower in all groups analysed.

4.4 Presentation of Result: Hypothesis 2

There will be a relationship between gender and nursing numeracy test score, with males outperforming females.

An independent t-test ran compared Total exam scores (Exam T) for Sex (males and females). No significant difference in scores for males and females were identified. Males (M=78.40, SD=16.96) and females (M=74.00, SD=14.34). Applying Levene's test (.255) suggested equal variances being assumed, with no significant differences between the groups and variances are indeed equal (t (241) = 1.137, p=0.257 two tailed). The magnitude of the differences in the means (mean difference=4.935, 95% CI -3.22 to 12.01) was very small (eta squared= .005) so .5% of the variance in total exam score is explained by sex. Therefore, males did not outperform females in the total exam score.

4.4.1 Table 9 Independent t test between sex and total exam score

Total exam score (Exam T)	Mean	SD	Sig. (2-tailed)
Males	78.4	16.96	.257
Females	74.00	14.34	.257
Levenes equal variances assumed No significant differences between groups and variances are equal (t (241)=1.137 P=0.257 Mean difference =4.935 (95% CI -3.22 to 12.01) Very small eta squared=0.05			

Further analysis of the impact of sex on other variables (section A and B of the exam and not total score) (table 9), identified that section A (the calculation element of the exam), demonstrated statistically significant differences between identified sex performance. Males (M=51.9, SD=11.93) scored better than females (M=45.53, SD=10.84) t (241) =2.204, p=.028 (equal variances assumed), with the magnitude of differences in means (mean differences=6.407, 95% CI .679 to 12.134). Eta squared effect is small at .0197, so accounting for 1.97% of the variance in section A exam results explained by sex, males did statistically significantly better in section A of the numeracy test, but this gain was only small.

Section B of the Exam demonstrated no statistically significant difference in scores for males and females. Males (M=26.47.40, SD=9.48) and females (M=28.49, SD=5.73) Levene's test .007 directed towards equal variances not being assumed and identified no significant differences between the groups (t (14.68) =-.861, p=0.428 two tailed)

Overall, the hypothesis is rejected, as there is no statistical significance between overall total exam results, but it is worthy to note the separate element of section A (the calculations element of the exam) did surmount to a significant result.

4.4.2 Table 10: Independent t-test statistics between sex and section A and section B exam results

Section	F	Sig.	T	Df	Sig. (2-tailed)
Section A	.026	.872	2.21	241	.028
Section B	7.44	.007	-.816	14.68	.428

4.5 Presentation of result: Hypothesis 3

There will be a positive relationship between mathematical qualification and anxiety score on the Mathematical Attitude Scale (MAS-UK), with individuals who hold a higher mathematical qualification experiencing less anxiety.

A Spearman's rank-order correlation (table 10) ran to determine the relationship between mathematics qualification and MAS-UK Anxiety score. No violation of assumptions of normality, linearity and homoscedasticity were noted. There was a small positive non-significant correlation between mathematics qualification and anxiety scores (Rho=.050, n=284 maths and 282 Anxiety) P=.407). Therefore, the type of qualification you have has a negligible impact and non-significant effect on mathematics anxiety score.

4.5.1 Table 11: Spearman's Rho statistic correlation between mathematics qualification and Anxiety score N=282

Correlations

		Mathematics qualification	**Anxiety score**
Mathematics qualification	Correlation Coefficient	1	.050
	Sig (2-tailed		.407
Anxiety Score	Correlation Coefficient	.050	1
	Sig (2-tailed)	.407	

4.6 Presentation of Result: Hypothesis 4

There will be a positive relationship between mathematical qualification and nursing numeracy test score.

A Spearman's rank-order correlation (table 11) was used to explore the relationship between mathematics qualification and Total Grade achieved in the nursing numeracy exam. Preliminary analyses performed ensured no violation of assumptions of normality, linearity, and homoscedasticity. There was no correlation between mathematics qualification and the total grade achieved in the nursing numeracy test (Rho=-.098, n=284 maths qualification n=243 p=.127). Suggesting that the type of mathematics qualification the participant had on entry to the programme had no statistically significant effect on the total grade achieved in the nursing numeracy test.

4.6.1 Table 12: Spearman's Rho statistic correlation between mathematics qualification and Total Grade N=243

Correlations

		Mathematics qualification	Total Grade
Mathematics qualification	Correlation Coefficient	1	-.098
	Sig (2-tailed		.127
Total Score	Correlation Coefficient	-.098	1
	Sig (2-tailed)	.127	

There was however a significant difference between grades when comparing total exam scores (table 12), with those attaining the lower grade mathematical qualifications (Mean score of 80.61 for functional skills level 1/2 and GCSE D/E 77.25), and the higher end A level mathematics (AS/A Level= 86.18), with the prerequisite entry requirement participants of a grade C/4 mean (69.87).

Other grade band achieved mean scores of GCSE B= (74.86), GCSE A= (83.75), , qualifications gained outside the UK deemed to be equivalent to GCSE's= (74.80).

A statistically significant ANOVA result (p=.000) with a large F value 5.005, eta squared large effect 0.11. Suggested there was a significant difference between mathematical qualification groups. Especially noted was the difference between students who had attained a grade C/4 pre-entry requirement and students that had functional skills or grade D/E qualifications. With functional skills and Grade D/E students scoring higher marks than their peers with C/4 grades (FS 10.74, P=.016 D/E 3 7.39 P=0.12).

So, whilst the hypothesis is rejected that there is no overall effect of mathematics qualification on total exam score, it is relevant to appreciate the significant difference between attainments of total exam score across the mathematics grade groups.

4.6.2 Table 13: One-Way Analysis of Variance Summary Table Comparing individual grade categories with Total numeracy grade.

Total Grade

	SS	DF	MS	F	Sig.
Between groups	5755.61	6	959.27	5.005	.000

Within Groups	45232.91	236	191.671
Total	50988.53	242	

4.7 Presentation of Result: Hypothesis 5

There will be a positive correlation between numeracy-screening assessment tool (BKSB) and the nursing numeracy test score.

Current numeracy ability assessed by BKSB screening tool, demonstrated a positive Pearson's correlation with higher BKSB scores achieving higher Nursing numeracy total exam scores (Pearson's=.412 (to a sig level two tailed of 0.01) P=.000) (table 13).

4.7.1 Table 14: Pearson's correlation statistic between BKSB screening score and Total Grade N=257

Correlations

	BKSB Screening score	Total Grade

BKSB Screening score	Correlation Coefficient	1	.412**
	Sig (2-tailed		.000
Total Score	Correlation Coefficient	.412**	1
	Sig (2-tailed)	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

Therefore, the hypothesis that current numeracy ability assessment (BKSB score), will have a positive effect on total score for the nursing numeracy exam is accepted.

4.8 Presentation of Results: Hypothesis 6

There will be a negative correlation between the MAS-UK and nursing numeracy test score, with individuals experiencing high levels of anxiety performing less well in the nursing numeracy test.

A Pearson product-moment correlation coefficient was undertaken to assess the relationship between the score of MAS-UK anxiety scores with section A, section B and Total exam score (table 14). There was a negative and statistically significant correlation on section A, B, and total exam scores with anxiety (Section A, r=-.362, p=.000, Section B r=-.150, p=.020, Total grade r=-.337, p=.000). Suggesting increased anxiety levels leads to lower mark attainment in all sections of the nursing numeracy exam.

Identifying that maths anxiety scores were significantly impacting on the attainment within the sections of the exam, with the most impact occurring in section A (calculation element) of the exam.

4.8.1 Table 15: A Pearson product-moment correlation coefficient ran to assess the relationship between the score of MAS-UK anxiety scores with section A, section B and Total exam score .N=241

Correlations

		Anxiety score	Section A	Section B	Total Grade
MAS-UK Anxiety score	Pearson's Correlation	1	-.362**	-.150*	-.337**
	Sig (2-tailed		.000	.020	.000
	N	284	241	241	241

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Amongst mathematical qualification groups, A level students were the least anxious (41.23 CI 31.85 to 50.63) and GCSE A Grade students the most anxious (61.25 CI 11.04 to 111.46). Remaining groups' mean anxiety scores, Functional skills level 1/2 mean (45.84 CI 38.59 to 53.09), GCSE D/E (53.18, 95% CI 48.77 to 57.59), GCSE C (57.24 CI 54.41 to 60.08). Grade B students (52.57 CI 44.58 to 60.56).

ANOVA suggested statistical significance at (P=.003) eta squared medium effect (.06)

4.8.2 Multiple regression:

Standard multiple linear regression allowed simultaneous entry of predictors into a model, allowing recognition of predictive power of the individual variables. With establishment of the individual variables' ability over and above that offered by all the other independent variables, to affect the outcome variable.

Assessment of multicollinearity established a relationship between the independent and dependent variable, with scale and categorical variables, Maths qualification and anxiety score, correlating substantially to the Numeracy exam total dependent variable (.412, -.337). There are no bivariate correlations of .7 or more, so all variables were retained in the model.

Collinearity diagnostics were inspected, including tolerance and Variance Inflation Factor (VIF) which established variability of specified independent variables that was not explained by other independent variables in the model. Tolerance levels for all independent variables were above 0.10 for this model, with VIF (inverse of tolerance value) values being below 10, all values around 1.0 showed no evidence of multicollinearity identified in this model. Therefore, there is confidence of no correlation between independent variables in this regression model and the fit of the model is good. Allowing the clear identification of which independent variable provides the main predictor value of numeracy performance in pre-registration nurses.

Outliers, normality, linearity, homoscedasticity, and independence of residuals achieved through the inspection of the Normal Probability Plot (P-P) of the Regression Standardised Residual and scatterplots, suggested no issues. On the normal P-P plot for this model all points were reasonably straight along the diagonal line, showing no major deviations from normality. The scatterplot of standardised residuals offered a roughly rectangular distribution shape, scores centred around point 0 and there were no violations of assumptions (appendix 8)

As each predictor contained a minimum of 243 cases, the findings can be generalised to the wider student population with some confidence (Field 2016). Regression Model (table 15) summary and R squared (.239) identified a medium to large effect of the independent variables on the dependent variable (Cohen 1988). 23.9% of the regression model (predictor variables) explained the variance in the dependent variable, total Exam score. ANOVA statistical significance tested the null hypothesis that multiple R in the populations equals 0 if the model is having a negligible effect. This regression model reaches statistical significance sig. =.000 or p<.0005, so rejection of the null hypothesis and recognition of the standard linear regression models' significant contribution, with an F value of 11.92, suggests a very large effect.

The study of coefficients evaluated each independent variable's contribution to the prediction of the dependent variable (Total exam score). Beta coefficient for BKSB identifies a unique positive contribution of BKSB dependent variable on exam total. A significant finding identified that achieving higher marks in the BKSB screening led to better achievement in the nursing numeracy exam, with a statistically significant p value (β=.361), (t(228)=5.96, p=.000) with 1 category higher in the BKSB screening tool, equating to a rise of 6.68 marks in the total exam score (B=6.68, 95%CI=4.48 to 8.89). Maths anxiety Beta coefficient score of (β=-.254) suggests that Maths anxiety has a negative impact on the exam total (t(288)=-4.17, p=.000), so more anxious students attained a lower mark in the nursing numeracy exam, with each point higher in the anxiety score resulting in a decrease of .203 mark in the total exam score (B=-.203, 95%CI=-.299 to -.107). Part correlations coefficients identifies that BKSB scores are contributing a partial correlation (.345) with an 11.9% (.345 squared) total contribution to R squared. Maths anxiety contributing 5.8% (-.241) to R squared and unique contribution to the explanation of variance in total exams scores.

No significant contribution to the prediction of nursing numeracy totals was made by Gender, age, nursing field and mathematics qualification with small beta values (β=-.029, .076, -.040, -.057 respectively).

4.8.3 Table 16: Multiple regression model

Model summary:

R	**R squared**	**Adjusted R squared**	**Standard error of the estimate**
4.89a	*.239*	.219	12.83

a. Predictors: (Constant), Anxiety scoring tool, Mathematics qualification, Nursing Branch, Gender identified, Age, BKSB screening score

b. Dependent Variable: Total Grade

Total Grade

	SS	DF	MS	F	Sig.
Regression	16.38	6	1962.43	11.92	.000b
Residual	**37528.36**	**228**	**164.59**		
Total	**49302.96**	**234**			

a. Dependent Variable: Total Grade

b. Predictors: (Constant), Anxiety scoring tool, Mathematics qualification, Nursing Branch, Gender identified, Age, BKSB screening score

	Beta	t	Sig,
(Constant)		8.733	.000
Gender identified	-.029	-.494	.622
Age	.076	1.287	.200
Nursing Branch	-.040	-.677	.499
Mathematics qualification	-.057	-.974	.331
BKSB screening score	.360	5.963	.000
Anxiety scoring tool	-.254	-4.171	.000

4.8.4 Supplementary findings

Through collation of student data and exploration in SPSS, other inter relationships between variables ensued. Differences between male and females' maths qualifications, genders influence on maths anxiety, field of nursing registration and total scores achieved in the final nursing numeracy exam, were further explored.

Analysing sex influence on total exam scores, led to further exploration of other potentially impacting factors. Participants' maths qualification on entry to the programme identified mean qualifications for males of (2.55), and females (2.86), congregating in the same brackets for average qualification between a GCSE D/3 towards a C/4. Independent t-test (table 16) suggested a negative but non-statistically significant correlation between maths qualifications and sex. (t (282) =-1.14, P= .254). Therefore, when recruiting students to pre-registration nursing programmes admissions tutors do not need to take into consideration the sex of the applicant when examining the mathematical qualification.

4.8.5 Table 17: Independent t-test statistics between sex and mathematical qualification

Section	F	Sig.	T	Df	Sig. (2-tailed)
Mathematics qualification	.478	.491	-1.14	282	.254

This was also the case with fields of nursing; Spearman's Rho demonstrating a positive non-statistically significant relationship or difference in means between attainments levels of maths qualification, on entry to the programme. Adult mean=2.88 (CI=2.71-3.04), Child=2.69 (CI 2.38-2.99), Mental health=2.89 (CI 2.38 TO 3.38) (Sig. 587). Age appeared to make no statistically significant impact on mathematical qualification gained prior to entry to the programme (table 18). With Spearman's Rho calculating only a very small positive coefficient and statistically non-significant p value (.009 p=.880).

4.8.6 Table 18: Spearman's Rho statistic correlation between mathematics

qualification and Age N=284

Correlations

		Age	Maths qualification
Age	Correlation Coefficient	1	.009
	Sig (2-tailed		.880
Total Score	Correlation Coefficient	.009	1
	Sig (2-tailed)	.880	

Following no statistically significant results of gender on the total score, but statistically significant data on the gender and section A of the exam results, exploration into the impact of participant's field of nursing on exam results, directed by the differences in mean for the total exam (table 19)

Mean scores across fields of nursing suggested child health students gained the highest mark range at (79.47, SD 10.89), Adult students (73.63 SD 14.30) and mental health students (68.35, SD 19.97). Statistically significant (ANOVA .008) F value of 4.87 suggested rejection of the null hypothesis no effect between fields of nursing on total exam. Bonferroni identified negative statistical significance in means between adult and child mean (-5.28) (CI -11.58 to -.897) p=.045, but no statistically significant difference between adult and mental health (mean difference 5.279, (CI -2.84 to 13.40) p=.356. As expected, after identifying mental health as the lowest mean there is a negative statistically significant correlation difference between mental health and child mean difference -11.12 (CI -20.37 to -1.86) p=.012

4.8.7 Table 19: One-Way Analysis of Variance Summary Table Comparing field of nursing and Total numeracy grade N=242

Total Grade

	SS	DF	MS	F	Sig.
Between groups	**1989.25**	**2**	**994.62**	**4.872**	**.008**
Within Groups	**48999.28**	**240**	**204.16**		
Total	**50988.53**	**242**			

Bonfferoni Total Grade:

Field of Nursing	Field of Nursing	MD	Std. error	Sig.
Adult	Child	-5.84*	2.38	.045
	Mental health	5.28	3.37	.356

Child	Adult	5.84	2.38	.045
	Mental Health	11.12	3.84	.012
Mental Health	Adult	-5.28	3.37	.356
	Child	11.12	3.84	.012

*. The mean difference is significant at the 0.05 level.

Non-statistically significant positive correlation between gender on BKSB test scores between males and females, Males (M=2.8, SD=.941) and females (M=2.78, SD=.77285), equal variances assumed (t (255) =.111, p=0.912 two tailed). Suggesting students scored between a level entry 3 and level 1 in the BKSB screening tool. Age also played no significant relationship to BKSB result, with a small negative correlation coefficient (-.075), non-statistically significant correlation (P=.234) (table 18).

4.8.8 Table 20: Spearman's Rho statistic correlation between Age and BKSB N=257

Correlations

		Age	BKSB
Age	**Correlation Coefficient**	**1**	**-.075**
	Sig (2-tailed		**.234**
BKSB	**Correlation Coefficient**	**-.075**	**1**
	Sig (2-tailed)	**.234**	

Age did however affect anxiety score (table 19), Spearman's rho suggesting a positive correlation coefficient and statistically significant effect (.156, p=.009) n=283 eta squared 0.04). With 45- to 54-year-old scoring lowest for anxiety levels (Mean=48.29, CI 32.33-64.24) and highest anxiety group aged 25 to 34 (Mean=59.58, CI 54.91-64.25)

4.8.9 Table 21: Spearman's Rho statistic correlation between age and anxiety scoring tool N=283

Correlations

		Age	Anxiety score

Age	**Correlation Coefficient**	**1**	**.156****
	Sig (2-tailed		**.009**
Anxiety scoring tool	**Correlation Coefficient**	**.156****	**1**
	Sig (2-tailed)	**.009**	

**. Correlation is significant at the 0.01 level (2-tailed).

Interestingly on further exploration of gender and maths anxiety (table 20), males were less anxious than females. Males (M=44.37, SD 13.64), females (M=54.65, SD 18.27).

The difference in these means was statistically significant, (ANOVA .017) with a high F value of (5.77), therefore the null hypothesis rejected. Tests for homogeneity identifies no violation of assumptions with sig. being (.163 and .190) for mean and median. Despite reaching statistical significance, the actual difference in mean scores between male and females was quite small with effect size eta squared .02.

4.9 Table 22: One-Way Analysis of Variance Summary Table Comparing gender and anxiety screening tool score N=283

Anxiety screening tool

	SS	**DF**	**MS**	**F**	**Sig.**
Between groups	**1872.42**	**1**	**1872.42**	**5.77**	**.017**

Within Groups	**91519.08**	**282**	**204.16**		
Total	**93391.49**	**283**			

Field of Nursing and anxiety scores mean scores (table 21) for adults (54.92), child (52.53) and mental health (48.88), demonstrating small differences between scores and fields. ANOVA statistically insignificant result (.241), low F value of 1.429 suggests acceptance of the null hypothesis, field of nursing has no significant effect on the levels of anxiety experienced; eta squared very small effect (.01).

4.9.1 Table 23: One-Way Analysis of Variance Summary Table Comparing field of nursing and Anxiety screening tool N=283

Anxiety screening tool

	SS	**DF**	**MS**	**F**	**Sig.**
Between groups	**940.54**	**2**	**470.27**	**1.429**	**.241**
Within Groups	**92450.96**	**281**	**329.01**		

Total		
	93391.49	**283**

4.9.2 Summary:

Hypothesis 1 stated there would be a positive relationship between the participants' original numeracy qualification and the result they achieve in the numeracy-screening tool BKSB. The results showed that participants in fact only had a very small negligible positive increase in scores in the BKSB screening tool. This was not statistically significant, so the hypothesis that there would be a positive relationship between these two variables rejected. Although an appreciation and understanding that 13% variance of the BKSB result predicted was from the original mathematics qualification on entry to the programme. Supplementary evidence also found no statistically significant relationships between both gender and field of nursing to the level of maths qualification achieved prior to entry into the nursing pre-registration programme. Significantly multiple regression identified positive BKSB scores contributed 11.9% of the total contribution to R squared, suggesting that current numeracy ability plays a significant part in a pre-registration nurse's ability, to complete nursing numeracy. Interestingly though age and gender appear to make no statistically significant effect on BKSB current numeracy levels assessment ability.

Age, gender, and numeracy qualifications have no statistically significant impact on current numeracy screening BKSB scores. However overall BKSB score makes a 11.9% contribution to the predictor of numeracy performance.

Hypothesis 2 suggested males would perform better in the numeracy test outcome (Exam T). Results suggested that this was not the case for the total exam, with a non-statistical p value identified and only a .5% of the variance explained by this variable.

Supplementary exploration of the two sections of the exam, discovered that males outperformed females in section A, with Section A designed to assess mental arithmetic problems including addition, multiplication, subtraction, and division. Questions involved simple fractions, decimal conversions, and basic drug calculations, including metric conversions. Eta squared effect was small at .0197, so accounting for 1.97% of the variance in section A exam results being explained by gender (sex). Males did statistically better in section A of the numeracy test, but this gain was only small, the original hypothesis that males would perform better in the total exam score rejected, however an appreciation that this was not the case for individual sections of the exam.

Gender did not impact on over all exam totals, but there was some increased performance for males in the mental arithmetic section of the examination.

Further supplementary exploration of the fields of nursing and their results in the total exam score, suggested that child health nurses performed the best with adult nursing students and mental health student's 2nd and 3rd respectively. P values demonstrated statistical significance between adult and child, with child scoring higher marks in the exam than adult students and mental health. However, no statistical significance between scores is noted between adult and mental health students.

Field of Nursing affected overall performance in the numeracy exam with Child field nurses performing best in exam totals.

Hypothesis 3, the higher the mathematical qualification at the start of the pre-registration programme, the less anxious participants will score on the Mathematics Anxiety Scale.

A very small positive correlation, but non statistically significant relationship between mathematical qualification and maths anxiety score, suggested the better the mathematics qualification the lower the anxiety score, however this was so marginal it was not significant, so the hypothesis is rejected. Further exploration of the effects of gender on anxiety scores, however, suggested females scored statistically significantly higher in the anxiety-screening tool, but this was a small effect .02

Mathematics qualifications of pre-registration nursing students does not affect their maths anxiety score, but identifying as female does.

Hypothesis 4: The higher the mathematical qualification on entry to the programme the better the achievement grade in the nursing numeracy test. A small negative correlation between mathematics qualification and the total grade achieved in the nursing numeracy test was noted, this was not a statistically significant relationship, leading to the rejection of the hypothesis. Equitable standards of mathematical qualifications between males and females in the study were noted. However, child health nurses attained the best overall grades.

Mathematics qualifications on entry to a pre-registration programme have no impact on the success in nursing numeracy examinations.

Hypothesis 5: There will be a positive correlation between numeracy-screening assessment tool (BKSB) and the nursing numeracy test score.

Current numeracy ability assessed by BKSB screening tool, demonstrated a positive Pearson's correlation suggesting that higher BKSB scores achieved higher Nursing numeracy total exam scores**.**

Current numerical ability has an impact on Nursing numeracy exam performance.

Hypothesis 6: The MAS-UK score will have a direct impact on the overall total of the numeracy exam with higher MAS-UK scores doing poorly in the nursing numeracy exam. There was a statistically significant negative effect of scoring high maths anxiety levels on the numeracy exam total score, section A and section B. Part correlations for maths anxiety contributing 5.8% to R squared of variance in total exams scores.

Experiencing maths anxiety will impact on achievement in nursing numeracy examinations.

The impact of these findings in correlation with current literature will be explored in the next chapter.

CHAPTER 5: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

5.0 Introduction

The aim of the study was to compare demographic and educational indicators including, Age, Gender, mathematics qualification, mathematics grade on entry to a pre-registration nursing programme, current mathematical ability (assessed using

BKSB diagnostic assessment tool) and Mathematical Anxiety (Mathematical Anxiety Scale MAS-UK) to predict nursing numeracy performance.

BKSB diagnostic assessment and Mathematics Anxiety Scale scores were the strongest predictors of nursing numeracy performance. Participants who scored higher on their BKSB diagnostic assessment performed better in the numeracy exam, and those scoring higher in the anxiety score scored lower in the nursing numeracy exam. An individual's mathematics qualification on entry to the programme did not show a statistically significant impact on the overall nursing numeracy exam performance.

5.1 Gained verses current ability in mathematics: impacting factors.

Participants' mathematics qualification showed no statistically significant impact on their current numeracy screening BKSB scores. However overall BKSB score made a 11.9% contribution to the predictor of numeracy performance in the final exam total, signifying the importance and impact of current numeracy ability of the individuals and their aptitude to succeed in nursing numeracy related testing. The negligible, statistically insignificant positive correlation noted between the two variables, brings into question the value and emphasis placed on mathematics qualifications as an entry criterion for pre-registration nursing programmes. The findings of this study indicate the that these qualifications may not be a useful measure or proxy of current numeracy ability. This accords with the findings of other studies, including Hutton's (1998) work, that identified no statistically significant impact or effect of mathematical qualifications on entry to the programme, to current mathematical ability. McDonald et al (2013), theorises in discussion of their participants' performance in fundamental numeracy assessment, that participants possessing a GCSE grade A or B, scored higher mark ranges in their numeracy assessment. However, if the participant possessed a grade C or D, this was associated with lower scores in the fundamentals assessment. When undertaking t-test analysis, the possession of this GCSE did not make a statistically significant difference in the student's fundamental numeracy assessment results overall, aligning with this study's results.

An entry qualification of GCSE grade C, obtained by 51.4% of the participants in this study, aligns with the national average entry qualification for pre-registration nursing (Harvey et al 2010). However, 36% of participants on BKSB Numeracy assessment scored an equivalent level 1 qualification, interpreted into the equivalent of GCSE D/E, below the entry standard for the programme. Only 17.8% attained a level 2 (GCSE A* to C) equivalent score in the BKSB Numeracy assessment, the level required to gain entry to the programme.

Hilton (1999), Weeks et al (2013), Hutton (1997), McDonald (2013) and this research study support the idea that reliance upon a student's possession of a GCSE grade C is not sufficient alone to ensure that pre-registration nursing students have developed the necessary numeracy skills to solve essential numerical problems for professional practice.

Consequentially, this information can impact on the understanding of the student's numerical ability when entering a nursing programme. Assumptions are made around students' ability to complete numeracy elements of pre-registration programmes, with a programme's numeracy entry requirements used as a proxy for competence, that the findings of this and other studies suggest may be a risky assumption. Hilton (1999) warns of the risk of placing to much respect and assumption around the attained numeracy grades, required for entry into pre-registration programmes, suggesting that assumptions student nurses are competent at arithmetic, because of the grades they have achieved is hazardous. Schools of nursing stipulating academic grades as a minimum requirement for entry to their programme, could also exclude competent individuals. Therefore, having an accurate and current assessment of their ability would provide a considerably accurate assessment of their current mathematical ability.

Implementation of a diagnostic screening assessment tool for all nursing students on entry to pre-registration nursing programmes, is shown to be a stronger predictor of performance and may, therefore, be more useful to educators wishing to identify needs across a cohort, allowing targeted and individualised numeracy intervention to nursing students. This study's multiple regression analysis identifies a 11.9% contribution of current mathematical ability to total exam scores.

Hutton (1998) identified that students entering pre-registration nursing courses with a mathematics qualification higher than the minimum C grade (the recommended prerequisite), performed significantly better in a devised nursing numeracy test. However, it was noted that there was no significant difference in performance in the test with those that did obtain the minimum requirement or below, this is in line with the average mean of a GCSE C/4 of the participants in this research study.

This study assessed current numeracy ability with the use of a BKSB screening tool, demonstrating a positive correlation between higher screening tool scores and the total grade achieved in the nursing numeracy test. When assessing the differences between the entry qualification recorded and the current ability of the student in this study, it was noted again, that the GCSE C group scored the lowest mean in the current numeracy ability tool, achieving level entry 3 or level 1 scores, equivalent of a GCSE D-E or below. As would be expected, A level students achieved the highest mean score moving very close to the level 2 BKSB accreditation, an ability of GCSE A-C, but again appeared to lack the replication of their acquired qualification.

Further analysis of individual grade groups performance in the nursing numeracy test, suggested large effect statistically significant differences, between those that attained the lower end of the grade mark (D/E GCSE) or functional skills and the higher end A level mathematics, in comparison to those that scored the standardised prerequisite entry requirement of a grade C/4. McDonald et al (2013) had similar findings when exploring mean scores of a Fundamental Numeracy Assessment (FNA), mapped against GCSE mathematics or no GCSE in mathematics respectively. Possession of an A or B grade gained a slight advantage, as also demonstrated in this research study. Participants with other qualifications gained as opposed to GCSE, such as access courses also did slightly better in mean FNA scores than C grade GCSE students.

T-test analysis indicated that possessing a GCSE in the subject of mathematics, as evidence of ability to enter a pre-registration programme, did not make a statistically significant difference in FNA results.

Uniquely in this study there was a statistically significant relationship between students that attained a grade C/4 pre-entry requirement and students that had functional skills or grade D/E. Mean differences for functional skills or grade D/E in mathematics outperformed the C/4 grade students, which does not fit with the expected norms of performance. A rationale could be that some of the participants in the study were part of an ongoing trial, that offered the opportunity to enter the programme with a D grade in mathematics, if the student was able to achieve a score of 70% and above in a GCSE C grade standard mathematics paper, set by the university's mathematics department with supported education and advice. The impact of this current advice and guidance could have been the influencing factor that resulted in the increase in their performance.

Hek (1994) recognises these opportunities, discussing minimum pre-requisites for mathematics to enter pre-registration programmes. Suggesting this is not always met, citing examples such as access course requirements and the current validity of the individual's qualification, especially if there is a time lapse between immersion in the subject area and using it in everyday practice. Identifying that apart from those gaining above a grade C/4 in their paper qualifications prior to entry to the programme, individuals completing a maths test in the first week of their course, and their subsequent result, was totally unrelated to the actual paper qualification that gained them entry to the programme, with students often performing significantly poorer in this test.

To rectify this Hek (1994) suggests a short revision style course in basic mathematical formulae. This bought 85% of students up to a more desired and acceptable standard within the assessment criteria of this study.

Kilic and Cheheroglu (2022) concur with this recommendation with their comparative study using the Drug Dosage Calculation Skills Test (DDCST). Participants that had undertaken a basic mathematics course prior to completing the DDCST scored statistically significantly higher marks than their counterparts that had not undergone the course (p value 0.001. It was also noted there was an increase in the average overall score achieved on in the DDCST to 61.06%. Overall, the recommendation suggested a need for an amendment of the nursing curriculum, to include the basic elements of arithmetic skills for the administration of medications.

Gregory et al (2019) outlines a three-step approach to numeracy teaching, commencing from the 1st year of undergraduates nursing programmes. A Foundation 1.5-hour session, providing a knowledge and instruction of basic numeracy concepts and calculations including the use of formulas, further supported with the use of online textbooks and resources.
A practice phase, providing time in class to practice questions, providing the answers, and identifying how these were achieved. Provision of further quizzes online and weekly opportunities in sessions for calculations to be practiced and discussed.
Finally, contextualisation, with opportunities to apply drug calculations as part of skills sessions in a clinical laboratory environment, allowing an appreciation of the overarching application to practice.

Also considered were the specific grade attainments of mathematical qualifications by field of nursing applications to HEIs, and if this needs to be an area for further consideration, exploration and understanding. This study suggests that there was no statistically significant relationships or differences, in mean mathematical qualifications on entry to the programme between fields of nursing. Entrants to programmes in Adult, Child, and Mental health Nursing all attained similar grades, therefore there would be no anticipated need to consider specific targeting on mathematical qualifications based on field specific applications to HEIs.

5.1.1Recommendation 1:

On entry to pre-registration nursing programmes, it would be recommended that students be screened with a fundamental numeracy assessment (FNA). Performance in FNA provides a strong indicator of numeracy performance and can support educators in the identification of students requiring specific and targeted numeracy support. Thus, enabling the supporting and constructing of calculation, conceptual and technical measurement competencies, that stretch over the whole period of pre-registration programmes (McDonald 2013) It would be recommended that this evidence is a key focus of current ability rather than take accreditation from their entry mathematics qualification. Hek (1994) recommended a calculations test as part of the selection process due to identifying several discrepancies between different colleges of nursing around not only entry requirements but also the provision of mathematics in their curricula. This had become the trend in nursing student recruitment but, due to falling numbers of applicants, many universities decided to drop this entry criterion and rely solely upon the mathematical qualification on entry.

With the notion of competence developing and increasing over time, it is pertinent to ensure that the commencement of dedicated endeavours within the areas of both pharmacology, medication management and drug calculations is commenced at the earliest opportunity, and continually streamed throughout the pre-registration nursing curriculum (Cleary-Holdforth and Leufer 2013).

Recognising the importance of having an early assessment of current mathematical ability, has been clearly identified in this research, with the main predictor of nursing numeracy performance being scores in the fundamental or diagnostic test. Therefore, to have an early step in the curriculum to identify areas of poor mathematical performance, could potentially influence the overall performance of the individual in nursing numeracy assessments. Diagnostic maths testing is commonplace during the early weeks of some university courses (Learning and Teaching Support Network 2003). Assessing basic maths competency at the beginning of programmes allows time for students and educators to devise strategies to help identify and remedy any knowledge gaps, using refresher classes to optimise current levels of mathematical ability (Atkinson 2004). McDonald et al (2013) suggests utilising an entry point numeracy assessment at the beginning of pre-registration nursing programmes, such as the Fundamental Numeracy Assessment test. Recommending that feedback to students highlights any diagnosed numerical deficits, and stresses to the student, the extreme importance of picking up ‘mathematical dropped stitches’. The programme should then support the construction and crafting of cognitive and functional competence in conceptual, calculation and technical measurement competencies, which should be implemented over the entire period of the pre-registration programme.

Whilst appreciating the current stance and approach of self-managed learning in higher educational institutes, there needs to be ownership from both the institute and student to use diagnostic tests and then develop appropriate electronic resources, handouts, and opportunities to practice and retest their skills (Lawson et al 2019). Johnson et al (2020) also suggest that students need to have an overarching responsibility for managing these opportunities and taking ownership of their self-directed study to attain these skills. This does however also require significant opportunities within practice placement settings, whether that be in real life practice or simulation, to complete these calculations practice opportunities.

Wennberg-Capellades, et al (2022) also identifies that pre-registration nursing programmes need to ensure that students have the time to develop basic numeracy competence, appreciating both the numerical and clinical aspects that underpin medication calculations, placing this into context and the realism of individual patients' conditions and lives.

Recognising the impact of maths anxiety in this learning journey or avoidance of opportunities to self-develop knowledge is important, ultimately allowing the opportunity to address deficits in procedural knowledge and conceptual understanding, by implementation of more precise teaching around identified need, through the screening process. This will allow a greater targeted teaching and evidence-based teaching strategy (Hembree 1990).

5.2 Age:

The average age of students successfully recruited onto this study's nursing programmes was 25.3 with an age range of 17 to 54 years.
Outcomes of this study related to age included a very small positive correlation with age and mathematics qualification, which was not statistically significant, so the age of the applicant to a pre-registration programme does not significantly affect the quality of the mathematical qualification held by them.

Analysis suggested a positive correlation and statistically significant effect of anxiety related to age. Younger students exhibited greater maths anxiety than older students. With the lowest levels of anxiety displayed amongst the age category 45 to 54 years old and the highest anxiety group being aged 25 to 34. Baloglu and Kocak (2006) partially agree with this, suggesting older students had higher levels of anxiety about exams, than their younger colleagues. However, they experienced less anxiety about the actual numerical tasks within these exams. On checking the distribution of ages across fields of nursing, these were equitable, and not statistically significant. Therefore, the impact of age within fields of nursing is minimal and does not account for this variation of results in exam totals.

Age appears to have little impact on BKSB results, with a non-statistically significant small negative correlation coefficient effect of age on BKSB results. This concurs with their mathematics qualification on entry to the programme and field of nursing as well, demonstrating age has no impact on the grade range achieved.

Kilic and Cheheroglu (2022) concur with these findings, identifying no statistically significant conclusions of achievement in their DDCST test between type of mathematics qualification and age.

5.2.1 Gender

Gender was not statistically significant in this study, when correlated with mean grades of mathematical qualification on entry to the programme. Historically, males and females appear to trade advantages within mathematics, dependent upon the age bracket assessed. Females gain the advantage in the early primary school years, when computational knowledge and speed is important, but gender makes little or no difference through the rest of the primary school years. Males gain the advantage, as mathematical assessments require more reasoning and spatial awareness, calculus and geometry, areas of mathematics that are often taught at secondary school level (Geary 1996, Hyde et al 1990). Males' mathematics scores are often widely distributed across a range of bands, which can on occasions, skew the mean/mode. With males being more variable in quantitative and visuospatial abilities, there will be more males at both the top and lower end of ability. Even small mean differences between males and females, will result in a disproportionately large number of males in the upper and lower ranges (Halpern et al 2007).

This study did not identify any statistically significant impact of gender on BKSB current numeracy ability scores. Both genders scored between level entry 3 and level 1 in the BKSB screening tool, despite them attaining a level 2 qualification to gain entry to the pre-registration programme. This appears to support the theory that the pre-registrants' mathematical qualification does not always reflect their current mathematical ability and suggests that the gender of participants on entry to pre-registration nursing programmes, should not make any difference to how they will perform in numeracy assessments. Kilic and Cevheroglu (2022) counter-argue this suggestion, identifying a statistically significant difference between gender and performance in their DDCST, with males outperforming females by 13.15%. There is however limited inferential statistical analysis to look at regression into the competing variables, so it may well be that these individual males possess other qualities that are contributing to the overall achievement levels in the DDSCT.

In this study it was predicted that Males would outperform females in the nursing numeracy test outcome. Geary (1996) and Hyde et al (1990) suggest that males gain the advantage with mathematics, especially with mathematical assessments requiring more reasoning and spatial awareness, calculus, and geometry, with these areas of mathematics often taught at secondary school level, closer to admission to university entry, this could account for some advantage towards males achieving better results. However, independent samples of total exam scores for this study suggested no significant difference in scores for males and females.

Analysis of the subsections of the exam, demonstrated statistically significant differences between males and females in section A of the exam (covering metric unit conversions, equivalent fractions, decimals, fractions and percentages, general numeracy, and technical measurement along with general calculation ability) which required participants to be more spatially aware. Spatially based questions usually favour male participants with them gaining an advantage in solving these problems (Halpern et al 2007). Crucially though, this gain was only small in the male population.

Questions could include the student being asked to rotate objects or place them in a differing space, co ordinating how space is used and represented. Within the nursing numeracy test, syringes were used to contextualise fluid volume, but a spatial awareness was required to ensure that the student could visualise that volume within that space.

This study's findings indicate that gender explains a 10% difference in the mark awarded for this section, with males achieving 81% and females 71% on average. The extra percentage of marks gained, would have a significant effect on the grade of the student, despite it being only a small effect noted.

So why might this be the case? Levine et al (1999) suggests that there are substantial differences in visuospatial information processing between genders. Visuospatial awareness involves the ability to observe the visual world, to form mental representations of objects, mentally manipulating these representations, turning, and reconstructing aspects of the visual experience into a meaningful and understandable process; (Miyake et al, 2001, Ogawa et al 2010). Visuospatial awareness also allows the individual to have an ability to place parts of a process into a whole journey, manipulating and constructing the visual representation and understanding the spatial orientation (Korkman et al 1998, Mervis and Klein-Tasman, 2000, Newcombe and Frick, 2010)

Halpern (2007) concluded that males perform better in spatial tasks right back from the age of four and a half, with males on average, being more accurate than females at spatial tasks measuring accuracy of spatial transformations, with males also scoring higher on intelligence scales as well.

The importance of understanding this visuospatial ability and working memory of these processes is its direct correlation to the multi digit calculations, complex algebraic and geometric problem-solving abilities (Reuhkala 2001). A strong visuospatial ability is also associated with superior performances in counting and mathematical tasks (Kyttala et al 2003, Lefevre et al 2003) and poor visuospatial awareness, having a direct impact on an individual's ability to complete written calculations and have conceptualisations of finished complex models, often associated with long process calculation in drug administration (Szucs et al, 2013)

In Section B of the numeracy exam, there was no significant difference in scores for males and females.

This section required the participant to transfer data from a descriptive piece of text, placing the numerical data onto either an observation chart or fluid balance chart at the correct times, and correct spaces. When solution strategies require a verbal approach or are similar in nature to representations found in mathematical tests or demonstrated in clinical practice, there is more equity amongst gender representation (Halpern et al 2007).

Willingham and Cole (1997) suggest that verbal abilities are essential to the successful completion of mathematical tasks, as the density of the information written within questions and the need to comprehend the information, are extremely important. Females in later secondary education perform significantly better in this area of verbal ability, especially in the fields of language use and writing. So, when being asked to transfer data and write out appropriate translations of information, they have a better technical ability to achieve this or be on a more equitable plane with their male counterparts for writing and language usage. However, when it comes to placing females in a high stakes test situation, females cannot always covert this ability in to attaining marks on the test, with them often attaining significantly lower grades (Halpern 2007). Further exploration of gender and maths anxiety suggests a small but statistically significant difference between the mean scores of males and females, with males mean MAS-UK anxiety score being lower, implying males were less anxious than females.

Hyde et al (1990) and Else-Quest et al (2010) support this small effect size, identify gender differences in relation to emotions provoked by mathematics, suggesting a greater rate of anxiety amongst females, especially with tasks that require mathematical reasoning.

In terms of gender differences related to emotions provoked by mathematics, studies on mathematics anxiety stand out. Research indicates (albeit with small effect sizes) the existence of greater rates of anxiety in females than males during tasks involving mathematical reasoning. Studies identify that positive emotional associations with mathematics have a more pronounced effect on females rather than males, ultimately affecting how dedicated they are towards achieving higher standards in mathematics (Pinxten et al 2014). Conversely Goetz et al (2013) suggests that the rates of negative emotions and anxiety experienced by females, may not actually negatively influence overall achievements in mathematics, as much as would be expected. The results from this study would support this, with males and females performing at similar levels in the nursing numeracy test, despite females appearing to display higher maths anxiety levels than males.

This is a significant area for pre-registration nursing educators, with female participants within this study representing 93% (266) of the overall participation numbers. This is reflective of the National population of pre-registration nursing, with an average of 90-92% being female (RCN 2020).

Having an appreciation of this in a female dominated profession is extremely important. Ensuring that students are appropriately supported, given a variety of access points, approaches to learning and working towards increasing confidence amongst these individuals, may help to reduce the associated anxiety around these tests and perceptions of high-stake test situations. The implementation of a designated individual to monitor and support basic mathematics and numeracy understanding, within the school of Nursing, would offer a reference point for students to access and provide a continuity of support to improve results, increase competency and reduce anxiety.

Managing maths anxiety throughout pre-registration nursing programmes, should be a key focus for HEI's, ensuring a variety of approaches to not only measuring this, but also providing appropriate resources and sessional support to enhance learning and reduce anxiety. Identifying specific strategies to manage maths anxiety when planning, organising, and implementing numeracy teaching.

McMullan et al (2012) suggest the loss in confidence in mathematical and calculation performance ability, increases the anxiety the student experiences when they are asked to perform such calculations. The need to address this anxiety and lack of confidence as soon as possible is paramount. This level of anxiety can prevent them from attaining their mathematical and drug calculation proficiency and their true potential. With a highly female dominant profession and student population, the recognition of the impact of gender on anxiety and the need for the deployment of strategies to manage this, such as workshops, online quizzes, making it fun, with good clear teaching strategies and skills appears to be essential (Ramjan 2011). McMullan et al (2012) also identify the use of more student focused teaching that avoids didactic methods and encourages the exchange of ideas and peer support. One such approach could be the use of student-based support networks such as the Peer Assisted Learning (PALS) programme, often already established within HEI's. Instructions for these sessions should be flexible enough to meet the needs of the students attending, addressing the experiences verbalised around frustration or poor understanding of processes that can often lead to levels of maths anxiety. With concerted efforts and the use of multi-modal approaches to supporting nursing students, calculate dosages and their abilities to complete these can be improved. The use of cross-discipline collaborations between nursing and education will enhance this achievement and success (Mackie and Bruce 2016)

5.3 Recommendation 2:

Possible interventions for both genders would be to individualise teaching to solve problems using both verbal and visuospatial solution strategies. This may allow learners to draw on a flexible range of skills when attempting to problem solve. Particularly focusing on improving visuospatial skills for females, potentially leading to greater success in nursing numeracy testing in the future. Providing a supportive environment and using a multiple teaching strategy approach, that aims to address the needs of all the students without the reliance on didactic teaching would be important. Achieving this by offering support and encouragement to the students, developing trust in their own judgements and ability, modelling, and creative brainstorming with opportunities offered to be creative in their thinking (Cole et al 2011, McMullan et al 2012).

5.4 Field of nursing

This study's university offered pre-registration nursing programmes in 3 fields of nursing, Adult, Mental Health, and Child. Exploration of the impact of field of nursing was explored in various sections of this study.

Total exam scores across fields of nursing, identified that children's nursing attained better mean average mark ranges, compared to adult nursing students, with mental health nursing students attaining the lower mark ranges. Statistically significant differences in means were noted, suggesting a high value and rejection of the null hypothesis that there would be no effect of field of nursing on total exam scores. Statistical differences are noted between adult and child mean differences and mental health and child. However, there was no statistically significant difference between adult and mental health. The importance of this information is pertinent when considering the groupings of teaching students in cross field numeracy sessions. Identifying the strengths of the students and allowing peer discussion, teaching, and encouragement, whilst recognising the need to monitor and identify anxieties amongst students, could impact on the achievement of the weaker members of the group whilst offer confirmation of ability to the higher performing students.

UCAS mean entry points achieved on entry to the programme were obtained, for the participants year of entry, according to field of nursing. Identifying if this could be a contributory factor towards the differing scores across the fields. Averages were very close, Adult 138.1, child health 140.2 and mental health 132.1. With entry requirements being from 96 to 144 points across pre-registration nursing courses (UCAS 2021), the HEI in this study appears to be attracting the higher end tariff point's students. Interestingly, these scores did appear to correlate with the outcomes of the numeracy test overall. With children's nursing having higher entry points on average and the highest scores on the numeracy test, and mental health having the lowest entry points on entry and the lowest scores on the numeracy test. This could be an area for further exploration in future research to see if the overall UCAS points profile, makes a significant contribution to performance in either a numeracy element of a programme or overall performance on a whole programme.

Özyazıcıoğlu et al (2018) provide evidence of the apparent excelling of Child health student nurses in their retrospective study, on 148 3rd year child health student nurses, indicating that most students (68.2%) answered four out of the five exam questions correctly. Sections of the exam that covered drug dosages based on a child's age and mg/kg calculations were correctly answered by 87.2% of the students. Only 6.7% of the students did not answer the question at all, although more generalised in field of nursing Wright (2005) work found that only 36.7% of the participating students did not answer half of the questions correctly. Whereas Oldridge (2004) pilot study of individuals answer 5 calculation questions, found less that 14% attained all 5 correct answers.

Moving forward HEI's need to establish why child health student nurses outperform other fields of nursing. With efforts made to try and encapsulate and emulate their success in other fields. Peer learning may also offer a positive contribution to learning across mixed field education sessions, allowing a greater depth of understanding and attainment for all fields of pre-registration nursing. Promoting students to work in a collaborative way, enables sharing of knowledge and access to alternative ways of problem solving (Chapman and Halley 2007). Consideration to potential barriers to learning and an understanding of motivational factors, should also be considered. These can include age, lack of time, university workload, competing priorities, poor mathematics knowledge and skill, procrastination, negative attitude, test anxiety and fear of failure (O'Reilly et al 2020)

Prizes, workshops, online quizzes, good clear teaching skills and having lots of practice time and replica questions, were all things cited by students and academics as strategies to improve motivation to learn mathematics (O'Reilly et al 2020).

5.5 Mathematics anxiety

This study's findings suggest the type of mathematical qualification you have has little influence on pre registrant nursing mathematics anxiety score. With non-statistically significant data generated.

Sarason and Mandler (1952) work, identifies a negative correlation between test and maths anxiety in outcomes of examinations and tests, labelling this as cognitive interference. Identifying an interference model which concludes that cognitive skills are impaired because of the individual experiencing anxiety. With individuals who experience high levels of test and maths anxiety, consistently attaining lower marks in exams, in comparison to low test and math anxious students of the same ability (Seipp, 1991; Sung, Chao, & Tseng, 2016).

Individual's cognitive ability during the tests was impaired due to stress, so they were unable to access their working memory so efficiently, to complete cognitive tasks for the exam (Beilock 2008)

Conversely, counterevidence suggests it is good to experience a small degree of stress, as this has found to be motivational and a positive attribute towards performing better when required (Derakshan & Eysenck, 2009)

It was predicted that the MAS-UK score would have a direct impact on the overall total of the numeracy exam, with higher MAS-UK scores doing poorly.

Multiple regression in this study identified Maths anxiety as a key factor, suggesting a negative 5.8% impact on total exam scores. The higher the levels of anxiety recorded, the lower the mark on the final nursing numeracy total. This was evident for all the individual sections of the exam as well, with higher anxiety levels having a negative correlation and statistically significant effect on section A, B, and total exam scores.

Williams and Davies (2016) recognise that a student's accuracy when undertaking drug calculation and mathematical equations associated with these, may be influenced by mathematical anxiety, impeding the individual's ability to complete mathematical problems. Without assistance and education to overcome these barriers, there is a risk of incorrect doses being administered to patients in the clinical setting.

With around 20% of the nursing student population possessing anxiety levels that were so significant and severe, that this would impact on their overall mathematical ability, contributing towards a negative attitude towards maths, increasing their anxiety about the subject area and lowering the tests scores achieved on drug calculation exams (Glaister 2007). The impending pressures and ramifications of making errors with drug doses within the clinical setting was also a contributory factor to the increase in maths anxiety levels. However, not all literature converges with this, Walsh's (2008) cohort study demonstrated no relationship between maths anxiety and performance in a drug dosage calculations nursing maths test, which included examples like those required in clinical practice. However, the cohort overall MAS scores demonstrated a low level of mathematical anxiety, so this could have affected the overall results and skew the interpretation. Macher et al (2012) appreciates that anxiety can also lead to improvements in numeracy performance, giving students the opportunity to do well in testing. However, with maths anxiety resulting in a level of working memory suppression, known to inhibit performance in testing, having an awareness of individuals levels of anxiety is useful (Ashcraft and Moore 2009).

McMullan et al (2012) research demonstrated students who failed their numeracy test were significantly more anxious and less confident when performing numerical and drug calculations than those students who passed. In addition, independent samples *t*-tests demonstrated that students who failed the drug calculation test, were significantly more anxious and less confident in performing numerical and drug calculations, than those who passed the test.

Significant correlations were noted, with the strongest between mathematics anxiety and self-efficacy, mathematics and drug calculation, numerical and drug calculation abilities, and mathematical anxiety and drug calculation ability. Overall, 228 students participated in this study, with at 60% pass rated for both elements. Concerningly 92% of participant (210) students did not attain this pass mark in the Drug Calculation Ability Test (DCAT) and 55% failed the Numeracy Ability Test (NAT). 93% of the students who took the numeracy ability test (NAT) and failed, demonstrated high levels of mathematical anxiety (scoring≥25%). 83% of students' who also failed the Drug Calculation Ability Test (DCAT) also demonstrated the same level of high mathematical anxiety. Mathematical anxiety signs were also displayed by the students that passed these tests, but at significantly lower levels. With 63% of the students passing the numeracy test and 32% of the students who passed the drug calculations test, demonstrating significant levels of mathematical anxiety.

Overall, only 10% of the participant reported low levels of mathematics anxiety, with the overall majority 70% identifying at a medium level.

Miller and Bichsel (2004) highlighted the relationship between mathematics anxiety and numeracy performance in undergraduate students, suggesting that maths anxiety significantly predicted performance in both basic and applied maths tests. With further authors supporting the relationship, that anxiety reduces performance and causes a negative effect on numeracy performance and tests (Loong 2012, Ashcroft, and Moore, 2009, Nunez-Pena et al 2013). Hembree (1990) meta-analysis of the literature concluded that reductions in maths anxiety, results in students gaining higher achievement and better test results.

Field of Nursing and anxiety scores were further explored with mean scores between fields only demonstrating small differences and no statistically significant effect on levels of anxiety. Suggesting that there needs to be no clear focus on field specific delivery of content for the reduction of anxiety in nursing curriculums, it is more pertinent to focus and identify individual groups of students with high anxiety scores.

Maths anxiety scores between the different mathematical qualifications groups unearthed some interesting results. A variety of anxiety scores were exhibited across the grade range. With ANOVA suggesting the type of grade you enter a pre-registration nursing programme has a medium effect on the levels of anxiety experienced (P=.003, eta squared with a medium effect .06).

Grade C/4 mathematical qualification holders demonstrated the highest anxiety mean scores. As an entry requirement for HEI's and the most attained level of mathematics qualification for students entering this pre-registration programme, and nationally, this appears to be a key piece of evidence to support the implementation of screening students for mathematics anxiety levels on entry to the pre-registration nursing programmes. This will ensure not only the identification of these individuals, but then enable us to have the ability to target teaching to reduce this anxiety and the implications of that anxiety, on their drug calculation and nursing numeracy function. This targeted teaching should also consider the type of mathematics being taught in its sessions. Section A of the exam in this study contained questions on Metric unit conversions, equivalent fractions, decimals, fractions, and percentages, targeting general numeracy, technical measurement, and medication calculation ability, placing a key focus on these area for teaching could enhance the success rates of individuals completing numeracy assessment tests. Gender is also a key factor, with females experiencing more anxiety than males in this study (statistically significant ANOVA .017, F value of 5.77). However, the actual difference in mean scores was quite small (eta squared .02) This is a significant area for pre-registration nursing educators, with female participants within this study representing 93% (266) of the overall participation numbers, although reflective of the National population of pre-registration nursing, with an average of 90-92% being female (RCN 2020). This does, however, still seem to suggest the need for specific strategies to manage maths anxiety when planning, organising, and implementing numeracy teaching strategy for high female population groups (McMullen et al 2012). Increasing mathematical confidence, maths values and self-efficacy, as well as individual student self-awareness, of both developmental needs and ability, could end up improving maths anxiety levels and improving performance overall (Khasawneh et al 2021).

Analysis of gender differences in mark ranges of section A of the exam suggested a statistically significant relationship between the gender of the student and their mark in section A of the exam (P=.028, F=4.87 eta squared .02 small effect). Males scoring higher than females. Considering that, females were statistically significantly more likely to experience maths anxiety, this could be the reason that females scored lower in section A of the exam.

Pozehl (1996) suggests that if an individual has some deficiency in conceptual ability related to mathematics, this can be compounded by anxiety. This then interferes with their ability to manipulate numbers and solve mathematical problems.

On assessing how mathematical anxiety affected nursing students and non-healthcare workers, Pozehl (1996) study suggested that although not statistically significant between the participants, nursing students were found to have a higher mathematical anxiety overall. Suggesting that the need for early identification of mathematical calculation problems throughout nursing programmes, curriculums, and encouraging exploration into ways to reduce maths anxiety, could have a positive effect on the management and impact of mathematics anxiety. Section B of the exam has a non-statistically significant result, but there was a switch in roles with females scoring slightly higher that males in this section that required more logical reasoning.

5.6 Recommendation 3:

Students to undergo Maths anxiety screening on entry to pre-registration nursing programmes. Knowing that maths anxiety results in a level of working memory suppression and inhibits performance when testing, to have a working understanding and awareness of the individuals' levels of anxiety will be extremely useful for the planning and implementation of teaching and strategy (Ashcraft and Moore 2009). An intervention program could be developed, that aims to identify and address students with high levels of mathematics anxiety. Identifying any negative attitudes or personal struggles with mathematics, with an aim of building the individual's confidence in these areas, helping to reduce these negative thoughts and attitudes. An injection of drop-in sessions for students to attend to share any anxieties and refresh their basic mathematic principles for addition, subtraction, multiplication, and division could see improvements in these areas (Stevens et al 2009). Challenging unsuccessful experiences with Maths in the past during these discussions and replacing these negative experiences with positive reinforced behaviours, may decrease the students' doubt in their mathematical ability, underperformance in mathematics and the purposeful withdrawal and "I can't do this" attitude (Turner et al., 2002; Scarpello, 2007, Allen 2021). Appreciating the impact of the teacher-learner relationship is an important factor when assessing and understanding the classroom climate. The importance of Instructional clarity and the teacher's ability to explain content clearly to students, with clear direction during teaching sessions is paramount. Developing a trusting, respectful and caring relationship and interactions between the teacher and learner, provides the intellectual and emotional context for engagement and related educational outcomes (Wilson Fadiji and Reddy 2023)

The overall aim of the sessions would be to increase confidence in mathematical ability, alleviate thoughts of anxiety and fear around mathematical processes, ultimately affect, and change their attitude towards using their mathematical ability in nursing numeracy and practice. Implementation of drug dosage calculation training programmes for nursing students can lead to the reduction of math anxiety and improvement of the drug dosage calculations, which ultimately will help improve patient safety and can significantly improve scores on major medication calculation exam results (Sayadi, Nasrabadi, Hosseini 2021, Rainboth, DeMasi 2006)

5.7 Teaching methods for teaching numeracy and drug dose calculations:

The educational methods HEI's use to teach drug-dose calculations, has a substantial impact on educating students (Basak 2016) With a variety of approaches identified including the cooperative learning approach (Basak & Yildiz 2014) or the problem-solving approach (Kelly & Colby 2003). Stoic (2014) suggests there are Four main types of teaching strategies that were identified in their literature review, these included traditional pedagogy, technology, psycho- motor skills and blended learning. With traditional approaches being considered effective for many years within nurse education, knowledge and information is imparted via traditional methods such as face to face presentations, tutorials, clinical practice laboratory sessions and remedial support, the aim is to allow students to acquire skills using a teacher centred approach (Adams and Duffield, 1991, Costello, 2011, Coyne et al, 2013, Craig and Seller, 1995, Dilles et al., 2011, Greenfield et al, 2007; Harne-Britner et al, 2006; Koohestani and Baghche- ghi, 2010, Pierce et al, 2008, Rice and Bell, 2005, Wright, 2007, 2008)

Interestingly exploration of curricula subthemes within this literature, identified differing approaches to teaching medication calculations. The first being numeracy or the teaching of mathematics and interventions on numeracy (Stolic 2014). Pierce et al (2008) delivered remediation for students' conceptual understanding of decimal numbers and Adams and Duffield (1991) work suggests the uses of repeated mathematical drills for calculation ability, allows the display of improvements over time.

Technology was the other area explored as an educational strategy, the use of learning software packages, personal digital assistants, DVD'S and strategies aimed at improving anxiety and attitudes towards computers, were all suggested to improve medication calculation ability (Stoic 2014). Utilising a blended learning approach, that includes lectures, drug calculation textbooks, tutorials, online mathematics resources, self-study workbooks, clinical practice sessions, tutorials and off placement practice sessions is another area of literature explored.

It is clear there is a plethora of theory on how to achieve success. With several strategies being discussed across both academia and practice. HEI'S need to scrutinise their curriculum to ensure that there is appropriate content for both skill development and practice of pharmacological interventions, drug calculations and medication management. As often this is difficult to clearly identify within nursing curriculums, with limited assurances that both theory and skill development opportunities are available (Cleary-Holdforth and Leufer 2013).

There needs to be a key focus on real life clinical practice simulation, rather than generic application of principles, as these are not seen as efficient in developing nursing students' calculation skills (Wright 2007). Developing Psychomotor skills and practicing the skill of medication administration is reported as a subtheme in Stoic (2014) review of the literature, suggesting the use of practice stations and off campus clinical settings with real patients using real medications, aids the development of medication calculation abilities (Coyne et al 2013; Wright 2013)

Cleary-Holdforth and Leufer (2013) also identify that it is imperative that this practice does not only happen in isolation, but students should be frequently offered the opportunity to dovetail these skills with clinical practice, conceptualising problems and allowing frequently afforded opportunities to link and apply these together, thus avoiding sometimes common approaches of front loading and teaching theory out of context. However, as Weeks et al (2000) warns, we should always ensure that we do not send out the novice with no formal preparation and potentially lead them towards episodes of blind practice.

Utilising Gregory et al (2019) previously discussed 3 step system to manage and deliver numeracy teaching to pre-registration nurses, may also help to impact on the levels of anxiety that the individuals are experiencing.

Foundation 1.5-hour sessions, that provide a knowledge and instruction of basic numeracy concepts and calculations including the use of formulas, supported with online textbooks and resources.

A practice phase, providing time in class to practice questions, provide the answers and identifying how these were achieved. Provision of further quizzes online and weekly opportunities in sessions for calculations to be practiced and discussed. Finally, contextualisation, with opportunities to apply drug calculations as part of skills sessions in a clinical laboratory environment, allowing an appreciation of the overarching application to practice. Ramjan et al (2014) also discuss strategies to implement to improve numeracy outcomes for students, including practice quizzes, with increased accessibility, simulated medication calculation scenarios that are incorporated within the first three clinical practice sessions in contact classes, a contextualised pen and paper test undertaken in tutorial classes in around week three of the skills. Remedial workshops with cross discipline lecturer delivery to around 20 students, offered around week 7 in the skills programme who did not score satisfactory scores in the first test, offering another pen and paper test in the contextualised format in week 8 of skills. Completing the final set of recommendation of a 'hands-on' contextualised workshop in the skill laboratory setting of 1 hour, with a ratio of one to two lecturers (nursing) to 10 students, in week 15—offered to those unsatisfactory in Test 2. Prior to a final contextualised 'pen and paper' test (test 3) administered in the final teaching week of skills. Whereas Wright (2005) discusses a three-stage approach to drug calculation as an effective teaching strategy for drug calculations. These stages involve addressing mathematical concepts, teaching drug calculation formulae and then practising these skills in a clinical setting.

Kinney & Henderson (2008), Medley & Horne (2005) identify the use of simulation in nursing education, suggesting this as an effective educational strategy to help develop nursing skills in a safe learning environment. Tailoring clinical skills workshops to include teaching techniques that encourage the development of drug-dosage calculation skills, as well as training strategies implemented during a Clinical skills Workshops, can enhance students' comprehension of mathematical calculations (Grugnetti 2014). The World Health Organization (WHO) (2011) recommends the use of simulation-based education, to improve the security of patients and ensure safe care delivery. However, Hemmingway (2014) participants did not rate the use of simulation as a form of clinical practice for medication administration and medication calculation opportunities, they felt that this lacked the clinical reality of everyday practice and induced a level of performance related stress, especially when part of a formal assessment, leading to the participants questioning the validity of this approach as a real-world assessment (Tabassum et al 2016)

5.8 Considerations of the current educational climate and impacting factors during this study.

This study commenced just before the pandemic hit the United Kingdom, with all data being secured before this became a limitation to accessing participants. However, having worked through this period and appreciated the impact of this experience, not only on the current students within the programme being run now, but the future participants that have lived through the pandemic and will register on future programmes. Thoughts and observations of this period would suggest that there has been a significant increase in anxiety with this student group. Kontoangelos et al., (2020); Fusar-Poli et al., (2021) identifies that university students demonstrate emotional instability under pressure, with their psychological characteristics differing from ordinary young people and the general public. The probability of post-traumatic stress, anxiety and episodes of depression being more likely to occur (Bruffaerts et al., 2018)

Son et al. (2020) suggested that this group of students were subjected to greater academic pressures and challenges, impacting on their perceptions and worries about academic performance and the creation of interpersonal relationships, leading to feelings of isolation, loneliness, and a decline in mental health. Garris and Fleck (2022) suggest that these issues will not disappear at the end of the pandemic but will have continually lasting effects on future engagements of university students. HEIs must have support networks and monitoring systems in place to ensure that these students are appropriately screened and supported during their programmes.

As previously identified within this study, the participants came from a large local rural population, with high areas of deprivation. Lee et al (2021) suggests that this is of particular concern as these females are academically more likely to underperform and suffer from psychological distress, limiting academic engagement and ability. With the additional psychological distress and pressure from the Covid pandemic era, this needs to be an area the HEI's focus on for future student provisions. Providing appropriate screening for general anxiety, mathematical anxiety, and numeracy performance. This will allow a greater insight into these areas and the development of holistic and accurate assessments of ability and impacting factors.

The provision and expectation of online engagement for learning during the pandemic and its continual use since, has evoked a heavy reliance on the use of technology and distance learning (Janes et al., 2023). Students experiencing the pandemic are considerably more susceptible to the adverse effects of distant learning, including the poor development of interpersonal and social relationships, a key aspect of personal development in professional registered programmes (Singh et al., 2020). With a lack of experience of time management and planning, current students are not accessing the required elements of their course at appropriate times, often leading to cramming and mis understanding of information. With the evidence discussed throughout this thesis around the importance of continued engagement with numeracy content and the spiralling of learning through increased exposure throughout a curriculum, it is key that HEI's appreciate these factors moving forward for future numeracy teaching and education.

The reliance on technology, whilst not appreciating IT poverty and the competence of the individuals using it, is another key factor for HEI's to consider (Janes et al., 2023). As this thesis identifies, there needs to be a continued appreciation and application of the pedagogical approaches to education and knowledge attainment. With technological advancements in educational delivery of nursing education, especially over the Covid pandemic, the appearance of these technologies to allow the accommodation of everyone's needs, through the liberation from perceived restraints of face-to-face based educational delivery is questioned (Gupta 2017). Whilst appreciating the potential enhancing characteristics of technological use in the delivery of nursing numeracy, Goodchild (2018) suggests that Nursing academics approach the use of learning technology with criticality, taking the time to consider what is lost by its use, as well as what may be gained. Evidence discussed throughout this thesis would suggest that a variety of approaches are required to deliver a rounded numeracy experience and education. Having base line assessments that allow the identification of these areas of development will allow HEI's to deliver a more bespoke and holistic approach to numeracy and its application to nursing.

5.9 Summary:

Upon careful analysis of the data from this study, it is clear there is a significant relationship between current mathematics diagnostic assessment result, mathematics anxiety and achievement in nursing numeracy testing. From these findings and recommendations as discussed above, other areas for exploration could include:

Extending this testing to staff members and offering professional development to lecturers and staff delivering skills-based sessions, around numeracy practice to increase their own knowledge base and assess and manage their own maths anxiety, hoping then that these strategies will be used more readily within tutorial sessions, skill teaching sessions and overall classroom delivery that involves mathematics content.

The allowing of an open and fluid discussion around the subject area, in a non-didactic approach, moving away from traditional classroom memories and memorising of algorithms, allowing the students and staff to lead the sessions and not the lecturer doing all the work. Exposing students to a culture and climate for redefining mathematical success. A paradigm shift from traditional testing methods to the implementation of a contextualised, intensive, numeracy teaching and assessment approach across campus sites, could enhance learning and promote best teaching practices and approaches. Embracing technology and its uses with Medication Dosage Calculation teaching and practice, could also reduce medication errors and increase success rates of student's medication dosage calculation tests, but it may not necessarily develop these skills in the longer term (Stake-Nilsson, K. et al 2022, Ramjan et al 2014). Weeks et al (2013b) identify that the 'proceduralisation' of medicines management and didactic transmission methods within education, creates a theory practice gap. To ensure patient safety there is a need to define, articulate, develop, assess, and evaluate competence, maintaining patient safety and education practice in the domain of medication dosage calculation problem-solving.

Simonsen (2014) suggest more emphasis should be put into basic nursing education around numeracy, medication procedures and safe practices. With a greater focus on the introduction and continued establishment of medication procedures in clinical practice, aiming to improve nurses' medication knowledge and reduce the risk of error.

Sulosaari et al (2015) propose that the core elements of medication competence are significantly interrelated, suggesting the provision of integrated and comprehensive medication education is delivered throughout undergraduate programmes. Students' learning style is associated with medication competence, therefore there is a need to utilise methods to not only identify, but support students having difficulties to self-regulate their learning.

Consideration of the demands from both the learner and the facilitator of the teaching and the learning of calculation competence, requires both the learner and facilitator, regardless of whether the learning takes place in practice or in classrooms, to be open and flexible in the teaching and approaches taken. The need to co-locate conceptual, calculation and technical measurement competence development and assessment, within authentic learning and diagnostic assessment environments, is critical to solving this ubiquitous problem. To construct medication calculation competence, there is a need for us to dispense with reductionist approaches that focus on calculation skill development in isolation. Placing a key focus on the exposure of highly authentic learning environments and construction of medication dosage calculation schema, will allow a significant improvement of completion of calculations as opposed to reliance on the sole exposure to traditional didactic methods. With classroom-based 'chalk and talk' didactic transmission environments, offering multiple barriers to accurate medication calculation completions amongst novice students (Weeks et al 2013b, Weeks et al 2013c, Weeks et al 2013d). A combination of a web-based authentic assessment activities-based programme, and the use of multiple environments for the administration of medications, allows the 'seeing' of the reality and practices of medication administration. Whilst allowing further assessments of safe technical measurement interpretation and dexterity of medications administration, assessed in both practice and practice simulation settings, will allow the ability for individuals to be assessed and referenced back to rubric based assessments, providing innovation, viability, reliability, and validity of assessment methods for the safe administration of medicines in pre-registration nursing programmes (Sabin et al 2013, Weeks et al 2013d) Mettiäinen et al (2014) also note the importance of revising medication administration before graduation and the utilisation of web-based learning can be an effective way of achieving this. Utilising these methods can strengthen competency and improve self-evaluated competency of nursing students in all fields.

5.9.1 Recommendations for Future Research

Whilst this research adds to the body of knowledge in this field of nursing practice and nursing numeracy. The findings of the study suggest the need to further expand the understanding in this area and affecting factors on nursing numeracy performance.

These include:

1) Results of this study being used to expand and plan further predictors of nursing numeracy performance and if there are any other factors that need consideration. This could include the need to consider the overall anxiety status of the student that was not measured in this study, and how this might affect the individual's performance generally.

2) To gain an appreciation and further understanding of teaching practices, to include methods and designs that have the greatest effects on both student mathematical achievement, reduction in mathematical anxiety, and its overall impact on nursing numeracy performance. Examining, exploring, and questioning the most effective methods for increasing knowledge and reducing anxiety with pre-registration nursing students, to aid improvement in performance both in testing and everyday practice.

3) A qualitative study that interviews students about their experiences of mathematics anxiety and its potential impact on nursing numeracy performance. To gain an insight and understanding on what previous experiences, exposures and impacts the students lived experiences could have, or may have on their overall performances.

4) Further exploration and discussion around the entry requirement of GCSE C/4 grade mathematics, and the potential expansion of the universities project of entry of D grade students with an entry exam set at a pass mark of 70%. With publication of data around these individuals and their performance.

5.9.2 Potentially confounding factors:

Addressing the apparent anomaly in performance of level one functional skills and GCSE D grade students in the study (not the normal accepted entry requirement for HEI pre-registration programmes). Could possibly be explained by a project that was implemented at the University of Plymouth, to this cohort of students. This offered the opportunity to access the pre-registration nursing programme even though the student had missed the GCSE requirement grade C/4 or only gained functional skills level 1. The university provided resources for revision and an opportunity to take a GCSE C/4 grade level exam (set by the universities mathematic department). If the student passed at 70% and above, they were offered a place on the pre-registration nursing course, with continued support from the mathematics department. This could have made a significant impact on the attainment of these individuals. As Hek (1994) suggests a short revision style course in basic mathematical formulae, bought 85% of students up to a more desired and acceptable national standard, for attaining the pre-requisite grade C standard of mathematics. The support, resources, and then taking the exam shortly after, may have influenced the students having knowledge that was more recent, plus revision of mathematical process, possibly lead to the students gaining more confidence in maths prior to this testing. Supporting this are lower levels of maths anxiety displayed in these groups, functional skills mean (45.84 CI 38.59 to 53.09), GCSE D/E (53.18, 95% CI 48.77 to 57.59) with GCSE C grades at a mean of (57.24 CI 54.41 to 60.08). ANOVA suggested statistical significance at (P=.003) eta squared suggesting a medium effect (.06)

5.9.3 Concluding Remarks

There cannot be a reliance on just a student's possession of a GCSE grade C/4 in mathematics, to ensure that the prospective student has developed arithmetical schema relevant to solving the essential numerical problems encountered in professional nursing practice. This also appears not to be a good over all predictor of performance in nursing numeracy tests, and is not an indication that the students have the essential numeracy skills to solve medication dosage calculations problems McDonald et al (2013)

Understanding and having evidence of the student's current numeracy ability, appears to be one of the best predictors of how the student will perform in nursing numeracy tests. Ensuring that there is a measurement and appreciation of the student's mathematics anxiety levels, with the implementation of strategies and adaptable curricula to accommodate and provide support to alleviate these anxieties, being imperative to lessen the impact of maths anxiety on nursing numeracy testing performance.

Introduction of mathematics screening on entry to the programme, along with identifying diagnostics, to categorise common themes of areas that require development. Leading to targeted teaching throughout the preceding three years, would appear to be an essential and wise step. Higher Educational Institutes cannot be reliant upon the age-old thought processes of "they have the qualification, so they must be competent" but take responsibility for the student's whole learning journey through their institutions. Identify the individual needs and working with other academic departments, to ensure the student leaves the institute the most competent rounded registrant possible. Van de Mortel et al (2014) suggests that substantial improvement in numeracy skills is achievable, by utilising a whole curriculum approach to developing applied numeracy skills in pre-registration nursing programmes. Recognising this and developing this approach will only enhance and improve outcomes for these students.

The need for more innovative pedagogical strategies for teaching mathematics to student nurses is required, and as Nurse educators, we play a central role in helping students learn the conceptual basis, as well as practical hands-on methods, to problem solving and mathematics competency. The use of an inclusive technological approach that is integrated throughout the curriculum and programme, will benefit students through better performance, increased understanding, and improved student satisfaction (Hunter Revell, McCurry 2013).

5.9.4 My own reflections:

Reflecting on my professional doctorate journey, has allowed me to appreciate how to think, act, read, write, communicate, present, question and answer as effectively as possible. I have learnt about the process of research, challenged my own mathematics anxieties by completing statistics modules and analysing data that I never would have dreamed of trying to do. Completing this process has allowed me to truly appreciate the research process and how to construct new knowledge from this. Immersing myself in data collection and analysis has been both a fascinating and stimulating experience, but an extremely challenging one. Managing such large sets of data and feeling and experiencing the excitement of data emerging has been a very rewarding experience.

I have learnt that despite several adversities (I seemed to have experienced all possible life events during this time!), I am able to have the resilience and motivation to keep going and complete this work. Periods of isolation, desperation and feelings of complete inadequacy have been experienced, but I sat there, and I kept going, because this subject is so very important. Every person that has ever struggled to understand concepts, especially in mathematics, felt lost and alone, I am so hoping this will make a change for you.

Completing this work has allowed me to develop my leadership and personal learning networking skills, infiltrating in more national and international forums, sharing work, and developing curriculums. This has allowed me to appreciate the connections we can make with others around the world and within our interest groups, leading to significant opportunities to expand my learning horizons.

I have made substantial changes to the way skills, mathematics and calculation teaching is delivered within my workplace. I have written business cases for new roles to help support the implementation of strategies to improve practices for students. Designated mathematics sessions are embedded within the curriculum, simulated practice and placements have been developed and implemented, to ensure a well-developed and holistic education delivery for our students. Medication calculation pass rates have increased and there has been significant qualitative feedback via module evaluation and personal emails, to outline how the students feel supported and developed.

What have I learned about myself:

I have learnt that I can have big ideas, discuss them in appropriate forums, debating and creating new avenues for exploration. I have learnt that I can take a complex idea, break it down and process the individual parts, implementing this in appropriate stages. I have learnt that sometimes my anxieties about my ability can become overwhelming for me, but I can rationalise that I do have the ability to be resilient and keep moving forward, despite significant challenges. I need to continue to work on this 'believe' process moving forward.

I have learnt that if we want to change things and challenge processes, we need to actually have a go at trying to change things, providing supportive evidence, reflecting, and evaluating as we move forward.

I have learnt that there is so much more to learn and explore, I feel like this is just the beginning and I cannot wait to see where this takes me. Encouraging an open and developmental process of both teaching strategy and curriculum development, that has a clear focus on identifying need, developing strategy, and revaluating at regular intervals to ensure that this maintains credibility and reliability.

What is my next step?

Sleeping, cuddling my children, and using every Sunday, as I have promised for so many months, if not years, to go out and have fun days with my two beautiful babies.

Laughing, crying, and generally enjoying life for a few months, whilst I wait until the next stage.

Then taking the time to ask more questions, listen to feedback and insights, make more connections, have more discussions, to move this work forward.

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Wright, K. (2005) An exploration into the most effective way to teach drug calculation skills to nursing students. *Nurse Eduction Today* 25(6):430-6. doi:

Wright, K. (2006) Barriers to accurate drug calculations. *Nursing Standard* Mar 22-28;20(28):41-5. doi: 10.7748/ns2006.03.20.28.41.c4099. PMID: 16596860.

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Wright, K. (2009) The assessment and development of drug calculation skills in nurse education - a critical debate. *Nurse Education Today*, 29(5), 544–548.

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Xu, C., Di Lonardo Burr, S. and LeFevre, J.-A. (2023) 'The hierarchical relations among mathematical competencies: From fundamental numeracy to complex mathematical skills', *Canadian Journal of Experimental Psychology* / Revue canadienne de psychologie expérimentale [Preprint]. doi:10.1037/cep0000311.supp (Supplemental).

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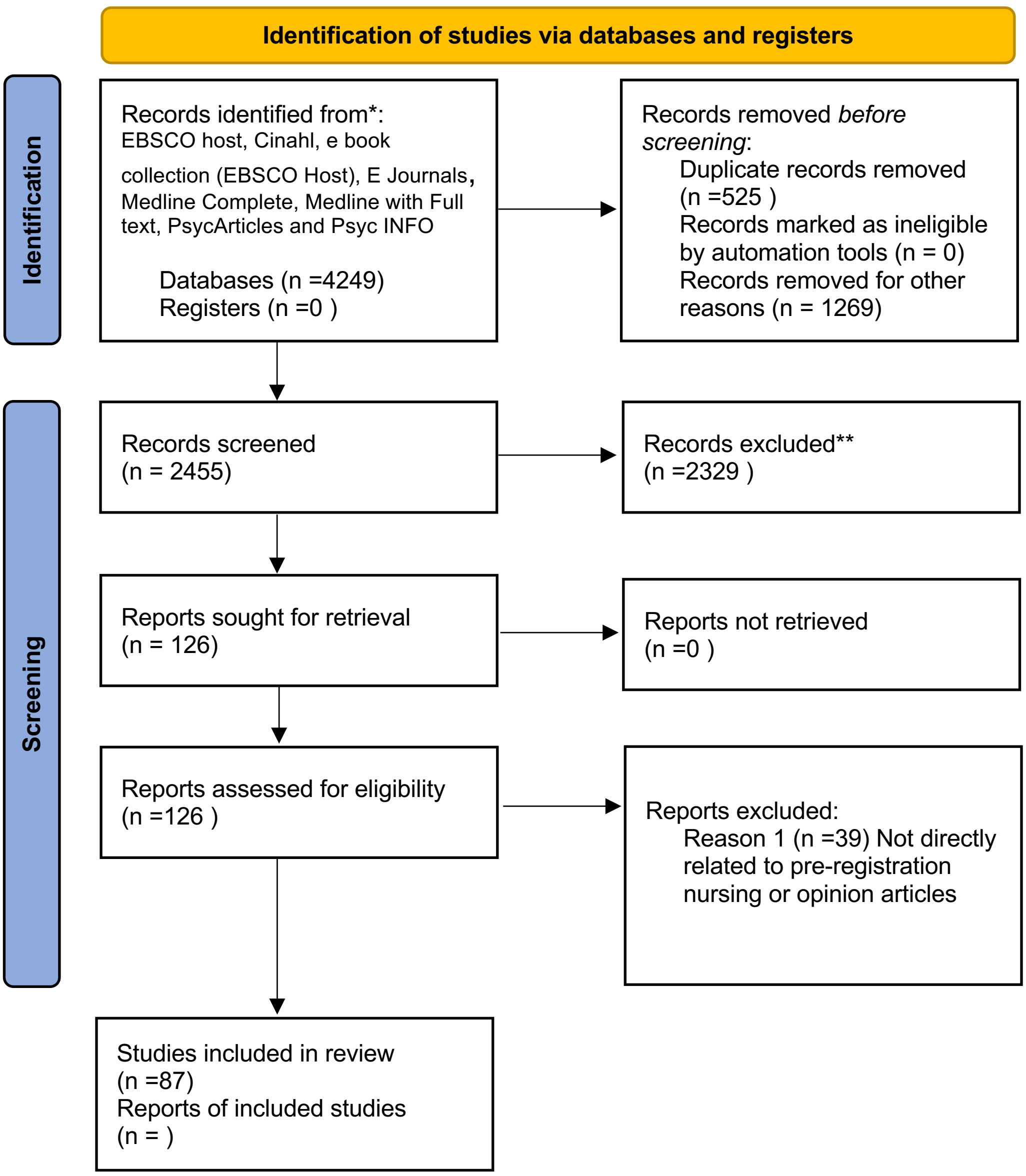
Zeidner, M. (1991) Statistics and mathematics anxiety in social science students: some interesting parallels *British Journal of Educational Psychology* 61:319–28

7.0 Appendix 1 PRISMA diagram

PRISMA diagram for literature search.



Included

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

7.1 Appendix 2 Hunt et al Math anxiety screening tool:

Hunt, T. E., Clark-Carter, D., Sheffield, D. (2011) The developent and part validation of a UK Scale for Mathematics Anxiety *Journal of Psychoeducational Assessment* 29 (5): 455-466 Sage

Mathematics Anxiety Scale–UK (MAS-UK)

	How anxious would you feel in the following situations? Please circle the appropriate numbers below.				
	Not at all	*Slightly*	*A fair amount*	*Much*	*Very much*
1. Having someone watch you multiply 12 x 23 on paper	1	2	3	4	5
2. Adding up a pile of change	1	2	3	4	5
3. Being asked to write an answer on the board at the front of a maths class	1	2	3	4	5
4. Being asked to add up the number of people in a room	1	2	3	4	5
5. Calculating how many days until a person's birthday	1	2	3	4	5
6. Taking a maths exam	1	2	3	4	5
7. Being asked to calculate £9.36 divided by 4 in front of several people	1	2	3	4	5
8. Being given a telephone number and having to remember it	1	2	3	4	5
9. Reading the word "algebra"	1	2	3	4	5
10. Calculating a series of multiplication problems on paper	1	2	3	4	5
11. Working out how much time you have left before you set off to work or place of study	1	2	3	4	5
12. Listening to someone talk about maths	1	2	3	4	5
13. Working out how much change a cashier should have given you in a shop after buying several items	1	2	3	4	5
14. Deciding how much each person should give you after you buy an object that you are all sharing the cost of	1	2	3	4	5
15. Reading a maths textbook	1	2	3	4	5
16. Watching someone work out an algebra problem	1	2	3	4	5
17. Sitting in a maths class	1	2	3	4	5
18. Being given a surprise maths test in a class	1	2	3	4	5
19. Being asked to memorize a multiplication table	1	2	3	4	5
20. Watching a teacher/lecturer write equations on the board	1	2	3	4	5
21. Being asked to calculate three fifths as a percentage	1	2	3	4	5
22. Working out how much your shopping bill comes to	1	2	3	4	5
23. Being asked a maths question by a teacher in front of a class	1	2	3	4	5

7.2 Appendix 3 Exam paper

Appendix 3

Section A: Marks ____/64

Section B: Marks ____/36

TOTAL: Marks ____/100

Percentage ______________%

(Marker to complete)

Please write your student name and ID number below

STUDENT NAME:______________________

STUDENT ID: _________________________

NRS403 Ways of Knowing

2018 Cohort – Year 1 Adult, Mental Health, and Paediatric Nursing

Formative Nursing numeracy exam as part of Clare Carpenter-Timmis Research project

There are **one hundred** *marks available in this exam. Please read all the questions before attempting to answer them. The number of marks awarded for each question is indicated in brackets at the end of the question. Scrap paper is provided if you wish to use it. Leave this on your desk after the exam to be collected in.*

You may **not** *use a calculator or any other electronic device.*

The exam will last for **ONE hour**. YOU WILL HAVE AN ADDITIONAL 10 MINUTES TO READ THE PAPER BEFORE THE START.

Instructions to candidates

- *On the desk, you should have an exam paper, and some supplementary scrap paper*
- *Please alert an invigilator immediately if you do not have these*
- *Write in black ink*
- ***Write your answers in this exam book where indicated***
- *Use the scrap paper for written workings if you wish.*
- *Please ensure writing is coherent and legible in line with NMC (2009) guidance on record keeping*
- ***Units: ALL*** *answers* ***must*** *also contain the* ***correct unit*** *of measurement (e.g., mg, mL, mL/hr) to be awarded the marks.*

SECTION A:

Section 1: Metric Unit Conversions (6 marks)

1000 micrograms (mcg) = 1 milligram (mg)

1000 milligrams (mg) = 1 Gram (g)

1. Convert the following quantities into **micrograms**:

a) 0.875 mg ____________________________ **(2 marks)**

b) 0.075 mg ____________________________ **(2 marks)**

c) 0.003 mg ____________________________ **(2 marks)**

2. Convert the following quantities into **milligrams:(6 marks)**

a) 0.9 grams ____________________________ **(2 marks)**

b) 325 micrograms ____________________________ **(2 marks)**

c) 6.7 grams ____________________________ **(2 marks)**

Section 2: Equivalent Fractions, Decimal Fractions, and Percentages (12 marks)

Fractions should be written in their <u>lowest/simplest terms</u>.

Fraction	Decimal	Percentage
$\frac{1}{2}$	0.5	50%
$\frac{1}{4}$		25%
$\frac{1}{10}$	0.1	
	0.2	20%
$\frac{2}{5}$	0.4	40%
$\frac{4}{5}$		80%
$\frac{1}{8}$	0.125	

$\frac{5}{8}$		62.5%

Section 3: General Numeracy & Technical Measurement (26 marks)

1. Round 4.657 to **two** decimal places:

____________________________ **(2 marks)**

2. Round 12.524 to **two** decimal places:

____________________________ **(2 marks)**

3.Six months ago, the weight of a young boy was 9.21 kg.
Since then, he has increased his weight by another 1950 grams.

(a) What is his weight now in kg?

(b) How many grams does his weight have to increase to reach a weight of 12 kg?

[4 marks]

4. Write twelve hundredths as a decimal number:

__________________________ **(2 marks)**

5. Write twenty-five hundredths as a decimal number:

__________________________ **(2 marks)**

6. Express the following **decimal value** in **hours** and **minutes**:

3.25 hours ________hrs ________ mins **(2 marks)**

7. Express the following decimal value in **hours** and **minutes**:

1.75 hours ________hrs ________ mins **(2 marks)**

8. A student nurse starts a shift at 07:30 and finishes at 19:30. He took a break of 45 minutes at midday. What are his total working hours for that day?

__________________________ **(2 marks)**

9. A baby's weight is 4346 g. What is this to the nearest:

(a) 10 g [ ] g

(b) 100 g [ ] g

[2 marks]

10. Calculate

(a) $4.92\ \text{m} + 3.09\ \text{m}$ [m]

(b) $7.12\ \text{m} - 3.705\ \text{m}$ [ ] m

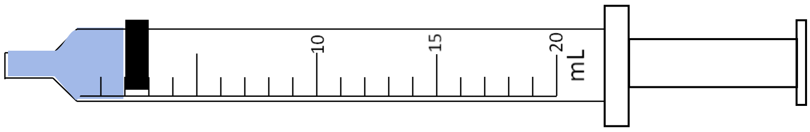
[2 marks]

11. Write down the volume that has been drawn up in the syringes (just the blue area NOT including the black line)

A

A = ________________

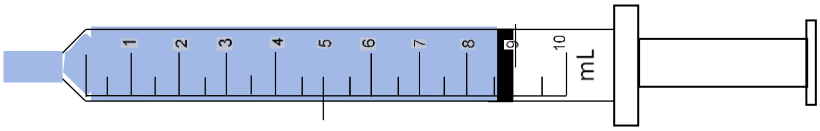
(2 marks)



B

B = _______________

(**2 marks)**



Section 4: Medication Dosage Calculations (14 marks)

1. Mair needs to take 750 mg of Ciprofloxacin. Each tablet contains 250 mg. How many tablets will you administer?

Answer: ____________

(2 marks)

2. Ruby needs to take 1 g of Paracetamol. Each tablet contains 500 mg. How many tablets will you administer?

Answer: ___________

(2 marks)

3. Steve requires Metformin Oral Solution, 750 milligrams. The stock dose is 500mg/5ml. What volume is required?

Answer: ___________

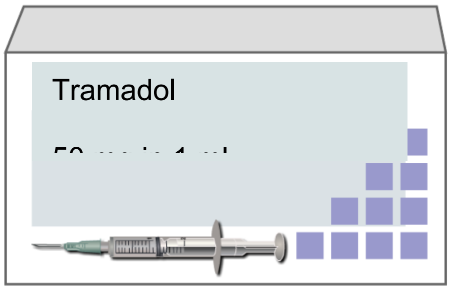
(2 marks)

4. Saffi requires Diazepam Oral Solution, 10 milligrams. The stock dose is 2mg/5ml. What volume is required?

Answer: ___________

(2 marks)

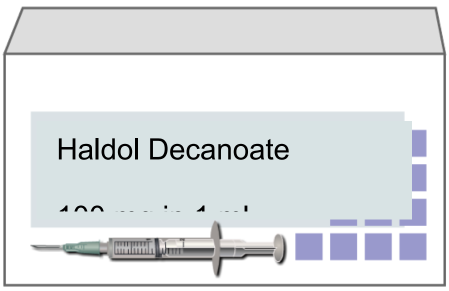
5. Abi is prescribed 100 mg of Tramadol. Stock strength in the medicine cabinet is 50mg/ml. How much do you draw up for injection?



Answer: ___________

(2 marks)

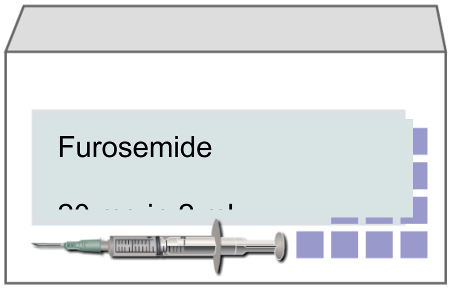
6. Barry is prescribed 50 mg of Haldol Decanoate. Stock strength in the medicine cabinet is 100mg/ml. How much do you draw up for injection?



Answer: ___________

(2 marks)

7. Joo is prescribed 20 mg of Furosemide. Stock strength in the medicine cabinet is 20mg/2ml. How much do you draw up for injection?



Answer: ___________

(2 marks)

Section B: Transferring numbers (18 marks)

1) Alicja Babik is a 53-year-old woman. Her date of birth is 28th February. She was admitted to a medical ward with suspected chest infection on 27th of September 2018 at 15.00hrs. She has no past medical history or allergies. You carry out a ward admission vital signs assessment. Mrs. Babik is alert and orientated.

   Please complete the following:

   - Patient's name
   - Date of Birth
   - Admission date

   Then transfer the following data to the observation chart:

- Blood pressure: 120/80
- Pulse rate 63
- Saturation rate 99
- Respiratory rate 18
- Temperature 36.8

If a piece of data is not available, please leave it blank.

NEWS KEY 0 | 1 | 2 | 3

NAME: D.O.B. ADMISSION DATE:

	DATE		DATE
	TIME		TIME
RESP. RATE	≥25	3	≥25
	21-24	2	21-24
	12-20		12-20
	9-11	1	9-11
	≤8	3	≤8
SpO_2	≥96		≥96
	94-95	1	94-95
	92-93	2	92-93
	≤91	3	≤91
Inspired O_2%	%	2	%
TEMP		2	
	≥39°	1	≥39°
	38°		38°
	37°		37°
	36°	1	36°
	≤35°	3	≤35°
BLOOD PRESSURE (NEW SCORE uses Systolic BP)	230	3	230
	220		220
	210		210
	200		200
	190		190
	180		180
	170		170
	160		160
	150		150
	140		140
	130		130
	120		120
	110	1	110
	100	2	100
	90	3	90
	80		80
	70		70
	60		60
	50		50
HEART RATE	>140	3	140
	130	2	130
	120		120
	110	1	110
	100		100
	90		90
	80		80
	70		70
	60		60
	50	1	50
	40	3	40
	30		30
Level of Consciousness	Alert		Alert
	V / P / U	3	V / P / U
BLOOD SUGAR			Bl'd Sugar
TOTAL NEW SCORE			TOTAL SCORE

2) You retake Mrs Babiks observations on the same day at 18.00 hours and they are recorded as below. Transfer these to the observation chart above.

- Blood pressure: 131/82
- Pulse rate 89
- Saturation rate 97
- Respiratory rate 18
- Temperature 37.8

3. Transfer the following data to the fluid chart below **(18 marks):**

- Alice Smith is admitted to the ward on the 18th of September 2018 at 10am.
- Alice has 500millilitres of fluid running into her vein; place this 500 millilitres in the correct place on the fluid chart at the correct time.
- At 12.00 Alice drinks a cup of tea at 180 millilitres place this in the fluid chart appropriately
- Alice's drip is replaced at 13.00 with a 1 litre bag of new fluid, document this on her fluid chart in millilitres

- Alice passes urine at 13.00 totalling 250 millilitres place this is the appropriate place in her fluid chart.

- Unfortunately, Alice vomits at 15.00 0.5 litres of fluid record this as millilitres on the fluid chart.

IV= Intravenous into the vein.

Oral= fluid taken in via the mouth

Fluid balance sheet

Name: Date:

Input Output

Time	Oral	IV				Urine	Stool	Vomit	
00.00									
01.00									
02.00									
03.00									
04.00									
05.00									
06.00									
07.00									
08.00									
09.00									
10.00									
11.00									
12.00									
13.00									

14.00									
15.00									
16.00									
17.00									
18.00									
19.00									
20.00									
21.00									
22.00									
23.00									

7.3 Appendix 4 Data collection sheet for Predictors of nursing numeracy research project

Data collection sheet for Predictors of nursing numeracy research project by Clare Carpenter

1) Student ID:

2) Full Name:

3) Email address (Plymouth university):

4) Age bracket please tick:

18-24	
25-34	
35-44	
45-54	
55+	

5) Gender identification (male, female, non-binary, trans, other, prefer not to say)

6) Mathematics qualification (i.e., GCSE O level, A level, Functional skills etc)

7) Grade achieved (i.e., A, B, C, D, E or 1-9 or level 1, 2 functional skills etc)

7.4 Appendix 5 Consent form

Student Identification Number:………………………….

Name:…………………………………………………………

Participation Identification Number for this Research:

CONSENT FORM

Title of Project: Indicators to Predict Numeracy performance in undergraduate Nursing students

Name of Researcher: Clare Carpenter-Timmis

Please initial box

1. I confirm that I have read and understand the information sheet dated ....(version ....) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my professional or legal rights being affected. ☐

3. I understand that relevant sections of any of my data and the data collected during the study may be looked at by responsible individuals from the University of Plymouth and the University of Essex or regulatory authorities as deemed appropriate, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my data. ☐

4. I agree to take part in the above study. ☐

___________________________	___________________	_______________________
Name of Participant	Date	Signature
___________________________	___________________	_______________________
Name of Person taking consent (If different from researcher)	Date	Signature
___________________________	___________________	_______________________
Researcher	Signature	Date

When completed, 1 for participant; 1 for researcher site file.

Any Further enquires please contact Clare Carpenter-Timmis 07813018280

7.5 Appendix 6 information sheet

Information sheet for pre-registration nursing students at the University of Plymouth. Undertaking research into Indicators to Predict Numeracy performance in undergraduate Nursing students

The higher education institute (in this case the university) that provides and runs the programme regulates the numeracy requirements for entry into pre-registration programmes. All students applying to the University of Plymouth for the pre-registration nursing programs are required to attain a Regulatory Qualification Framework level 2 qualification in numeracy. This could be a GCSE in mathematics or a level 2 mathematics qualification from an access course.

However, the Nursing and Midwifery Council who regulate nurses do not dictate what academic level of attainment a person registering with them needs to achieve, prior to registering or commencing pre-registration courses.

The aim of this research project is to explore the relationships between different things that relate to numeracy and how they potentially affect the ability of individuals to perform nursing numeracy. Nursing numeracy includes things like completing fluid charts, placing numbers on an observation chart, or drug calculations.

Why have I been chosen?

As a student on a pre-registration nursing course at the University of Plymouth, you are in a unique position of being an individual that holds all the elements that are required for this research project. By providing this data and participating in these tasks, it is hoped that it will provide evidence to help develop future entry requirements and programmes. Ensuring that they are designed to both widen participation for nursing programmes and increase supportive measures for our students.

Do I have to participate?

It is up to you to decide whether to take part. If you decide to take part, you will be asked to sign a consent form, to demonstrate your consent and awareness of what you are participating in, including your right to withdraw at any time. Regardless of this, if you wish to withdraw from the study at any time, you are free to do so and if you wish, all information you have given will be shredded/deleted or returned at your request. Decisions to withdraw at any time or a decision not to participate, will not in any way have a negative impact on your place or position within the pre-registration nursing programme, or any opportunities within that programme. You will not be treated with any prejudice by the university or any member of staff.

What is the purpose?

The purpose of this research is to ascertain if any relationships exist between numeracy qualifications, maths anxieties and an ability to complete nursing numeracy tasks. It is hoped that having this new information will help to establish what the needs of pre-registration students are, as well as future entry requirements of pre-registration nursing programmes.

What will happen? What type of study is it? In addition, how will I benefit?

You will be invited to attend a 1.5-hour introduction session during your first module where the project will be outlined. During this session, you will be given a participation information leaflet, a consent form, and a basic information sheet to complete if you chose to take part in the research. There are four stages to this research project, which will take place between September 2018 and November 2018.

- The first stage is to collect information about your numeracy qualification you have prior to entry to the programme and some generic information about gender and age.

- Secondly, you will be asked to complete a screening test to assess your current level of numeracy, this will be done on a computer, tablet, mobile phone, or other electronic device connected to the internet, during a class-based session. This should take about 1 hour of your time to complete.

- Thirdly, you will also be asked to complete a Maths anxiety screening tool, this will ask you to rate how you feel about certain aspects of mathematics and your experiences with mathematics. This should take no more than 10 minutes to complete.

- Finally, you will be asked to complete a nursing numeracy test. This aims to test your ability to apply numeracy principles to nursing numeracy tasks, like the ones described above in the introduction.

All this information will then be collated together, to see if there are any relationships between these elements or if one particular element affects people's ability to complete nursing numeracy.

All this data will be collated by Clare Carpenter-Timmis Chief Investigator and stored on an encrypted and password protected hard drive. Ensuring that your data is protected at all times. The data will then be inputted into a computer package programme and analysed, with the use of equations to assess its significance and explore relationships between each of the sections you have completed.

This will then generate information that will be discussed and analysed in the principle researcher's project, towards their professional doctorate qualification.

How much of my time will be taken up?

All activities will be part of your normal attendance hours for University and there will be no additional time requests placed upon you. Your appropriate programme leads, and module leads will be aware of this and support this use of time.

A breakdown of times include:

- 1.5-hour discussion section on the research projects and its commitments. If you decide to participate, you will be asked to complete a consent form and a basic data information sheet.
- A 1-hour numeracy screening computer-based programme
- 10 minutes Maths anxiety screening tool
- 1 hour nursing numeracy test (part of a formative submission for your first module)

Who will have access to this information?

Clare Carpenter-Timmis will have access to all the data collected, all such data will be stored electronically on an encrypted, and password protected hard drive. Any hard copy data will be securely locked within a designated filing cabinet at the address below.

All data collected will be anonymised for all participants with each individual being allocated a participant number. Only the principle researcher will have access to the correlating information that identifies the participant, with the sole purpose of this being to ensure that data can be matched together once collected. The data findings will be discussed with the principles researchers' supervisor during the analysis, but no identifiable factors will be given to the supervisor, just the data's findings.

The principle researcher being a lecturer on the Adult Nursing programme.

As the Principle researcher is an adult nurse lecturer on the programme, there is the possibility that they will mark academic submissions submitted by the participants. Participation or non-participation in this research project will have no negative impact on this marking process. Assignments submitted to the University are anonymously marked, so the principle researcher will be unable to identify any of the submissions, or how they relate to the participants, therefore the result cannot be influence or prejudiced in anyway.

What if something goes wrong?

It is not anticipated that this research carries a risk of physical or significant psychological harm, however if taking part in the study does harm you either physical or psychologically, there is no special compensation arrangements in place.

However, there are arrangements with the Universities student well-being services https://www.plymouth.ac.uk/student-life/services/learning-gateway/counselling

Who will be able to see you on a self-referral or written referral basis. Further information about this referral process can be obtained from the principle researcher.

If you are harmed due to someone else's negligence, then you may have grounds for legal action, but you may have to pay for this yourself. Regardless of this, if you wish to complain, or have any concerns about any aspect of the study then the normal University of Plymouth Complaints mechanisms, whistle blowing policy framework or grievance procedures will be available to you. As well as the University of Plymouths Ethics & Integrity Committee contactable on 01752 586992 email hhsethics@plymouth.ac.uk

Whilst collecting this data if an issue or incident of a serious nature is disclosed, whether it is personal or professional in nature, then the data reviewer Clare Carpenter-Timmis will identify the participant and seek to attain clarification. The participants will then be offered advice and guidance on how the individual should deal with the matter, including referral to the most appropriate person to assist with the matter; including the module lead/ programme lead or access to an appropriate impartial advisor or occupational health counselling service.

Any poor practice or evidence of foul play will be taken extremely seriously and dealt with by either your personal tutor or programme lead. This could lead to you being investigated and interviewed under the universities conduct and capability procedure and ultimately end in the removal of you from the nursing programme if this is deemed the most appropriate action. The researcher anticipates this to be highly unlikely, due to the nature of how the data being collected.

What will happen to the results of the study?

The results and recommendations will be published in the form of a professional doctorate thesis, submitted to the University of Essex as part of the researchers professional doctorate programme. A copy of the report will be available to you upon request from the researcher at the address detailed below.

For further information or queries, please contact

Clare Carpenter-Timmis

Lecturer, Adult Nursing,

207, 9 Portland Villas,

Plymouth University,

Plymouth PL4 8AA.

Phone No.07813018280

Chris **Green** PhD SFHEA

Placements and Employability Development Director

Programme Lead: Medical and Clinical Education

School of Health and Social Care (HSC)

University of Essex

T +44 (0)1206 874980

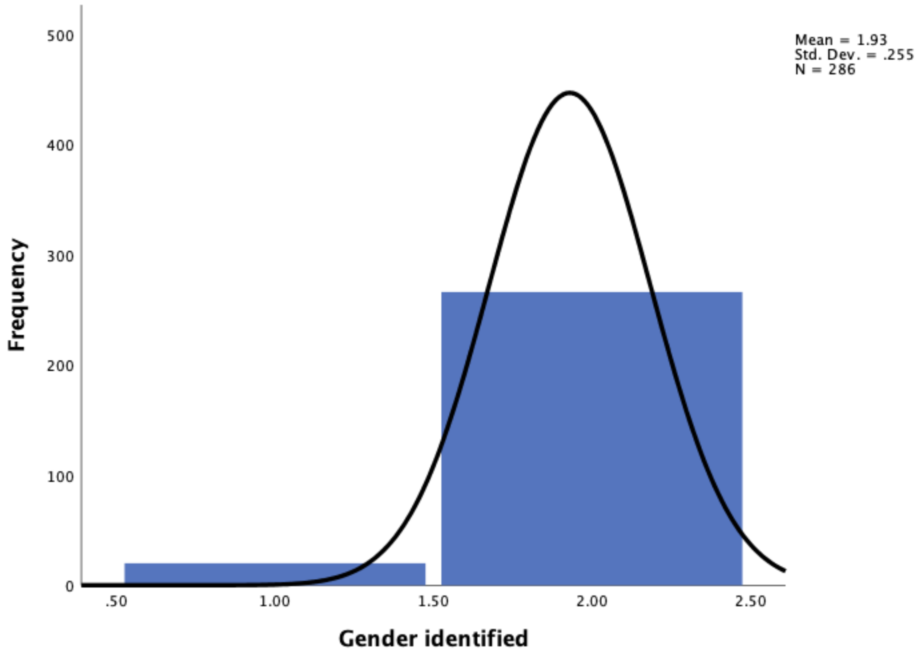
E cmgreeb@essex.ac.uk

7.6 Appendix 7 Coding data sheet

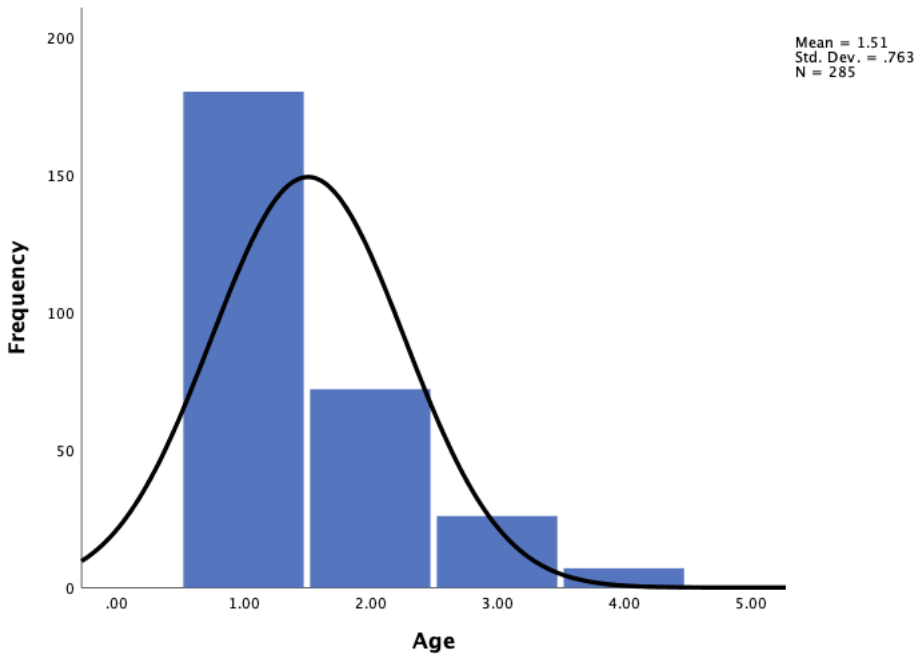
SPSS Name	Variable	Coding Instruction	Measurement Scale
ID	Identification Number	Number assigned to each survey	Scale
Sex	Sex	1=Males 2=Females 3=Nonbinary 4=Transexual	Nominal
Age	Age	1=18-24 2=25-34 3=35-44 4=45-54 5=55+	Ordinal Ages are in groups
Field	Field of Nursing	1=Adult 2=Child 3=Mental Health	Nominal
Maths	Highest level of Mathematic qualification achieved plus grade	1=GCSE A 2= GCSE B 3=GCSE C 4=GCSE D 5=GCSE E 6=AS Level 7=A level 8=Functional Skills level 1 9=Functional skills level 2 10=other Maths qualification gained outside England or the United Kingdom	Ordinal/Categorical
BKSB	Level achieved in screening test	1=Entry level 2 2=Entry level 3 3=Level 1 4=Level 2	Ordinal/Categorical
Anxiety	Mathematics anxiety screening tool	Number recorded on screening tool	Scale
Exam A	Nursing numeracy exam calculations	Result assigned according to number of correct answers	Scale
Exam B	Transferring of numbers	Result assigned according to number of correct answers	Scale
Overall Exam	Total score of exam	Result assigned according to number of correct answers	Scale

7.7 Appendix 8 Histograms and scatterplots

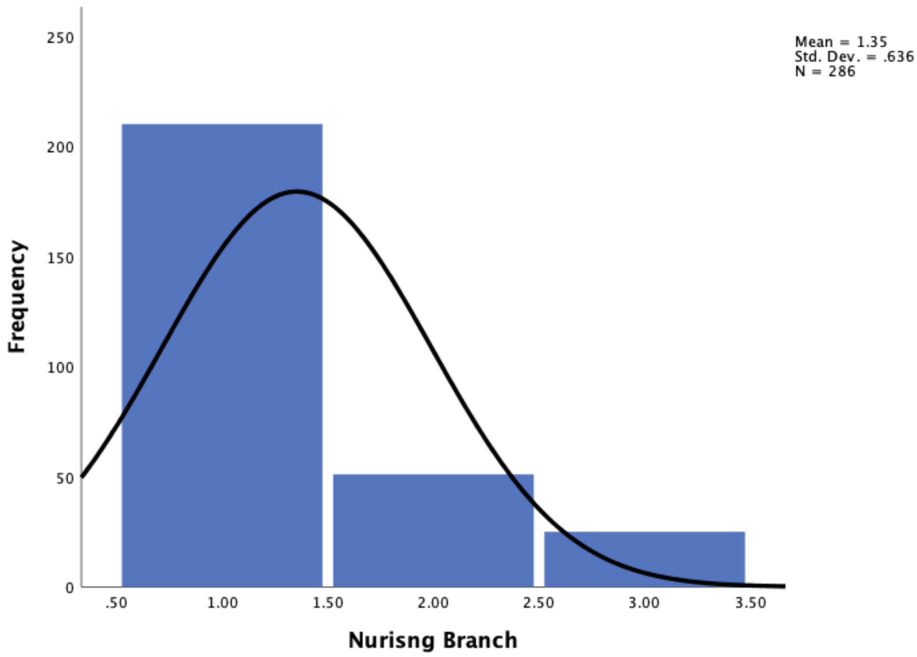
Sex



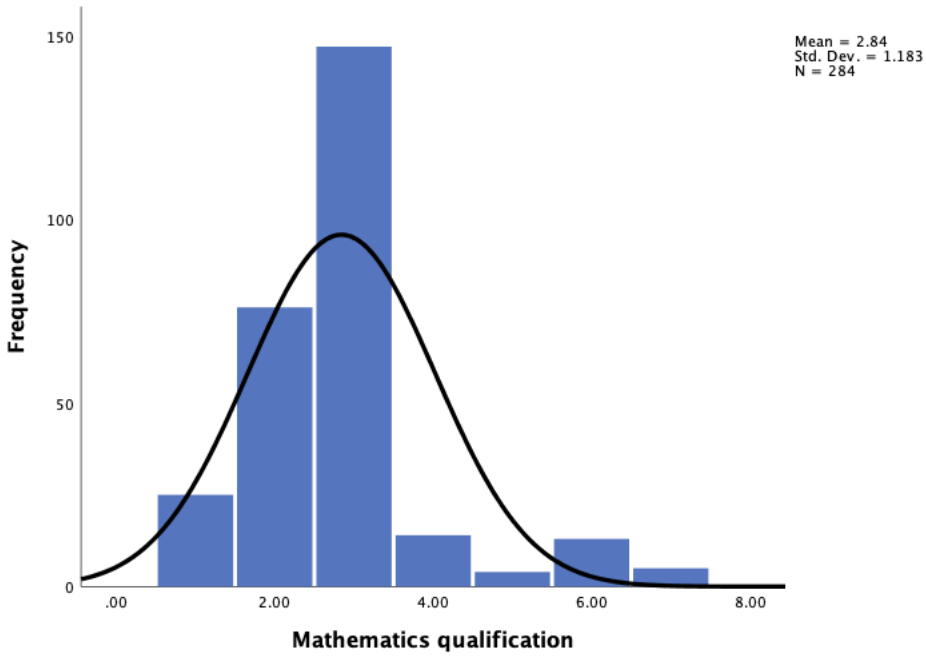
Age


Mean = 1.51
Std. Dev. = .763
N = 285
Frequency
200
150
100
50
0
.00
1.00
2.00
3.00
4.00
5.00
Age

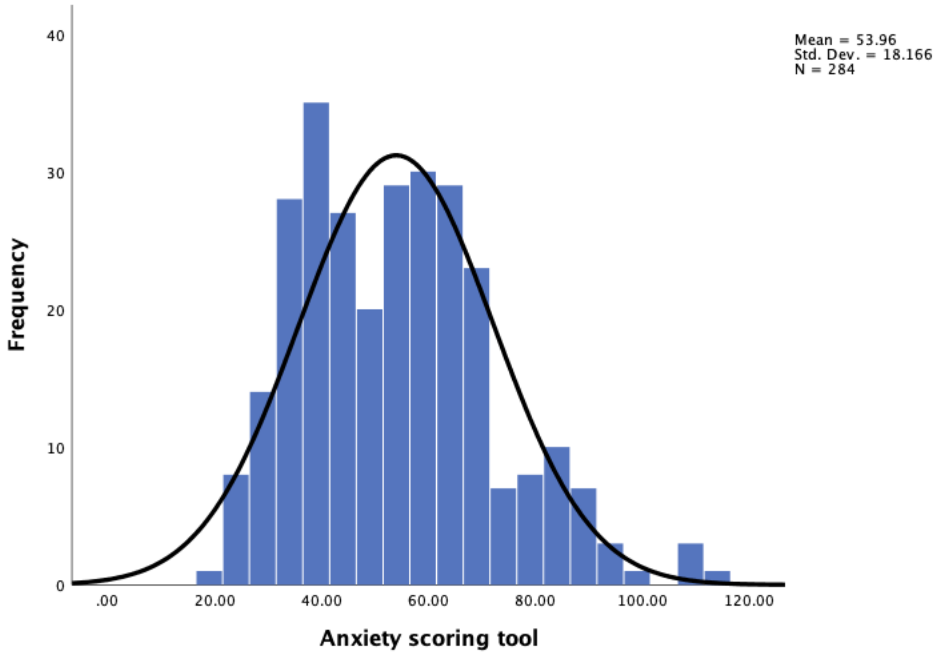
Nursing Branch



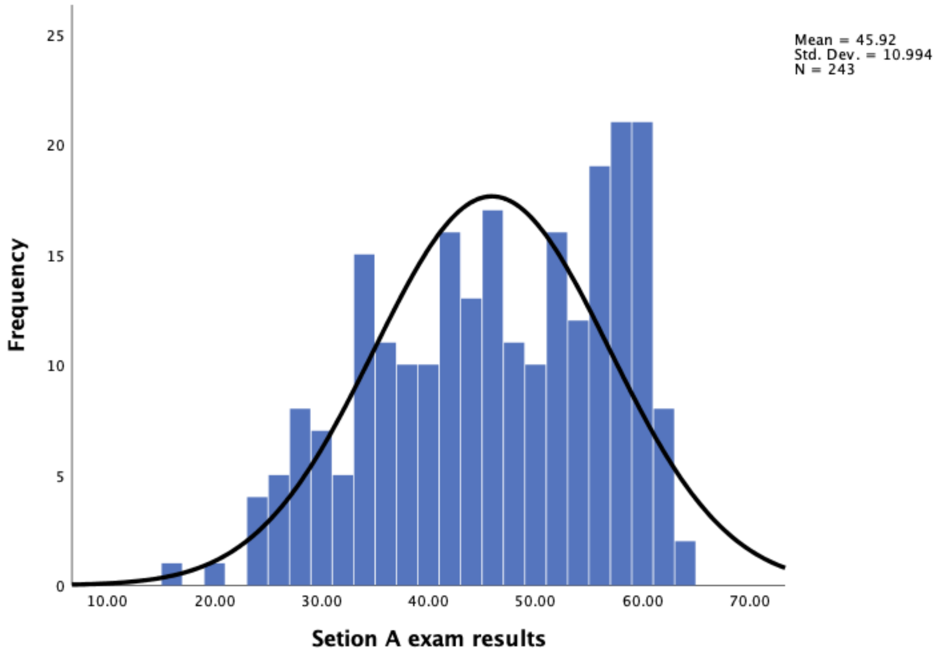
Mathematics qualification



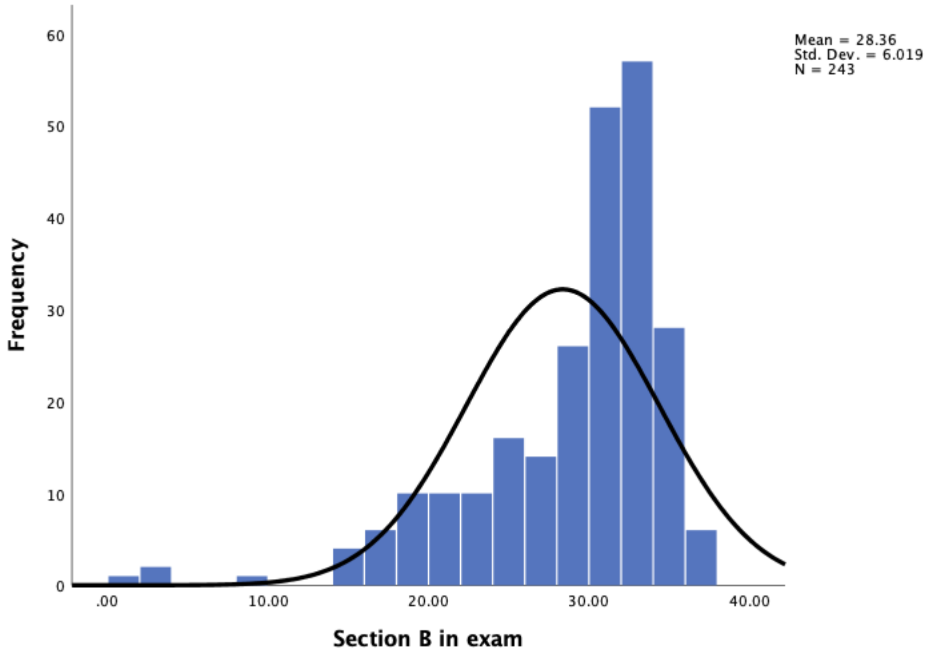
Anxiety score



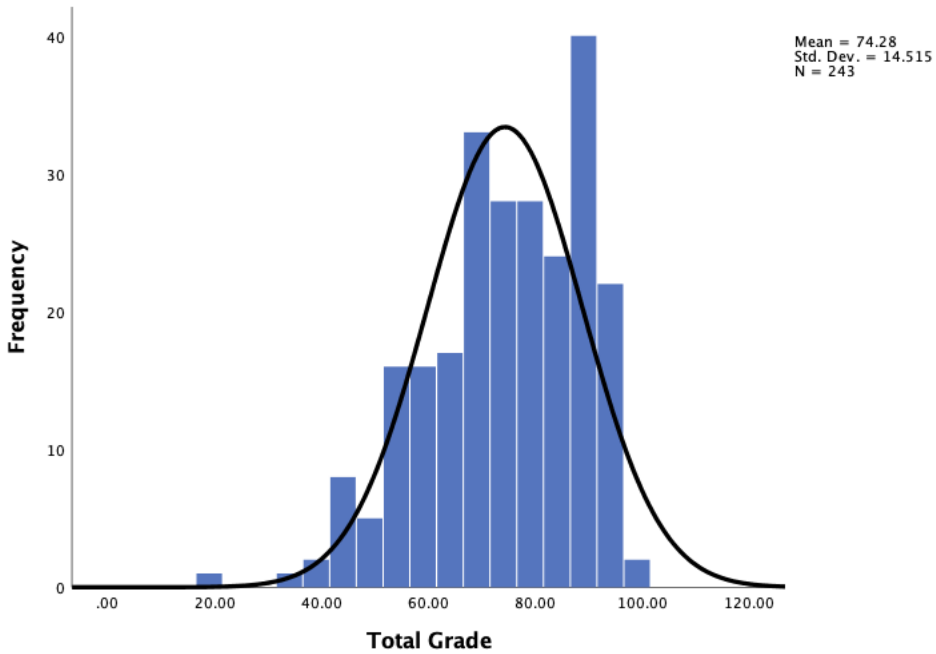
Section A


Mean = 45.92
Std. Dev. = 10.994
N = 243
Frequency
25
20
15
10
5
0
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Setion A exam results

Section B

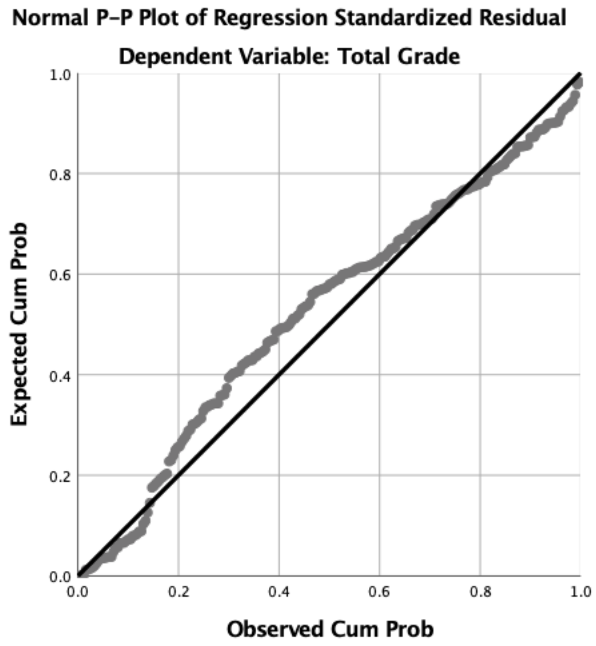

Mean = 28.36
Std. Dev. = 6.019
N = 243
Frequency
60
50
40
30
20
10
0
.00
10.00
20.00
30.00
40.00
Section B in exam

Total exam

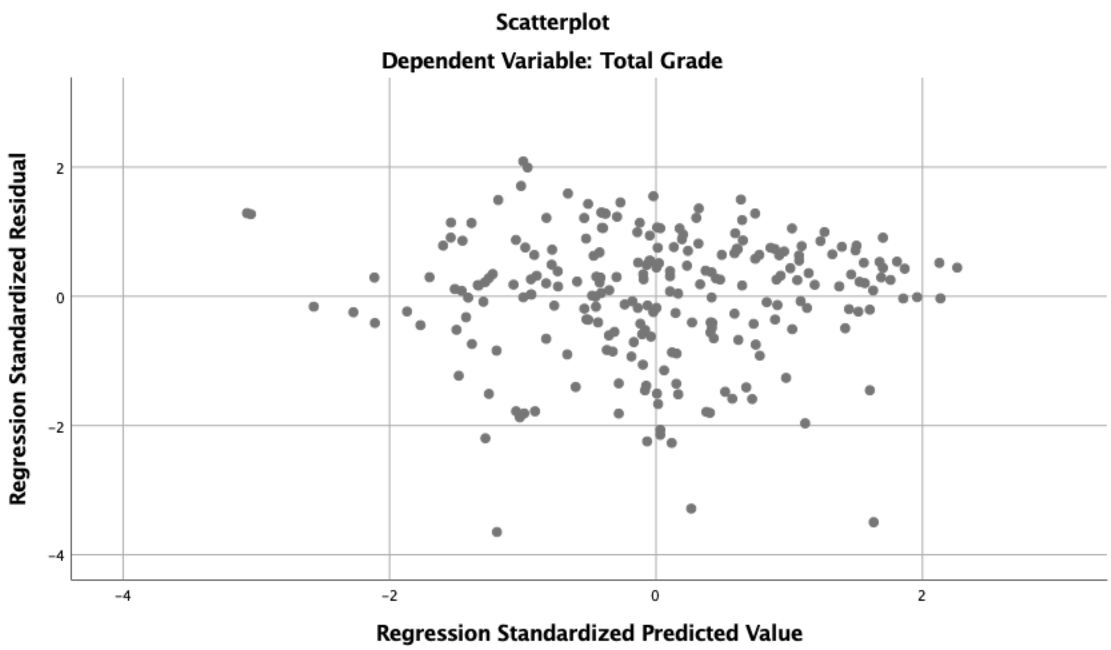


Mean = 74.28
Std. Dev. = 14.515
N = 243
Frequency
40
30
20
10
0
.00
20.00
40.00
60.00
80.00
100.00
120.00
Total Grade

Multiple regression PP plot



Scatter plot



7.8 Appendix 9 Literature table summary

Article reference	Study aims and design	Methods of data collection and analysis	Key findings	Comments
Thompson, R., Wylie, J., Mulhern, G., & Hanna, D. (2015). Predictors of numeracy performance in undergraduate psychology, nursing, and medical students. *Learning and Individual Differences*, *43*, 132–139. https://doi.org/10.1016/j.lindif.2015.08.008	Exploratory cohort study aiming to identify predictors of numeracy performance	Participants were requested to provide demographics and educational background information in the same measure as the attitudinal questions. four subscales from the Fennema-Sherman Mathematics Attitude Scale. Maths anxiety, motivation, usefulness, and confidence. In order to measure numeracy, a performance test was used. Consisting of 20 questions. Some questions entailed solving more than one problem, resulting in a total of 32 problems (items) for participants to answer. Each item was worth one point. Between them, these items measured six broad components of numerical knowledge: calculation involving decimals and fractions (9 items), algebraic reasoning (10 items), graphical interpretation (6 items), proportionality and ratio (3 items), probability and sampling (2 items) and estimation (2 items). These questions varied in format. For example, one item asked	Maths anxiety was the strongest affective predictor for psychology and nursing students, with motivation being more important for medical students. Across participant groups, pre-university maths qualifications were the strongest demographic/educational predictor of performance. The results can be used to suggest ways to improve performance in students having difficulty with numeracy-based modules.	Differences across specialisms Maths qualification is a key performance indicator Maths anxiety playing key role

		participants to solve 0.02 × 0.12. Statistical test Cronbach's alpha reliability coefficients and Pearson product–moment correlations		
Pettigrew, J., Stunden, A., & McGlynn, S. (2020). Contextualising numeracy skill development and assessment in a first-year undergraduate nursing subject: A mixed methods research study. *Nurse Education Today*, *92*, N.PAG. https://doi.org/10.1016/j.nedt.2020.104426	Mixed methods study aiming to understand the impact of contextualising numeracy skills and its impact on numeracy testing success. The aim of this study is to investigate the effect on undergraduate nursing students' learning performance and test performance of a practical, clinically contextualised numeracy workshop featuring individual and collaborative modes of assessment with numeracy related	Administration of individual and collaborative short-answer pre and post-tests, a survey, and facilitation of team-based, clinically related numeracy activities over a 1.5 h workshop. Statistical testing using R	Positive responses to survey questions probing students' judgement of the effect of contextualised learning on their confidence, engagement, and proficiency in nursing numeracy, as well as the value of working in a clinical setting. Significant improvement in students' performance in pre/post-tests.	Use of alternative ways of testing Teaching strategies for numeracy in nursing programmes Differing ways of completing final tests that may have influenced outcomes.

	sessions of 1.5 hours in weeks 12 and 14 of an undergraduate nursing programme			
Gregory, L. *et al.* (2019) 'The influence of mathematics self-efficacy on numeracy performance in first-year nursing students: A quasi-experimental study', *Journal of Clinical Nursing*, 28(19–20), pp. 3651–3659. doi:10.1111/jocn.14963.	To examine the factors that influence nursing students' mathematics self-efficacy, the effect of numeracy instruction on self-efficacy, and the association between self-efficacy and numeracy test performance	Using a quasi-experimental design, pretest–post-test survey data were collected at three time points: (a) Week 1 of unit commencement (baseline survey); (b) Week 6 (survey at the 6-week follow-up before first numeracy test); and (c) Week 7 (collection of numeracy test performance grades only). The paper followed the Strengthening the Reporting of Observational Studies (STROBE) checklist for cohort studies	This study showed that first-year nursing students with higher mathematics self-efficacy and those with higher grade point average were more likely to achieve a satisfactory mathematics grade in their first numeracy assessment related to medication administration. The study also provided evidence that a structured three-step pedagogical approach to teaching not only increased mathematics self-efficacy but also improved numeracy performance among first-year nursing students.	Three stage approach to teaching numeracy Foundation Practice Contextualisation
	To identify strategies and potential predictors	This mixed method study surveyed students (n=405) enrolled in their final semester	The study reinforced that nursing students preferred a 'hands-on,'	A paradigm shift from traditional testing methods to

Ramjan,LM, Stewart, L, Salamonson Y, Morris, MM, Armstrong, L , Sanchez, P, Flannery, L (2014) Identifying strategies to assist final semester nursing students to develop numeracy skills: A mixed methods study, Nurse Education Today, 34 (3), Pg 405-412	that may assist nurse academics to tailor their drug calculation teaching and assessment methods. This project builds on previous experience and explores students' perceptions of newly implemented interventions designed to increase confidence and competence in medication calculation.	of study at a large, metropolitan university in Sydney, Australia. Tailored, contextualised interventions included online practice quizzes, simulated medication calculation scenarios developed for clinical practice classes, contextualised 'pen and paper' tests, visually enhanced didactic remediation, and 'hands-on' contextualised workshops. Surveys were administered to students to determine their perceptions of interventions and to identify whether these interventions assisted with calculation competence. Test scores were analysed using SPSS v. 20 for correlations between students' perceptions and actual performance. Qualitative open-ended survey questions were analysed manually and thematically.	contextualised approach to learning that was 'authentic' and aligned with clinical practice. Our interventions assisted with supporting students' learning and improvement of calculation confidence. Qualitative data provided further insight into students' awareness of their calculation errors and preferred learning styles. Some of the strongest predictors for numeracy skill performance included (1) being an international student, (2) completion of an online practice quiz, scoring 59% or above and (3) students' self-reported confidence. .	the implementation of intensive, contextualised numeracy teaching and assessment within tertiary institutions will enhance learning and promote best teaching practices Idea around implementation for differ testing methods and structures for numeracy delivery.
Roberts S, Campbell, A (2017) Striving for a good standard of maths for potential	Small scale exploration of study of one cohort of	Analysis of descriptive data from potential student applicants undertaking a screening process to enter a	Lack of numerical ability was found to not only be a problem for pre-registration nursing	Limited exploration and literature review. Not generalisable

student nurses *British Journal of Nursing* 26 (1): 32-36	child health students	pre-registration nursing programme.	programmes but also for a third of all undergraduate students. Numerical skill was found to impact the results of the entry-level numerical test as candidates with GCSE grade B performed better than their counterparts with a grade C. Centralised numerical testing for all pre-registration student nurses should be considered as this will provide a standardised approach and an equitable experience and is something that could be further explored.	While it is recognised within the literature that anxiety and lack of confidence appears to inhibit numerical success it was not possible for the University to measure this within this small-scale study.
Xu, C., Di Lonardo Burr, S. and LeFevre, J.-A. (2023) 'The hierarchical relations among mathematical competencies: From fundamental numeracy to complex mathematical skills', Canadian Journal of Experimental Psychology / Revue canadienne de psychologie expérimentale [Preprint].	The study, tested an expanded hierarchical symbol integration (HSI) model by examining the hierarchical	Statistical analysis and testing	Adults' addition and subtraction skills predict their multiplication and division skills, their multiplication and division skills predict their fraction performance, and	Foundations of knowledge and application to more complex mathematics calculations.

doi:10.1037/cep0000311.supp (Supplemental).	relations among mathematical skills		fraction performance predicts algebra.	Relationships between addition and multiplication abilities.
Schultz, C.M. et al. (2023) ‘A multisite transition to nursing program: an innovative approach to facilitate incoming nursing students’ academic success’, International Journal of Nursing Education Scholarship, 20(1), pp. 1–11. doi:10.1515/ijnes-2022-0016.	Evaluation of the effectiveness of a multisite program promoting the successful transition of baccalaureate and graduate entry (with a prior degree) students into pre-licensure curricula. Faculty concern around nursing students’ successful completion of nursing programs and passage of the nursing licensure exam stems from challenges students encounter in core courses, study habits, and civility	Quasi-experimental pre-post-test mixed-methods study. Students completed content modules and open-ended surveys.	Students found the program helpful. Statistically significant improvements were shown in medication calculation, reading comprehension, and medical terminology. No statistically significant improvement was shown in anatomy and physiology	Students had limited improvement with simulation skills and felt these did not always help
Wennberg-Capellades, L. et al. (2022) ‘Where do nursing students make mistakes when calculating drug doses? A retrospective study’, BMC Nursing, 21(1),	A descriptive retrospective study where all the examination papers that included at	Random sample of papers covering all the different exams. In the absence of an existing rubric for classifying errors, two members of the	A total of 285 exam papers including 1034 calculation exercises were reviewed. After excluding those that had	Most common errors were related to unit conversion, more complex concepts such as maximum

pp. 1–11. doi:10.1186/s12912-022-01085-9.	least one dose calculation exercise were reviewed. All papers were submitted over two academic years (2017-18 and 2018-19) completed by students from years 1, 2, and 3 of a nursing degree program at our university	research team, working independently, initial content analysis completed to identify different types of error made by students in each exercise. This process yielded a consensus list of 23 categories that were used to analyse the total sample of papers Final analysis, was distributed among pairs of researchers, first reviewing them individually before comparing and discussing their evaluation with that of the co-evaluator, to reach a consensus decision. Papers were coded so that only the evaluator knew the identity of the student. Error was checked.	been left blank, a total of 863 exercises were analysed in detail. A correct answer was given in 455 exercises (52.7%), although this varied enormously depending on the type of exercise: 89.2% of basic dose calculations were correct, compared with just 2.9% of those involving consideration of maximum concentration.	concentration and minimum dilution, or failure to contextualize the answer to the clinical case. Other frequent errors involved not extracting the key information from the question, not including the units when giving their answer, and not understanding the question
Stake-Nilsson, K. et al. (2022) 'Medication dosage calculation among nursing students: does digital technology make a difference? A literature review', BMC Nursing, 21(1), pp. 1–11. doi:10.1186/s12912-022-00904-3.	Literature review aiming to identify and critically evaluate research investigating how the use of digital technologies informs the development of nursing students' MDC skills	A systematic literature review was performed within Scopus (Elsevier), Academic Search Elite (Ebsco), Cinahl (Ebsco), ERIC (Ebsco), Web of Science and PubMed. Research papers on MDC using digital technologies were considered for inclusion	Use of digital technologies can reduce nursing students' medication errors. Interestingly, web-based courses were the most commonly used digital technologies aimed at developing nursing students' Medication Dosage Calculation skills	Literature review so content used to snowball articles or relevance and seek out primary peer review research.

Khasawneh, E., Gosling, C. and Williams, B. (2021) 'What impact does maths anxiety have on university students?', BMC psychology, 9(1), p. 37. doi:10.1186/s40359-021-00537-2.	A scoping review utilising Arksey and O'Malley framework six methodological steps: identifying the research question, identifying relevant studies, selecting studies, charting the data, collating, summarising, and reporting the results and consulting experts	The scoping approach systematically mapped and reviewed existing literature on what impacts maths anxiety at university both peer-reviewed research and the non-peer reviewed literature.	Maths anxiety is an issue that effects many disciplines across multiple countries and sectors. Developing anxiety toward maths might be affected by gender; females are more prone to maths anxiety than males. Maths confidence, maths values and self-efficacy are related to self-awareness. Improving these concepts could end up with overcoming maths anxiety and improving performance.	Notes on gender and female dominated profession
Barroso, C. et al. (2021) 'A meta-analysis of the relation between math anxiety and math achievement', Psychological Bulletin, 147(2), pp. 134–168. doi:10.1037/bul0000307.supp (Supplemental).	To gain an understanding of how to improve achievement in mathematics and the impact of mathematics anxiety. Focusing on demographic characteristics of gender, race/ethnicity, country, or grade level moderated the	Meta analysis, using Ma' meta-analytic search techniques plus contacting the Cognitive Development Society (CDS) to look for unpublished works around maths anxiety and achievement Pearson coefficient and metafor package from the statistical program R	223 studies included in the present meta-analysis consisted of 747 correlation coefficients from 332 independent samples with approximately 385,441 individual participants	Date range limited research accessed.

	relation between math anxiety and math achievement			
Khasawneh, E., Gosling, C. and Williams, B. (2020) 'The Correlation between Mathematics Anxiety, Numerical Ability and Drug Calculation Ability of Paramedic Students: An Explanatory Mixed Method Study', Advances in medical education and practice, 11, pp. 869–878. doi:10.2147/AMEP.S258223.	Exploratory mixed methods To explore the relationship between numerical ability, math anxiety and drug calculation performance and the factors that contribute to drug calculation ability among paramedic students	A sequential explanatory mixed-method approach that included a paper-based questionnaire followed by face-to-face interviews. The participants completed a 30-minute survey composed of demographics, the 10-item Mathematics Anxiety Rating Scale (MARS), a 12-question numerical ability test (NAT) and a 9-question drug calculation ability test (DCAT) and then were invited for a structured interview	Drug calculation is fundamental in paramedic practice. It is affected by the numerical ability of the students and is negatively and indirectly impacted by mathematics anxiety. Modifications of a paramedic program curriculum can improve student's ability to think critically and to overcome medication dosage problems. Emerging themes: Impact of technology, classmates' impact, mathematics competence and experiencing a mental block	Numerical ability was one of the factors that contributed to the low drug calculation ability scores.
Basak, T. et al. (2016) 'Effectiveness of the training material in drug-dose calculation skills', Japan Journal of Nursing Science, 13(3), pg. 324–330. doi:10.1111/jjns.12112.	Quasi experimental design that aimed to evaluate the effectiveness of the training material based on low-level	Quasi experimental on one group of students. 82 participants using a paired sample t test for analysis.	This study revealed that the training material based on low-level environmental fidelity simulation positively impacted accurate drug-	Reliability and validity analysis was not performed

	environmental fidelity simulation in drug-dose calculation skills in senior nursing students		dose calculation skills in senior nursing students.	
Guneş, U.Y., Baran, L. and Yilmaz, D. (Kara) (2016) 'Mathematical and Drug Calculation Skills of Nursing Students in Turkey', *International Journal of Caring Sciences*, 9(1), pg 220–227.	A descriptive and cross-sectional design, to investigate the mathematical and drug dose calculation skills of nursing students.	128 nursing students participated in the study. Validated numerical and drug calculation tests were given to senior-year nursing students. demographic data form was used for data collection. SPSS chi-square test and Pearson's correlation analysis were used for analysis of the data and the number and percentage distributions	Median mathematical skill scores were 50%, ranging between 0% and 100%. Drug dose calculation scores varied between 10% and 100%, median 60%. Of the 128 students, 36.4% scored below 60%, and 82.9% scored below 80%. This study indicates that nursing students have poor mathematical and drug dose calculation skills	38.9% response rate
Sulosaari, V. *et al* (2015) 'Factors associated with nursing students' medication competence at the beginning and end of their education', *BMC medical education*, 15, p. 223. doi:10.1186/s12909-015-0513-0.	Descriptive, correlational study design with a structured instrument including a set of potential associated factors, knowledge test,	Data was analysed statistically. Evaluate the theoretical, practical, and decision-making competence of nursing students and to identify factors associated with their	The core elements of medication competence are significantly interrelated, highlighting the need to provide integrated and comprehensive medication education	

	medication calculation test and patient vignettes. Participants were nursing students at the beginning (n = 328) and at the end of their education (n = 338).	medication competence at the beginning and end of their education.	throughout the undergraduate education. Students' learning style is associated with medication competence. There is a need for methods to identify and support students having difficulties to self-regulate their learning	
Savage AR (2015) Educational audit on drug dose calculation learning in a Tanzanian school of nursing. *African health sciences*. 15(2):647-655. doi:10.4314/ahs.v15i2.44	Aim of the study- educational audit on drug dose calculation learning in a Tanzanian school of nursing. Assessment of the learning from targeted teaching, identification of problem areas in performance and identification of ways in which these problem areas might be addressed	A total of 268 registered nurses and nursing students in two-year groups of a nursing degree programme were the subjects for the audit; they were given a pretest, then four hours of teaching, a post-test after two weeks and a second post-test after eight weeks. Statistical analysis	There was a statistically significant improvement in correct answers in the first post-test, but none between the first and second post-tests. Particular problems with drug calculations were identified by the nurses / students, and the teacher; these identified problems were not congruent	Audit-background information Significant encouragement of students to work hard that could have skewed results. Significant changes in test scores between pre and post tests
Alomari, A. *et al* (2015) 'Families, nurses and organisations contributing factors to medication administration error in	To explore the factors involving nurses, families and	Medline, Embase, CINAHL and the Cochrane library. The	Factors contributing to medication administration errors are	Literature review Strategies that were reported to reduce

paediatrics: a literature review', *International Practice Development Journal*, 5(1), pp. 1–14. doi:10.19043/ipdj.51.007.	healthcare systems that impact on medication administration errors in paediatric patients	title, abstract and full article were reviewed for relevance	communication failure between the parents and healthcare professionals, nurse workload, failure to adhere to policy and guidelines, interruptions, inexperience, and insufficient nurse education from organisations	errors were double-checking by two nurses, implementing educational sessions, use of computerised prescribing and barcoding administration systems Not pre reg
Simonsen, B.O. *et al.* (2014) 'Differences in medication knowledge and risk of errors between graduating nursing students and working registered nurses: comparative study', *BMC health services research*, 14, p. 580. doi:10.1186/s12913-014-0580-7.	Comparison of two cross-sectional studies with an aim of the study was to compare medication knowledge, certainty, and risk of error between graduating bachelor students in nursing and working registered nurses	Bachelor students in closing term and registered nurses with at least one year job experience underwent a multiple-choice test in pharmacology, drug management and drug dose calculations: 3x14 questions with 3–4 alternative answers (score 0–42). Certainty of each answer was recorded with score 0–3, 0–1 indicating need for assistance. Risk of error was scored 1–3, where 3 expressed high risk: being certain that a wrong answer was correct	Medication knowledge among experienced nurses was superior to bachelor students in nursing, but nevertheless insufficient. As much as 25% of the answers to the drug management questions would lead to high risk of error. More emphasis should be put into the basic nursing education and in the introduction to medication procedures in clinical practice to improve the nurses' medication knowledge	Interesting understanding of pre-registration issues but not so applicable to the overall pre reg forum.

		Chi-square or Fishers exact test; t-test or Mann-Whitney U-test; ANOVA or Kruskal-Wallis; and Pearson or Spearman tests for correlation	and reduce the risk of error	
Stolic, S. (2014) ‘Educational strategies aimed at improving student nurse’s medication calculation skills: A review of the research literature’, *Nurse Education in Practice*, 14(5), pp. 491–503. doi:10.1016/j.nepr.2014.05.010.	Integrative review of the literature using a nonexperimental design in which information derived from primary research is systematically considered	• Related to student nurse or nursing student • Related to medication or drug calculation or dosage or numeracy • Published between 1990 and 2012 • Hypothesis tested Included educational strategies and written in English Exclusion criteria were as follows: • Not abstract and • Not repeated		Literature search
Hemingway, S et al (2014) ‘Mental health and learning disability nursing students’ perceptions of the usefulness of the objective structured clinical examination to	Evaluate mental health and learning disability nursing students'	A 10-item survey questionnaire was used, comprising open- and closed-response questions	The OSCE was rated highly compared to other theoretical assessments; it was also reported as	Noted the types of assessment that reflects the reality of assessing

assess their competence in medicine administration', *International Journal of Mental Health Nursing*, 23(4), pp. 364–373. doi:10.1111/inm.12051.	perceptions of the usefulness of the objective structured clinical examination (OSCE) in assessing their administration of medicine competence	Thematical analysis	clinically real and as a motivational learning strategy However, it did not rate as well as clinical practice. Content analysis of written responses identified four themes: (i) benefits of the OSCE; (ii) suggestions to improve the OSCE; (iii) concern about the lack of clinical reality of the OSCE; and (iv) OSCE-induced stress. The themes, although repeating some of the positive statistical findings, showed that participants were critical of the university setting as a place to conduct clinical assessment, highlighted OSCE-related stress, and questioned the validity of the OSCE as a real-world assessment	competence of medication administration.
Barra, M. (2013) 'The effect of medical mathematics retention strategies in decreasing attrition rate among African	The aim of the study was to examine African	Quasi experimental	The majority of students who failed the course were African American,	Interesting aspect of work about ethnicity and race

American licensed practical nursing students in a community college', *Journal of cultural diversity*, 20(3), pp. 125–133.	American students entering the Practical Nursing program and the strategies of medical mathematics bridge and tutoring programs to reduce attrition		and failure was found, for the most part, to be due to not being able to master the medical mathematics component on the exams. The retention rate in Nursing Fundamentals was found to be a predictor of success and had a correlative effect on the overall graduation rate of minority LPN students especially among those of African American descent. Some initiative was needed to reverse this trend.	Interesting aspect around fundamentals testing.
Wright, K. (2013) 'The role of nurses in medicine administration errors', *Nursing Standard*, 27(44), pp. 35–40. doi:10.7748/ns2013.07.27.44.35.e7468.	This article explores the commonly held belief that nurses are to blame for the high rate of medication administration errors in health care. Looking at a way forward to move	Literature review	Discusses the approaches of papers to present evidence on medication administration errors that include prospective chart review, direct observation, and error reports.	Article piece Some useful background discussion

	away from a culture of blame and to consider changes to medicine and the increasing complexity of administration as potential reasons for error. Medicine administration should be viewed within the wider context of health care rather than as an isolated process in order to develop effective solutions to reduce medicine-related errors.			
Leufer, T. and Cleary-Holdforth, J. (2013) ‘Let’s do no harm: Medication errors in nursing: Part 1’, *Nurse Education in Practice*, 13(3), pp. 213–216. doi:10.1016/j.nepr.2013.01.013.	Illuminate the extent and severity of the problem of medication errors in practice and to explore elements within the practice setting that can compound the	Literature review	Highlighted problems with medication errors in healthcare practice and the worrying trends around this area. Medication management is one of the functions in healthcare that is clearly multidisciplinary, and	Discussion literature review. General immersion into the topic area

	problem. The multi-faceted nature of the problem will also be considered.		therefore collaborative, in nature. However, from a nursing context, medication management is one of the most labour intensive and potentially one the most risk-laden duties undertaken in the provision of patient care.	
Cleary-Holdforth, J. and Leufer, T. (2013) 'The strategic role of education in the prevention of medication errors in nursing: Part 2', *Nurse Education in Practice*, 13(3), pp. 217–220. doi:10.1016/j.nepr.2013.01.012.	A discussion on key clinical and educational strategies to combat medication errors	Discussion of the current literature	Increasing educational opportunities to explore medication calculations and administrations. HEI's integrating this from the very beginning of pre-registration programmes.	Literature review
Young, S., Weeks, K.W. and Hutton, B.M. (2013) 'Safety in numbers 1: Essential numerical and scientific principles underpinning medication dose calculation', *Nurse Education in Practice*, 13(2), pp. e11-22. doi:10.1016/j.nepr.2012.10.012.	To understand the essential applied numerical knowledge skills and the wider pharmacological principles required to meet the MDC-PS requirements of professional nursing practice.	Discussion of current literature	The findings inform nurse education practice via advancing our understanding of unified taxonomy of generic numerical competencies mapped to the 42 revised UK Nursing and Midwifery Council (NMC) Essential Skills Clusters	Good application to last NMC standards

	To identify: a. Provide a definition of numeracy. b. Articulate the relationship between numeracy, healthcare numeracy, medicines management and medication dosage calculation. Present a unified taxonomy of generic numerical competencies and examples of representative medication dosage calculation computation requirements mapped to the 42 NMC ESC. Review the esoteric symbols and			

	measurement units that represent important components of calculation competence in healthcare and medicines management practice. Outline the fundamental pharmacokinetic knowledge that explains how the body deals with medication; and illustrates through clinical correlations why numeric and scientific knowledge and skills must be mastered to ensure safe medicines management practice.			
Weeks, K.W. *et al.* (2013) 'Safety in numbers 2: Competency modelling and diagnostic error assessment in medication	The aim of this paper was to explore		The combination of didactic transmission methods of education	

dosage calculation problem-solving', *Nurse Education in Practice*, 13(2), pp. e23-32. doi:10.1016/j.nepr.2012.10.013	competence in MDC-PS. Illustrating the design of an MDC-PS competence model that articulates the relationship between the conceptual, calculation and technical measurement facets of MDC-PS competence. Allowing for the diagnosis of errors in three competence domains. Describe how the traditional classroom-based transmission models of education, as well as the proceduralisation of the medicines management process in clinical		and the 'proceduralisation' of medicines management in practice settings generates a theory practice gap. The need to define, articulation, development, assess, and evaluate competence are central to maintaining patient safety and education practice in the domain of medication dosage calculation problem-solving Facilitation of teaching and learning in calculation competence requires considerations and demands from both the learner and facilitator regardless of whether the learning takes place in practice or in classrooms. The literature continuation of reported medication errors relating to a lack	

	practice generate a theory practice gap and contribute to MDC-PS conceptual errors. Explore the origin of calculation errors and offer an assessment tool to assist diagnosis of errors in calculation that manifest as MDC-PS arithmetical operation and computation errors.		of calculation competence in healthcare practice in order to construct MDC-PS competence we must dispense with reductionist approaches that focus on calculation skill development in isolation. The need to co-locate conceptual, calculation and technical measurement competence development and assessment within authentic learning and diagnostic assessment environments is critical to solving this ubiquitous problem.	
Weeks, K.W. et al. (2013c) 'Safety in numbers 4: The relationship between exposure to authentic and didactic environments and Nursing Students' learning of medication dosage calculation problem solving knowledge and skills', *Nurse Education in Practice*, 13(2),	Outcomes of UK PhD and USA post-doctorate experimental research. Evaluating the relationship between exposure	Proof of concept study 1. Random assignment of subjects to experimental conditions. 2. At least one control group.	A highly significant relationship between exposure to authentic learning environments and construction of medication dosage calculation schema than that demonstrated	Use of authentic world two countries involved in the study.

pp. e43-54. doi:10.1016/j.nepr.2012.10.010.	to traditional didactic methods of education, prototypes of an authentic medication dosage calculation problem-solving (MDC-PS) environment and nursing students' construction of conceptual and calculation competence in medication dosage calculation problem-solving skills	3. Clear and unambiguous specifications of the manipulation of an independent variable.	following sole exposure to traditional didactic methods.	
Sabin, M. *et al.* (2013) 'Safety in numbers 5: Evaluation of computer-based authentic assessment and high fidelity simulated OSCE environments as a framework for articulating a point of registration medication dosage calculation benchmark', *Nurse Education in Practice*, 13(2), pp. e55-65. doi:10.1016/j.nepr.2012.10.009.	ON key educational initiative undertaken by NHS Education for Scotland (NES), based upon recommendations from a 'Numeracy in Healthcare' consultation. Discussing the design of a web-based technical measurement authentic	63 third-year pre-registration nursing students was recruited from four participating universities in the UK. Counterbalanced design was employed where the virtual authentic assessment environment was evaluated for internal consistency reliability and criterion-related validity against an objective structured clinical assessment (OSCE) undertaken in high-	Concluded that the combination of a web-based authentic assessment environment and further assessment of safe technical measurement interpretation and dexterity in a practice/practice simulation setting, populated with a benchmark and a criterion referenced rubric validated by the	Multiple uses of assessments

	assessment environment evolved from the safe Medicate suite of programs. Providing a model for an environment within which a medication dosage calculation problem-solving (MDC-PS) benchmark could be articulated.	fidelity simulated clinical environments	profession, is an innovative, viable, valid, and reliable assessment method for the safe administration of medicines.	
Weeks, K.W. *et al.* (2013d) 'Safety in Numbers 7: veni, vidi, duci: A grounded theory evaluation of nursing students' medication dosage calculation problem-solving schemata construction', *Nurse Education in Practice*, 13(2), pp. e78-87. doi:10.1016/j.nepr.2012.10.014.	Evaluation of nursing students' transition through schemata construction and competence development in medication dosage calculation problem-solving (MDC-PS)	Grounded theory from interview data reflecting on the experiences and perceptions of two groups of undergraduate pre-registration nursing students: eight students exposed to a prototype authentic MDC-PS environment and didactic transmission methods of education and 15 final year students exposed to the safeMedicate authentic MDC-PS environment	Classroom-based 'chalk and talk' didactic transmission environments offered multiple barriers to accurate MDC-PS schemata construction among novice students. While conversely it was universally perceived by all students that authentic learning and assessment environments enabled MDC-PS schemata construction through facilitating: 'seeing' the	Use of multiple methods of teaching. Didactic limited application.

			authentic features of medication dosage problems; context-based and situational learning; learning within a scaffolded environment that supported construction of cognitive links between the concrete world of clinical MDC-PS and the abstract world of mathematics; and confidence-building in their cognitive and functional competence ability	
McMullan, M., Jones, R. and Lea, S. (2012) ‘Math anxiety, self-efficacy, and ability in British undergraduate nursing students’, *Research in Nursing & Health*, 35(2), pp. 178–186. doi:10.1002/nur.21460.	Study, involving 229 second year British nursing students, exploring the influence of mathematics anxiety, self-efficacy, and numerical ability on drug calculation ability, and determined which	A cross-sectional research design was used with a convenience sample of all the second-year undergraduate nursing students (n 1⁄4 229) attending a British University	Strong significant relationships ($p < .001$) existed between anxiety, self-efficacy, and ability. Students who failed the numerical and/or drug calculation ability tests were more anxious ($p < .001$) and less confident (p .002) in performing calculations than those who passed. Numerical ability made the	British students only

	factors would best predict this skill.		strongest unique contribution in predicting drug calculation ability (beta 1⁄4 0.50, p < .001) followed by drug calculation self-efficacy (beta 1⁄4 0.16, p 1⁄4 .04). Early testing is recommended for basic numerical skills. Faculty are advised to refresh students' numerical skills before introducing drug calculations	
Dyjur, L., Rankin, J. and Lane, A. (2011) 'Maths for medications: an analytical exemplar of the social organization of nurses' knowledge', *Nursing Philosophy*, 12(3), pp. 200–213. doi:10.1111/j.1466-769X.2011.00493.x.	To explore literature that circulates in the discourses organizing nursing education, exploring the embedded assumptions that links to student performance on maths examinations to safe medication practices	Literature review	Numeracy skills serve as powerful distraction for both students and teachers. Operating under specious claims of safety and objectivity. Nurse educators, captured by taken-for-granted understandings of practices intended to produce safety. We contend that some of these practices are not congruent with how	Literature review, for discussion purposes

			competency unfolds in the everyday world of nursing practice. Ontologically grounded in the materiality of work processes, we suggest there is a serious disjuncture between educators' assessment and evaluation work where it links into broad nursing assumptions about medication work	
Sherriff, K., Wallis, M. and Burston, S. (2011) 'Medication calculation competencies for registered nurses: a literature review', Australian Journal of Advanced Nursing, 28(4), pp. 75–83. Available at:	To describe the literature that focuses on safe administration of medications, medication calculation skills development and maintenance of ongoing competence in nurses	Literature review	The theoretical literature focuses on drug administration errors, development of tools and techniques to improve nurses' medication calculation skills and guidelines. Debating nurses' self-perception of their arithmetical skills, their educational needs in this area and the relationship between skill level and patient outcomes. Empirical literature focuses on the incidence of	Further research is required to determine the robustness of the current processes to assess nurses' medication calculation competence and ensure optimal patient safety

			errors, evaluation of medication calculation skills; the relationship between test results and errors, effectiveness of strategies to improve medication calculation skills and medication calculation testing and policy. Course content and delivery are thought to influence safe medication administration; however, there has been a lack of rigorous research demonstrating the efficacy of educational models. Several studies report low levels of calculation proficiency in nurses; however, it is unclear whether medication calculation testing affects medication administration error rates.	
Hemingway, S., Stephenson, J. and Allmark, H. (2011) 'Student experiences of	Reports on research involving	Literature review and questionnaire	Results showed an overall satisfaction with	

medicines management training and education', *British Journal of Nursing*, 20(5), pp. 291–298. doi:10.12968/bjon.2011.20.5.291.	midwifery and nursing students, who were asked to complete a questionnaire related to their experiences of medicines-related training and education, and how it prepared them for practice		the pre-registration delivery, but differences emerged in the perceived efficacy of different educational strategies Clinically based and simulated aspects of the programme delivery were highly rated, with theoretical delivery scoring poorly in contrast. A stepped approach is suggested, with medicine course delivery needing to be strongly highlighted as a lead up to safe and competent nursing interventions when administering medication and all other related interventions	
McMullan, M., Jones, R. and Lea, S. (2010) 'Patient safety: numerical skills and drug calculation abilities of nursing students and Registered Nurses', *Journal of Advanced Nursing (John Wiley & Sons,*	A correlational study of the relations of age, status, experience, and drug calculation ability to	A cross-sectional study was carried out in 2006 in one United Kingdom university. Validated numerical and drug calculation tests were given to 229 second year nursing	The numeracy test was failed by 55% of students and 45% of Registered Nurses, while 92% of students and 89% of nurses failed the drug	To prevent deskilling, Registered Nurses should continue to practise and refresh all the different types

Inc.), 66(4), pp. 891–899. doi:10.1111/j.1365-2648.2010.05258.x.	numerical ability of nursing students and Registered Nurses	students and 44 Registered Nurses attending a non-medical prescribing programme	calculation test. Independent of status or experience, older participants (‡35 years) were statistically significantly more able to perform numerical calculations. There was no statistically significant difference between nursing students and Registered Nurses in their overall drug calculation ability, but nurses were statistically significantly more able than students to perform basic numerical calculations and calculations for solids, oral liquids, and injections. Both nursing students and Registered Nurses were statistically significantly more able to perform calculations for solids, liquid oral and injections than calculations for drug percentages, drip, and infusion rates	of drug calculations as often as possible with regular (self)-testing of their ability. Time should be set aside in curricula for nursing students to learn how to perform basic numerical and drug calculations. This learning should be reinforced through regular practice and assessment

Reyna, V.F. *et al.* (2009) 'How numeracy influences risk comprehension and medical decision making', *Psychological Bulletin*, 135(6), pp. 943–973. doi:10.1037/a0017327.	Outline four theoretical approaches (psychophysical, computational, standard dual-process, and fuzzy trace theory), review their implications for numeracy, and point to avenues for future research	Systematic literature search and literature review	Low numeracy distorts perceptions of risks and benefits of screening, reduces medication compliance, impedes access to treatments, impairs risk communication (limiting prevention efforts among the most vulnerable), and, based on the scant research conducted on outcomes, appears to adversely affect medical outcomes. Low numeracy is also associated with greater susceptibility to extraneous factors (i.e., factors that do not change the objective numerical information). That is, low numeracy increases susceptibility to effects of mood or how information is presented (e.g., as frequencies vs. percentages) and to biases in judgment and decision making (e.g.,	

			framing and ratio bias effects)	
Walsh KA (2008) 'The relationship among mathematics anxiety, beliefs about mathematics, mathematics self-efficacy, and mathematics performance in associate degree nursing students', Nursing Education Perspectives (National League for Nursing), 29(4), pp. 226–229	The purpose of this study was to examine the relationships among these factors and performance on a medication mathematics test by nursing students. Exploring nursing students' mathematics anxiety, beliefs about mathematics, and mathematics self-efficacy in relation to performance on a medication mathematics test.	Mixed methods approach with a questionnaire using Likert scales and qualitative interviews	Results revealed that the participants experienced some mathematics anxiety and had positive beliefs about mathematics and mathematics self-efficacy. Qualitative responses indicated that participants worried about the consequences of failing the medication mathematics test and that practice helped reduce this anxiety. In addition, participants acknowledged the importance of correct dosage calculations for nursing practice.	
Pierce, R.U. *et al.* (2008) 'Understanding Decimal Numbers: A Foundation for Correct Calculations', *International Journal of Nursing Education Scholarship*,	This paper reports on the effectiveness of an intervention designed to improve nursing	Mixed methods Quantitative (pre- and post-tests) and qualitative data (anecdotal from the intervention, and responses	A significant minority of students had an inadequate understanding of decimal numbers. The	Direction around ensuring that students understand the basic principles of mathematics.

5(1), pp. 1–17. doi:10.2202/1548-923X.1439.	students' conceptual understanding of decimal numbers	from a short survey completed with the post-test) were collected	intervention aimed to improve nursing students' basic understanding of the size of decimal numbers, so that, firstly, calculation rules are more meaningful, and secondly, students can interpret decimal numbers (whether digital output or results of calculations) sensibly	
Pentin J and Smith J (2006) 'Drug administration. Drug calculations: are they safer with or without a calculator?', *British Journal of Nursing*, 15(14), pp. 778–781. doi:10.12968/bjon.2006.15.14.21582.	Discuss the dilemmas facing nurse educators in post registration settings in relation to the use of calculators in drug administration calculations	Discussion of literature	The administration of medicines is a key nursing task. Lack of ability to calculate drugs accurately is one of the issues that contribute to medication errors. Nurses' ability to calculate drug dosages without a calculator remains contentious and many nursing programmes test their students but allow them to use a calculator, or do not assess the process of the calculation when a calculator is used.	Discussion piece that nots peer reviewed

Oldridge, G.J. *et al.* (2004) 'Pilot study to determine the ability of health-care professionals to undertake drug dose calculations', *Internal medicine journal*, 34(6), pp. 316–319. doi:10.1111/j.1445-5994.2004.00613.x	The aims of the present study were to evaluate the ability of health-care professionals to perform drug dose calculations accurately and to determine their preferred concentration convention when calculating drug doses	A selection of nurses, medical students, house surgeons, registrars and pharmacists undertook a written survey to assess their ability to perform five drug dose calculations surveys were marked then analysed for health-care professionals as a whole and then by sub-group analysis to assess the performance of each health- care-professional group Mann–Whitney *U*-tests Chi-squared tests	Overall, less than 14% of the surveyed health-care professionals could answer all five questions correctly. Subgroup analysis revealed that health-care professionals' ability to calculate drug doses were ranked in the following order: registrars ≈ pharmacists > house surgeons > medical students >> nurses. Ninety per cent of health-care professionals preferred to calculate drug doses using the mass concentration convention	Overall, drug dose calculations were performed poorly. Mass concentration was clearly indicated as the preferred convention for calculating drug doses
Allen, D. (2021) 'Maths anxiety: how to conquer your fears and calculate with confidence: Nurses use numeracy every day, when calculating drugs doses, fluid balance or in other essential tasks, but many worry about their competence when it comes to doing the maths', *Nursing Standard*, 36(7), pp. 51–54. doi:10.7748/ns.36.7.51.s22.	To discuss strategies to manage Maths anxiety when doing medication calculation and numerical activities in nursing practice	Discussion of literature and suggestion to manage identified issues	Advised to practice Estimate the correct answer so you have a rough figure in your mind Seek support Stick to what works	Opinion piece

Weeks, K.W. *et al.* (2013) 'Safety in numbers: An introduction to the nurse education in practice series', *Nurse Education in Practice*, 13(2), pp. e4–e10. doi:10.1016/j.nepr.2012.06.006.	This paper introduces this Nurse Education in Practice 'Safety in Numbers' series. We introduce the background and seven papers that explore the outcomes of a 20-year programme of healthcare education translation research and education action research that focuses on medication dosage calculation problem-solving (MDC-PS) education	Introduction and discussion of the series of papers.	The combination of healthcare education translation research and education action research offers a systematic approach that engages multiple stakeholders in generating new knowledge; and a process for translating that knowledge into virtual world solutions that form a synergy with clinical practice-based experiences to address real world education and clinical problems.	
Rhodes-Martin S, Munro W (2010) Literacy and numeracy for pre-registration nursing programmes: 1. An innovative way to widen access to nursing programmes for students without formal qualifications by enabling them to give evidence of their literacy and numeracy skills. Nurse Educ Today May;30(4):321-6. doi: 10.1016/j.nedt.2009.08.0	Cohort study of pre-registration nursing programmes that looked at widening participation to students without formal qualification in literacy and numeracy.	Descriptive statistical analysis	The successful progression rates of learners entering the nursing programme from the portfolio module and their subsequent academic performance (which shows no obvious pattern of higher fails	

	Use of a portfolio module		and lower grades when compared to standard entry students), has proved the success of the portfolio entry route.	
Harvey S, Murphy F, Lake R, Jenkins L, Cavanna A, Tait M. Diagnosing the problem: using a tool to identify pre-registration nursing students' mathematical ability. Nurse Educ Pract. 2010 May;10(3):119-25. doi: 10.1016/j.nepr.2009.04.007. Epub 2009 May 24. PMID: 19467618	To devise a tool that assesses mathematical ability for pre-registration nursing programmes	A tool was devised to assess the mathematical abilities of nursing students. This was administered to 304 nursing students in one Higher Education Institution (HEI) in Wales, United Kingdom (UK) on entry to a pre-registration undergraduate nursing course. The students completed a diagnostic mathematics test comprising of 25 non-clinical General Certificate of Secondary Education (GCSE) level multiple choice questions with a pass mark set at 72%.	The key findings were that only 19% (n = 53) of students passed the test. Students appeared to have difficulties with questions involving decimals, SI units, formulae, and fractions	
Wright K (2007a) 'A written assessment is an invalid test of numeracy skills', *British Journal of Nursing*, 16(13), pp. 828–831. doi:10.12968/bjon.2007.16.13.24252.	This article discusses the Fitness for Practice initiatives from the Nursing and Midwifery Council, which aims to ensure new registrants are numerate.	Discussion of articles	Written numeracy assessment tools are not a valid test of the numeracy skills candidates will require for clinical practice and that nurse education needs to focus on researching and examining how best to	Opinion piece

			support, assess and develop the numeracy skills of nursing students within their clinical practice placements to ensure that at the point of registration they are fit for practice	
Chapman L and Halley L (2007) ‘Numeracy skills: a student-centred approach to gaining confidence’, *Nurse Prescribing*, 5(4), pp. 157–160. doi:10.12968/npre.2007.5.4.23612.	Discusses how the University of Reading has developed an 'introduction to Numeracy' module which is enabling practitioners to increase their confidence and competence in calculating doses when prescribing and administering drugs	Discussion piece	The numeracy module promotes individualised, student-centred learning. Allowing students to self-assess their knowledge and learning needs with respect to accurately calculating and administering medication. A combination of teaching methods allows each student to challenge their assumptions and fears of mathematical and calculation skills and became more confident and competent m prescribing and administering drugs in the workplace.	Opinion piece

Wright K (2006) Barriers to accurate drug calculations Nursing Standard Mar 22-28;20(28):41-5. doi: 10.7748/ns2006.03.20.28.41.c4099. PMID: 16596860.	To examine the drug calculation skills of nursing students	A mathematics test and a structured questionnaire were used to determine level of skill and perceptions related to mathematics	The test revealed difficulties in multiplying fractions and interpreting information, and the questionnaire showed that drug calculation skills were related to education level, confidence, and enjoyment of maths at school	Nursing students should be given opportunities to improve their maths skills alongside developing their knowledge of drug calculations in clinical practice.
Ofori R (2000) Age and 'type' of domain specific entry qualifications as predictors of student nurses' performance in biological, social, and behavioural sciences in nursing assessments. Nurse Educ Today. May;20(4):298-310. doi: 10.1054/nedt.1999.0396. PMID: 10827101.	As study that explored the effects of age and 'type' of entry qualifications in psychology, sociology, and biology on student performance in 'the psychological, sociological and biological perspectives in nursing' module assessments, respectively.	Data from 222 students undertaking 'the pre-registration diploma in nursing' programme at a university in the northwest of England were analysed	The study found no significant differences in performance among those students with GCSE 'O' level, those with access and those without any type of domain specific qualifications. However, student age significantly predicted performance, with such performances found to be highly consistent across the three modules. The 'non-mature' students (aged < 20 years) were identified in the study as being at risk in terms of academic performance whilst the 'very mature' students	

			(aged > 34 years) were found to predict better overall performance. The findings suggest that paper qualifications such as GCSE O level, GNVQ or BTEC in psychology, sociology or biology should not be relied upon as predictors of academic performance in their related nursing modules when selecting potential nurses.	
Hilton DE (1999) Considering academic qualification in mathematics as an entry requirement for a diploma in nursing programme. Nurse Education Today. Oct;19(7):543-7. doi: 10.1054/nedt.1999.0344. PMID: 10808896	Small cohort study completed a pilot study in northern England	Descriptive statistics The test consisted of 20 questions and the skills addressed were: • Addition of three-digit integers • Subtraction involving three-digit integers • Multiplication involving two-digit integers • Division of an integer by a number between 1 and 9 • Multiplication of two decimal numbers • Multiplication of two fractions	Students with GCSE grade B and above perform consistently better at mathematical tasks than students with lower grades The range of scores of students with lower grades is wider and three students without any academic qualification performed reasonably well in the test	

		• Division of two fractions • Conversion of fractions to decimals • Conversion of decimals to percentages • Calculating percentages of integers • Conversion between SI units		
Hutton BM. Do school qualifications predict competence in nursing calculations? Nurse Education Today. 1998 Jan;18(1):25-31. doi: 10.1016/s0260-6917(98)80031-2. PMID: 9528527.	Do entry characteristics in mathematics of student nurses selected to undertake nurse training have any predictive value for competence in nursing calculations	Analyses the results of a diagnostic mathematics test given to students entering the Project 2000 course at one college of nursing in England in relation to the students' entry qualifications in mathematics	The results suggest that paper qualifications in mathematics, other than those of above GCSE grade C or equivalent, should not be relied upon to predict performance in a test of calculations required in nursing	
Wilson Fadiji A, Reddy V (2023) Well-being and mathematics achievement: What is the role of gender, instructional clarity, and parental involvement? *Frontiers in psychology*.;13:1044261. doi:10.3389/fpsyg.1044261	To explore the role of gender, instructional clarity, and parental involvement in mathematics achievement	Using the Trends in Mathematics and Science Study (TIMSS 2019) based on a sample of 20,829 learners (females = 11,067 and males = 9,719), and employing structural equation modelling (SEM), we examined the nature of the relationship between satisfaction with life and mathematics achievement, considering the	Findings showed that satisfaction with life is positively related to mathematics achievement but is not moderated by gender. Additionally, instructional clarity contributes to, and is a partial mediator of, the relationship between life satisfaction and mathematics	

		role of gender, parental involvement, and instructional clarity	achievement. This suggests that greater instructional clarity is positively associated with high achievement in mathematics, over and above the relationship with satisfaction with life. By contrast, parental involvement negatively mediates this relationship, suggesting that mathematics achievement is negatively associated with certain forms of parental involvement, such as setting time aside for homework; and checking if homework is done	
McKenna L, Johnston J, Cross R, Austerberry J, Mathew T, McKenzie G (2022) Mathematics anxiety and associated interventions in nursing: A scoping review. Nurse Educ Today May;112:105335. doi: 10.1016/j.nedt.2022.105335. Epub 2022 Mar 26. PMID: 35367862.	To explore what is known and reported about mathematics anxiety in nursing and the nature of interventions developed.	A scoping review guided by the work of Arksey and O'Malley and Joanna Briggs Institute methodology. CINAHL, Medline, ERIC and ProQuest Nursing and Allied Health	Ten studies were included in the final review, and numerous different tools used to measure mathematics anxiety. Several factors were found to influence mathematics anxiety and various local interventions are reported. There is a lack	Overall, despite its importance, there is scant research into mathematics anxiety in nursing. There is a need for a consistent, valid, and reliable tool for its measurement, as well as validated interventions to address it. Furthermore, there is

			of consistency in research reporting on mathematics anxiety, with most being single-site studies and small in scale	a deficit in research evaluating mathematics anxiety longitudinally across the duration of an education program. There is a need for nurse education providers to work to address these important gaps and establish entry-level benchmark requirements
Sayadi L, Nasrabadi AN, Hosseini A. (2021) The effect of drug dosage calculation training program on math anxiety and nursing students' skills: A non-randomized trial study. *Nursing Practice Today*. 2021;8(3):194-205. doi:10.18502/npt.v8i3.5934	This study aimed to determine the effect of mathematical calculation and drug dosage training programs on math anxiety and nursing students' drug dosage calculation skills	The present research was a non-randomized trial study. As a result of convenience sampling, 80 nursing students (40 in the control group and 40 in the intervention group) participated in the study. The study intervention included a mathematical and drug dosage training program including lecture, workshop, and practicing mathematical and drug calculations at the patient's bedside. The data were collected using a demographic, Betz' math anxiety, and drug dosage calculation skills questionnaires. Finally,	The two groups were homogeneous in terms of demographic variables, math anxiety, and drug calculation scores in the baseline. Two-way analysis of variance with repeated measures indicated the significant effect of the group on math anxiety (P=0.024). Given the interaction between group effect and time for the drug dosage calculations, comparing the differences between the second- and third-time scores of the	Implementation of a drug dosage calculation training program for nursing students can lead to the reduction of math anxiety and improvement of the drug dosage calculations; this can ultimately help improve patient safety

		descriptive, and analytical statistics were used to analyse the data	baseline scores showed a statistically significant difference between the two groups in terms of drug dosage calculations (P <0.001)	
Johnson J, Kareem A, White D, Ngwakongnwi EM, Mohammadpour M, Rizkika N, Ouattas R, Shahrour Y, Ali R, Roshanuddin J. (2020) Nursing students' perspectives on learning math for medication calculations in a Canadian nursing program in Qatar. Nurse Educ Pract. Nov;49:102885. doi: 10.1016/j.nepr.2020.102885. Epub 2020 Oct 2. PMID: 33096334.	This study describes nursing students' perspectives on learning math for medication calculations in a Canadian baccalaureate nursing program in Qatar	Data collected from focus groups was analysed using interpretive description	Themes emerging from the data included from first year students, 1. Fear of math resulting in resistance to learning math for medication administration. 2. Student success is dependent on good instructors. 3. Student resentment towards perceived 'complicated' math in the nursing program. Themes from second year students included 1. Lack of nursing student's confidence with medication calculation	

			within the clinical settings 2. Lack of self-directedness to uptake math knowledge 3. Incongruence amongst clinical instructors with applied math practice whilst in the clinical setting.	
O'Reilly R, Ramjan LM, Fatayer M, Stunden A, Gregory LR (2020) First year undergraduate nursing students' perceptions of the effectiveness of blended learning approaches for nursing numeracy. Nurse Educ Pract. May;45:102800. doi: 10.1016/j.nepr.2020.102800. Epub 2020 May 7. Erratum in: Nurse Educ Pract. 2020 Jul;46:102825. PMID: 32485538.	conducted at a single multi-campus university in the western Sydney region of Australia, was to determine the effectiveness of a suite of blended learning approaches on numeracy self-efficacy from the students' perspective	Surveys were ad- ministered as part of the study and included open-ended questions. 525 students provided open-ended responses that were analysed by the research team	Four main themes were identified from the open-ended responses: (i) Self-realisation; (ii) Practice, practice, practice; (iii) Boosting confidence; and (iv) Wanting more	The study showed that a structured pedagogical approach to nursing numeracy in undergraduate programs improved students' self-reported self-efficacy with mathematics and assisted students in realising the importance of learning and applying these skills as nursing clinicians.
Özyazıcıoğlu N, Aydın Aİ, Sürenler S, Çinar HG, Yılmaz D, Arkan B, Tunç GÇ (2018) Evaluation of students' knowledge	To evaluate the knowledge of nursing students about	Retrospective study that covers a population consisting of all the 3rd grade students at the	It is seen that in dosage calculations, the students failed mostly in	

about paediatric dosage calculations. Nurse Educ Pract. Jan;28:34-39. doi: 10.1016/j.nepr.2017.09.013. Epub 2017 Sep 19. PMID: 28942096.	paediatric dosage calculations	bachelor's degree in May 2015 (148 students). Drug dose calculation questions in exam papers including 3 open ended questions on dosage calculation problems, addressing 5 variables were distributed to the students and their responses were evaluated by the researchers	calculating ml/dzy (decimal). This result means that as dosage calculations are based on decimal values, calculations may be ten times erroneous when the decimal point is placed wrongly. Moreover, it is also seen that students lack maths knowledge in respect of four operations and calculating safe dose range	
Roberts S, Campbell A. Striving for a good standard of maths for potential student nurses. Br J Nurs. 2017 Jan 12;26(1):32-36. doi: 10.12968/bjon.2017.26.1.32. PMID: 28079413.	Exploration of some of the issues surrounding numerical competence for potential pre-registration children's nursing students, with examples of success and failure, at the University of Hertfordshire.	Descriptive data analysis of exam results.	This lack of numerical ability was found to not only be a problem for pre-registration nursing programmes but also for a third of all undergraduate students Centralised numerical testing for all pre-registration student nurses should be considered as this will provide a standardised approach and an equitable experience and is something that	

			could be further explored. Future research in exploring issues surrounding numeracy and student nurses could include asking applicants about their experiences of both their previous mathematical assessment experiences and their experience at selection days	
Wallace D, Woolley T, Martin D, Rasalam R, Bellei M (2016) Medication calculation and administration workshop and hurdle assessment increases student awareness towards the importance of safe practices to decrease medication errors in the future. *Education for health (Abingdon, England)*;29(3):171-178. doi:10.4103/efh.EfH_312_14	Evaluates the effectiveness of this educational activity as a long-term strategy to teach medical students' essential skills in calculating and administering medications.	This longitudinal study used a pre- and post-test design to determine whether medical students retained their calculation and administration skills over a period of 4 years. The ability to apply basic mathematical skills to medication dose calculation, principles of safe administration (Part 1), and ability to access reference materials to check indications, contraindications, and writing the medication order with correct abbreviations (Part 2) were compared between Year 2 and 6 assessments	Scores for Parts 1, 2 and total scores were nearly identical from Year 2 to Year 6 (P = 0.663, 0.408, and 0.472, respectively), indicating minimal loss of knowledge by students in this period. Most Year 6 students (86%) were able to recall at least 5 of the "6 Rights of Medication Administration" while 84% reported accessing reference material and 91% reported checking their medical calculations	The "Medication Calculation and Administration" workshop with a combined formative and summative assessment - a "hurdle" - promotes long-term retention of essential clinical skills for medical students. These skills and an awareness of the problem are strategies to assist medical graduates in preventing future medication-related

				adverse events., Database: MEDLINE Ultimate
Williams B, Davis S. Maths anxiety and medication dosage calculation errors: A scoping review. Nurse Educ Pract. 2016 Sep;20:139-46. doi: 10.1016/j.nepr.2016.08.005. Epub 2016 Aug 22. PMID: 27589091.	To examine the effects of maths anxiety on healthcare students' ability to accurately calculate drug dosages by performing a scoping review of the existing literature	This review utilised a six-stage methodology using the following databases; CINAHL, Embase, Medline, Scopus, PsycINFO, Google Scholar, Trip database (http://www.tripdatabase.com/) and Grey Literature report (http://www.greylit.org/).	Four factors including maths anxiety were identified as having an influence on a student's drug dosage calculation abilities	
Mackie JE, Bruce CD (2016) Increasing nursing students' understanding and accuracy with medical dose calculations: A collaborative approach. Nurse Educ Today. May;40:146-53. doi: 10.1016/j.nedt.2016.02.018. Epub 2016 Mar 2. PMID: 27125165.	The objective of this study was to determine areas of challenge for students in performing medication dosage calculations in order to design interventions to improve this skill	Strengths and weaknesses in the teaching and learning of medication dosage calculations were assessed. These data were used to create online interventions which were then measured for the impact on student ability to perform medication dosage calculations. The qualitative research participants were 8 nursing students from years 1-3 and 8 faculty members. Quantitative results are based on test data from the same second year clinical course during the	Students identified conceptual understanding deficits, anxiety, low self-efficacy, and numeracy skills as primary challenges in medication dosage calculations. Faculty identified long division as a particular content challenge, and a lack of online resources for students to practice calculations. Lessons and online resources designed as an intervention to target mathematical, and	This study suggests that with concerted effort and a multi-modal approach to supporting nursing students, their abilities to calculate dosages can be improved. The positive results in this study also point to the promise of cross-discipline collaborations between nursing and education

		academic years 2012 and 2013 Students and faculty participated in one-to-one interviews; responses were recorded and coded for themes. Tests were implemented and scored, then data were assessed to classify the types and number of errors	concepts and skills led to improved results and increases in overall pass rates for second year students for medication dosage calculation tests	
Suárez-Pellicioni M, Núñez-Peña MI, Colomé À. Math anxiety: A review of its cognitive consequences, psychophysiological correlates, and brain bases. *Cognitive, affective & behavioral neuroscience*. 2016;16(1):3-22. doi:10.3758/s13415-015-0370-7	Aims to provide a full and updated review of the field, ranging from the initial studies of the impact of math anxiety on numerical cognition, to the latest research exploring its electrophysiological correlates and brain bases from a cognitive neuroscience perspective	Literature review	The ultimate aim of research on MA should be to prevent children from developing MA, and also to reduce the high level of MA in those students who have already experienced its negative effects on their academic performance. To this end, it is important to bear in mind the multi- factorial nature of its origin, such that any attempt to detect, assess, and intervene with MA must consider environmental (e.g., classroom context, peers, teachers, parents), cognitive (e.g.,	

			math ability), and personality (e.g., self-efficacy beliefs, regulation skills) variables	
Røykenes K (2016) "My math and me": Nursing students' previous experiences in learning mathematics. Nurse Educ Pract. Jan;16(1):1-7. doi: 10.1016/j.nepr.2015.05.009. Epub 2015 May 23. PMID: 26072444.	Explore the experiences of nursing students in learning mathematics	Qualitative, narrative thematical analysis	Emphasizes the importance of previous experiences in learning mathematics to nursing students when learning about drug calculation Most students had a positive relationship with the subject in primary school, when they found mathematics fun and were able to master the subject	
Bagnasco A, Galaverna L, Aleo G, Grugnetti AM, Rosa F, Sasso L (2016) Mathematical calculation skills required for drug administration in undergraduate nursing students to ensure patient safety: A descriptive study: Drug calculation skills in nursing students. Nurse Education Practice. Jan;16(1):33-9. doi: 10.1016/j.nepr.2015.06.006. Epub 2015 Jun 24. PMID: 26347449.	The aim of our study was to explore where students had most difficulty and identify appropriate educational interventions to bridge their mathematical knowledge gaps.	Quali-quantitative descriptive study that included a sample of 726 undergraduate nursing students.	Undergraduate nursing students mainly had difficulty with basic maths principles. Specific learning interventions are needed to improve their basic maths skills and their dosage calculation skills	

Tabassum N, Saeed T, Dias JM, Allana S (2016) Strategies to Eliminate Medication Error among Undergraduate Nursing Students. *International Journal of Nursing Education*. ;8(1):167-171. doi:10.5958/0974-9357.2016.00030.1	To discuss about the possible factors which might have contributed towards the reported errors, even after moving with the vigilant process	Retrospective study was conducted to identify the reported medication errors, their types, and associated factors, through a document review, for the enrolled four-year BScN students at AKUSONAM between 2010 to 2013 Data was entered in and analysed through SPSS version 19. Descriptive analysis was used to analyse the data. There was a total of 325 BScN students from 3 admission cohorts between 2010 and 2013	Practice for drug dosage calculations, the students are already doing in classroom set up, but its reinforcement and integration can be practiced in real ward seeing. The second strategy is to inform the demerits of not performing the medication error without the policy. They must understand and informed in the beginning that they are not licensed and practice with their faculties only	
Alteren J, Nerdal L (2015) Relationship between High School Mathematics Grade and Number of Attempts Required to Pass the Medication Calculation Test in Nurse Education: An Explorative Study. Healthcare (Basel). May 27;3(2):351-63. doi: 10.3390/healthcare3020351. PMID: 27417767; PMCID: PMC4939530.	To explore the relationship between high school mathematics grade and the number of attempts to pass a medication calculations exam	The study used an exploratory design Participants were 90 students enrolled in a bachelor's nursing program. They completed a self-report questionnaire, and statistical analysis was performed	Provided no basis for the conclusion that a statistical relationship existed between high school mathematics grade and number of attempts required to pass the medication calculation test. Regardless of their	All of the students who had achieved grade 5 had passed by the third attempt. High grades in mathematics were not crucial to passing the medication calculation test.

			grades in mathematics, 43% of the students passed the medication calculation test on the first attempt	Nonetheless, the grade may be important in ensuring a pass within fewer attempts
Mettiäinen S, Luojus K, Salminen S, Koivula M (2014) Web course on medication administration strengthens nursing students' competence prior to graduation. Nurse Educ Pract Aug;14(4):368-73. doi: 10.1016/j.nepr.2014.01.009. Epub 2014 Jan 24. PMID: 24508302.	The study investigated the efficacy of an additional medication administration web course in increasing nursing students' self-evaluated competence on medication administration	Finnish nursing students self-evaluated their medication administration competence before and after the web-based medication course. Design was quasi-experimental 244 students answered the questionnaire before and 192 after the web course An online self-evaluation questionnaire was developed to measure students' competence on basic pharmacotherapy, intravenous medication and infusion, blood transfusion and epidural medication. The data was analysed with SPSS 18.0 software using descriptive analyses and comparing sum variables with Man-Whitney U-test	The medication administration web course, which took 8 h on average, significantly improved self-evaluated competence of nursing students in all the fields. Prior to the education most defects were found in matters concerning compatibility and adverse effects of pharmaceuticals and solutions and in epidural medication competency. The education strengthened all these competencies	It is necessary to revise medication administration before graduation and web-based learning can be used in it
Grugnetti AM, Bagnasco A, Rosa F, Sasso L (2014) Effectiveness of a Clinical	To evaluate the effectiveness of a	A descriptive pre-post-test design	Study results showed a significant improvement	Our study shows that Clinical Skills

Skills Workshop for drug-dosage calculation in a nursing program. Nurse Educ Today. Apr;34(4):619-24. doi: 10.1016/j.nedt.2013.05.021. Epub 2013 Jun 27. PMID: 23810339.	Clinical Skills Workshop on drug administration that focused on improving the drug-dosage calculation skills of second-year nursing students, with a view to promoting safety in drugs administration	The workshop covered integrated teaching strategies and innovative drug-calculation methodologies which have been described to improve psychomotor skills and build cognitive abilities through a greater understanding of mathematics linked to clinical practice The sample population included 77 nursing students from a Northern Italian University who attended a 30-hour Clinical Skills Workshop over a period of two weeks.	between the pre- and the post-test phases, after the intervention. Pre-test scores ranged between 0 and 25 out of a maximum of 30 points, with a mean score of 15.96 (SD 4.85), and a median score of 17. Post-test scores ranged between 15 and 30 out of 30, with a mean score of 25.2 (SD 3.63) and a median score of 26 ($p<0.001$)	Workshops may be tailored to include teaching techniques that encourage the development of drug-dosage calculation skills, and that training strategies implemented during a Clinical skills Workshop can enhance students' comprehension of mathematical calculations
Van de Mortel TF, Whitehair LP, Irwin PM (2014) A whole-of-curriculum approach to improving nursing students' applied numeracy skills. Nurse Educ Today. Mar;34(3):462-7. doi: 10.1016/j.nedt.2013.04.024. Epub 2013 May 16. PMID: 23684524.	The objective of the study is to assess the efficacy of a whole-of-curriculum approach in improving nursing students' applied numeracy skills	Two cycles of assessment, implementation and evaluation of strategies were conducted following a high fail rate in the final applied numeracy examination in a Bachelor of Nursing (BN) programme. Strategies included an early diagnostic assessment followed by referral to remediation, setting the pass mark at 100% for each of six applied numeracy examinations across the programme, and employing a specialist mathematics	The percentage of students who obtained 100% correct answers on the applied numeracy examinations was significantly higher in 2011 than in 2008 in CNC III ($\chi(2)=272, 3; p<0.001$), IV ($\chi(2)=94.7, 3; p<0.001$) and VI ($\chi(2)=76.3, 3; p<0.001$)	A whole-of-curriculum approach to developing applied numeracy skills in BN students resulted in a substantial improvement in these skills over four years

		teacher to provide consistent numeracy teaching Data on the percentage of students who obtained 100% in their applied numeracy examination in up to two attempts were collected from CNCs III, IV, V and VI between 2008 and 2011. A four by two χ(2) contingency table was used to determine if the differences in the proportion of students achieving 100% across two examination attempts in each CNC were significantly different between 2008 and 2011		
Coyne E, Needham J, Rands H. Enhancing student nurses' medication calculation knowledge; integrating theoretical knowledge into practice. Nurse Education Today. 2013;33(9):1014-1019. doi:10.1016/j.nedt.2012.04.006	A review of the literature on different approaches for teaching and assessing medication calculation with student nurses revealed three main factors that influenced student nurses' ability to calculate	Evaluation study with teaching interventions and Time 1 and Time 2 medication tests. Participants: 156, 2nd year Bachelor of Nursing students from an Australian University	For Time 1 medication test pre interventions, the mean was 7.3 with a mode of 8 out of ten. Maths and incorrect medication formula were the most common mistake. For Time 2 medication test post interventions, the mean was 9.3 with a mode of 10. The most common reason for incorrect answer Time 2 was	The teaching intervention improved the accuracy of students' medication calculation, specifically, understanding the correct formula to use and identifying errors of calculation.

	medications accurately and identify mistakes. These factors include mathematical ability, particularly around multiplying with decimals, understanding medication formulas, and conceptualising medication dose		incorrect medication formula. The students identified that the smaller tutorial sizes and remediation of errors was the main reason for continued attendance	
Macdonald K, Weeks KW, Moseley L. Safety in numbers 6: Tracking pre-registration nursing students' cognitive and functional competence development in medication dosage calculation problem-solving: The role of authentic learning and diagnostic assessment environments. Nurse Education in Practice. 2013;13(2):e66-77. doi:10.1016/j.nepr.2012.10.015	This paper tracks the transition of the pre-registration nursing students' MDC-PS cognitive and functional competence development following exposure to the safe Medicate essential skills suite of programs and learning within the practice settings	Longitudinal analysis and evaluation of two nursing student cohorts' progress in the construction of cognitive and functional competence development in MDC-PS	There is a need for sustained and integrated MDC-PS education programmes within the pre-registration nursing curriculum	Authors co directors of the authentic world system

Arkell S, Rutter PM (2012) Numeracy skills of undergraduate entry level nurse, midwife, and pharmacy students. Nurse Education Practice Jul;12(4):198-203. doi: 10.1016/j.nepr.2012.01.004. Epub 2012 Feb 2. PMID: 22305744.	To determine first year nursing, midwifery, and pharmacy students' ability to perform basic numeracy calculations	All new undergraduate entrants to nursing, midwifery and pharmacy sat a formative numeracy test within the first two weeks of their first year of study	Test results showed that pharmacy students significantly outperformed midwifery and nursing students on all questions. In turn midwifery students outperformed nurses, although this did not achieve significance. When looking at each cohorts general attitude towards mathematics, pharmacy students were more positive and confident compared to midwifery and nursing students	Pharmacy students expressed greater levels of enjoyment and confidence in performing mathematics and correspondingly showed the greatest proficiency. In contrast nurse, and to a lesser extent midwifery students showed poor performance and low confidence levels.
Eastwood KJ, Boyle MJ, Williams B, Fairhall R (2011) Numeracy skills of nursing students. Nurse Educ Today. Nov;31(8):815-8. doi: 10.1016/j.nedt.2010.12.014. Epub 2011 Jan 15. PMID: 21239088.	Exploration of numeracy skills of nursing students	A descriptive survey collecting demographical data, attitudes towards drug calculation performance and basic mathematical and drug calculation questions was administered to the 52 undergraduate nurses who participated in the study	The average score was 56.1%. Interestingly 63.5% of the students denied any drug calculations issues. On average those who completed a minimum of year 12 mathematics, or who had entered the course directly from secondary education achieved scores over 50%. Of all the errors that occurred 36.0%	

			were conceptual, 38.9% were arithmetical and 25.1% were computational	
Ramjan LM. Contextualism adds realism: nursing students' perceptions of and performance in numeracy skills tests. Nurse Educ Today. 2011 Nov;31(8):e16-21. doi: 10.1016/j.nedt.2010.11.006. Epub 2010 Dec 3. PMID: 21126812.	Investigated nursing students' perceptions of and performance in a de-contextualised diagnostic maths paper (i.e., questions only) and a contextualised diagnostic maths paper (i.e. visual pictures along with questions)	SPSS software and a Professional Development Officer. The survey data were analysed manually and thematically by the researcher.	Students preferred the visual images and revealed that it led to a "deeper learning" of numeracy skills, reduced stress and anxiety levels and simulated 'the real life' clinical setting, thus adding "an element of realism" to the situation	
Røykenes K, Larsen T (2010) The relationship between nursing students' mathematics ability and their performance in a drug calculation test. Nurse Education Today. Oct;30(7):697-701. doi: 10.1016/j.nedt.2010.01.009. Epub 2010 Feb 4. PMID: 20133029.	To explore the relationship between mathematic ability of nursing students and drug calculation tests	Quantitative design with a questionnaire and test results together with the average high school grade level of the students	A total of 116 students answered the questionnaire; 95.7% (*n* = 111) were female. Their ages ranged from 19 to 46 years old, and the mean was 25.4 years. Four of the students had not been to secondary school but gained entry to the Bachelor of Nursing degree through recognition of prior learning and work	

			experience. The average grade level for mathematics in students' first year in high school was a D grade in a system where grade A is the highest grade achievable, and E is a pass grade. The results of the student's drug calculation test shows that 36% failed first time taking the test and more than half of these students (62%) failed the second time. On group level this indicates a relationship between low grades and test failures.	
Wolkowitz AA, Kelley JA (2010) Academic predictors of success in a nursing program. J Nurs Educ. Sep;49(9):498-503. doi: 10.3928/01484834-20100524-09. PMID: 20509584.	The purpose of this research was to apply a multiple regression model to student test scores to determine the relative strength of science, mathematics, reading, and English content areas in predicting	Using a standardized nursing entrance examination, the subtest scores of these four academic areas for 4,105 registered nurse students were used as the predictors in the regression model. Performance on a standardized Fundamentals of Nursing assessment was the criterion variable	Results confirmed those found in the majority of the literature indicating that science is both a statistically significant predictor and the strongest of the four content areas in the prediction of early nursing program success.	

	early nursing school success			
Wright K (2010) Do calculation errors by nurses cause medication errors in clinical practice? A literature review. Nurse Education Today Jan;30(1):85-97. doi: 10.1016/j.nedt.2009.06.009. PMID: 19666199.	Exploring if calculation errors by nurse’s cause medication errors in clinical practice	Literature review	The literature suggests that there are other more pressing aspects of nurses' preparation and administration of medications which are contributing to medication errors in practice that require more urgent attention and calls into question the current focus on calculation and numeracy skills of pre-registration and qualified nurses	
Wright K. (2009). The assessment and development of drug calculation skills in nurse education - a critical debate. Nurse Education Today, 29(5), 544–548.	The drug calculation skill of nurses continues to be a national concern. The continued concern has led to the introduction of mandatory drug calculation skills tests which students must pass in order to go on to the nursing register-	Literature review	This paper argues that nurse educationalists have inadvertently created a problem that arguably does not exist in practice through use of invalid written drug assessment tests and have introduced their own pedagogical practice of solving written drug calculations	

	exploration of the literature			
Brady, A.M., Malone, A.-M., & Fleming, S. (2009). A literature review of the individual and systems factors that contribute to medication errors in nursing practice. *Journal of Nursing Management*, *17*(6), 679–697.	This paper reports a review of the empirical literature on factors that contribute to medication errors	Literature review The databases CINAHL, PubMed, Science Direct and Synergy were searched from 1988 to 2007 using the keywords medication errors, medication management, medication reconciliation, medication knowledge and mathematical skills, and reporting medication errors	Contributory factors to nursing medication errors are manifold and include both individual and systems issues. These include medication reconciliation, the types of drug distribution system, the quality of prescriptions, and deviation from procedures including distractions during administration, excessive workloads, and nurses' knowledge of medications	
Andrew S, Salamonson Y, Halcomb EJ. Nursing students' confidence in medication calculations predicts math exam performance. Nurse Educ Today. 2009 Feb;29(2):217-23. doi: 10.1016/j.nedt.2008.08.005. Epub 2008 Oct 1. PMID: 18834649.	The aim of this study was to examine the psychometric properties, including predictive validity, of the newly developed nursing self-efficacy for	The NSE-Math is a 12-item scale that comprises items related to mathematic and arithmetic concepts underpinning medication calculations. The NSE-Math instrument was administered to second year Bachelor of Nursing students enrolled in a nursing practice subject.	The NSE-Math demonstrated two factors 'Confidence in application of mathematic concepts to nursing practice' and 'Confidence in arithmetic concepts' with 63.5% of variance explained. Cronbach alpha for the	

	mathematics (NSE-Math)	Students' academic results for a compulsory medication calculation examination for this subject were collected. One-hundred and twelve students (73%) completed both the NSE-Math instrument and the drug calculation assessment task	scale was 0.90. The NSE-Math demonstrated predictive validity with the medication calculation examination results (p=0.009). Psychometric testing suggests the NSE-Math is a valid measure of mathematics self-efficacy of second year nursing students	
Pierce RU, Steinle VA, Stacey KC, Widjaja W (2008) Understanding decimal numbers: a foundation for correct calculations. Int J Nursing Education Scholarsh ;5:Article7. doi: 10.2202/1548-923X.1439. Epub 2008 Feb 28. PMID: 18312228.	The intervention aimed to improve nursing students' basic understanding of the size of decimal numbers, so that, firstly, calculation rules are more meaningful, and secondly, students can interpret decimal numbers (whether digital output or results of calculations) sensibly	Quantitative (pre and post-tests) and qualitative data anecdotal from the intervention, and responses from a short survey completed with the post-test) were collected	We conclude that nurse educators should consider diagnosing and, as necessary, plan for remediation of students' foundational understanding of decimal numbers before teaching procedural rules.	
Wright K (2007) Student nurses need more than maths to improve their drug calculating skills. Nurse Educ Today.	To explore and study, which implemented and	Quasi-experimental approach and a pre- and post-test design.	The study highlights the importance of ensuring that strategies address	

May;27(4):278-85. doi: 10.1016/j.nedt.2006.05.007. Epub 2006 Jul 31. PMID: 16876919.	evaluated several strategies to improve the drug calculations skills of student nurses in their second year of training by focusing on improving both the mathematical ability of students as well as the application to practice encouraging conceptualisation	• Online maths sessions were available which covered the areas identified from the maths test to be poorly understood. These included place value, decimals, fractions, percentages and multiplying fractions. Quizzes and tests were utilised throughout to give feedback on students' understanding. • A 2-h lecture explaining formulas and how to use these. • A drug calculation workbook, with answers, which was given out to students. • Practical sessions in the skills labs were held which linked drug calculations to clinical practice. This included	conceptual as well as mathematical skills of student nurses to improve their drug calculation skills and suggests that these strategies have the potential of encouraging student nurses to retain these skills over time	

		calculating drip rates with intravenous infusions and drug dosages using drug ampoules and syringes. Private study with books recommended from the reading list.		
Glaister K. The presence of mathematics and computer anxiety in nursing students and their effects on medication dosage calculations. Nurse Educ Today. 2007 May;27(4):341-7. doi: 10.1016/j.nedt.2006.05.015. Epub 2006 Jul 20. PMID: 16857301.	To determine if the presence of mathematical and computer anxiety in nursing students affects learning of dosage calculations	The quasi-experimental study compared learning outcomes at differing levels of mathematical and computer anxiety when integrative and computer-based learning approaches were used. Participants involved a cohort of second year nursing students (n=97)	Mathematical anxiety exists in 20% (n=19) of the student nurse population, and 14% (n=13) experienced mathematical testing anxiety. Those students more anxious about mathematics and the testing of mathematics benefited from integrative learning to develop conditional knowledge ($F(4,66)=2.52$ at $p<.05$). Computer anxiety was present in 12% (n=11) of participants, with those reporting medium and high levels of computer anxiety performing less	Instructional strategies need to account for the presence of mathematical and computer anxiety when planning an educational program to develop competency in dosage calculations.

			well than those with low levels (F(1,81)=3.98 at p<.05)	
Rainboth L, DeMasi C (2006) Nursing students' mathematic calculation skills. Nurse Educ Today Dec;26(8):655-61. doi: 10.1016/j.nedt.2006.07.022. Epub 2006 Oct 10. PMID: 17034904.	To evaluate the efficacy of a teaching strategy in improving beginning nursing student learning outcomes	This mixed method study used a pre-test/post-test design to evaluate the efficacy of a teaching strategy in improving beginning nursing student learning outcomes. During a 4-week student teaching period, a convenience sample of 54 sophomore level nursing students were required to complete calculation assignments, taught one calculation method, and mandated to attend medication calculation classes	Results demonstrated a statistically significant improvement from pre- to post-test and the students who received the intervention had statistically significantly higher scores on the major medication calculation exam than did the students in the control group	
Grandell-Niemi H, Hupli M, Puukka P, Leino-Kilpi H (2006) Finnish nurses' and nursing students' mathematical skills. Nurse Educ Today. Feb;26(2):151-61. doi: 10.1016/j.nedt.2005.08.007. Epub 2005 Oct 10. PMID: 16216391.	The purposes of this study were to investigate self-rated and actual mathematical skills of registered nurses and graduating nursing students in Finland and to discover how well the Medication Calculation Skills Test (MCS Test) works. The	The MCS Test was developed for the purposes of this study, to discover the mathematical skills of nurses and nursing students. The MCS Test includes parallel structured questions and computations for nurses and students and differs only in sociodemographic and professional/educational questions. The MCS Test was designed based on the research literature and pharmacology textbooks	This study revealed that there seems to be a significant difference between nurses' and students' mathematical and dosage calculation skills. Nurses' skills were better than those of graduating nursing students. Also, earlier successful performance in mathematics was associated with better test results	

	research questions were as follows: • 1. What are nurses' and nursing students' self-rated and actual mathematical skills? • 2. Are there any differences between the two groups (nurses, students) in their mathematical skills? • 3. How are their mathematical skills associated with background factors?			

Wright K (2005) An exploration into the most effective way to teach drug calculation skills to nursing students. Nurse Educ Today;25(6):430-6. doi: 10.1016/j.nedt.2005.04.004. PMID: 15982788.	To explore the most effective ways to teach drug calculations	Bruner's spiral of action research	A three-stage approach to drug calculation appears to be an effective teaching strategy. These stages involve addressing mathematical concepts, teaching drug calculation formulae and then practising these skills in a clinical setting	
Rice JN, Bell ML. Using dimensional analysis to improve drug dosage calculation ability. J Nurs Educ. 2005 Jul;44(7):315-8. doi: 10.3928/01484834-20050701-05. PMID: 16094790.	To provides evidence of the value of dimensional analysis as an effective teaching strategy for calculating drug dosages		The use of dimensional analysis is an effective teaching strategy for calculating drug dosages	
Wright K. An investigation to find strategies to improve student nurses' maths skills. Br J Nurs. 2004 Nov 25-Dec 8;13(21):1280-7. doi: 10.12968/bjon.2004.13.21.17114. PMID: 15580076.	A study that was carried out to investigate whether strategies implemented within a second-year preregistration course were perceived by students to be	A semi structured questionnaire was given to 71 students at the start of the course, which asked for information on how they felt about mathematics and included a maths test. Students were given the option of putting their names on the questionnaire to	Indicates that student nurses were able to integrate the mathematical skills into their nursing practice by having different strategies that allowed them to develop conceptual, mathematical, and	

	helpful in improving their mathematical skills for drug calculations.	receive written feedback about their strengths and weaknesses or completing it anonymously	practical skills concurrently	
Kelly LE, & Colby N. (2003). Educational innovations. Teaching medication calculation for conceptual understanding. *Journal of Nursing Education*, *42*(10), 468–471.	To develop a calculation course for sophomore students based on principles from the constructivist learning model	Encouraging conceptual understanding, delivering lectures around constructivist principles	Instructors should facilitate learning and not do the learning for the learner. Robbing the ways of knowing for students rather than allowing them to create their own understanding.	
Hunter Revell SM, McCurry MK (2013) Effective pedagogies for teaching math to nursing students: a literature review. Nurse Educ Today. 2013 Nov;33(11):1352-6. doi: 10.1016/j.nedt.2012.07.014. Epub 2012 Aug 24. PMID: 22922029	This paper discusses a literature review which examined undergraduate nursing student challenges to learning math, methods used to teach math and problem-solving skills, and the use of innovative pedagogies for teaching	The literature was searched using the Cumulative Index of Nursing and Allied Health Literature and Education Resource Information Centre databases. Key search terms included: math*, nurs*, nursing student, calculation, technology, medication administration, challenges, problem-solving, personal response system, clickers, computer, and multi-media. Studies included in the review were published in English from 1990 to 2011	The review concludes that there is a need for more innovative pedagogical strategies for teaching math to student nurses. Nurse educators in particular play a central role in helping students learn the conceptual basis, as well as practical hands-on methods, to problem solving and math competency. It is recommended that an integrated approach inclusive of technology will benefit students	Literature review

			through better performance, increased understanding, and improved student satisfaction.	