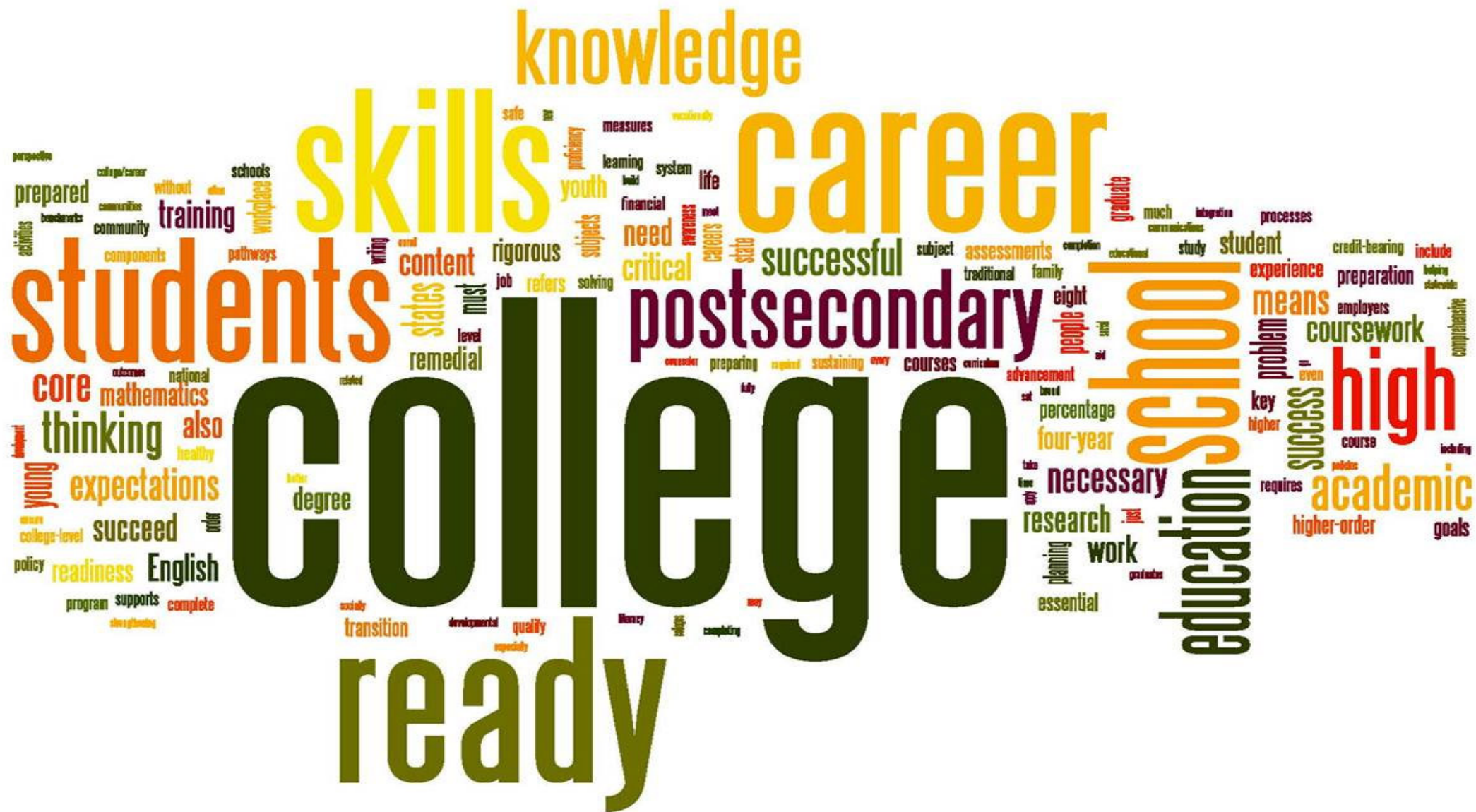


Patient Centered Teaching Increases the Medication Calculation Accuracy of Baccalaureate Nursing Students

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Background: Drug Dosage Calculations

Over 70 years ago Faddis (1939) reported the problem in *The American Journal of Nursing*

Institute of Health (2000) reported approximated 7000deaths/yearly

Estimated that 100,000 to 200,000 deaths/yearly (Institute for Safe Medication Practice, 2015)

World Health Organization (2010) appointed Joint Commission International to seek ways to decrease mortality and morbidity from medication errors.

Students entering higher education in US were 77% deficient in basic math skills(National Mathematics Advisory Council, 2008).

ACT (2014) scores and international assessments (National Center for Education Statistics, 2015) report math deficiencies.

Research has focused on the number and types of errors being made



Problem Statement

Determine if an innovative teaching intervention at a college in New York State would have an effect on the ability of baccalaureate nursing students to correctly calculate medication dosages.



Problem
Analysis
Solution

Johnson and Johnson's 4cs Model for the Learning of Medication Calculations

- Compute (add, subtract, divide, multiple hole numbers, fractions, decimals)
- Conceptualize (set-up problems)
- Convert within and between systems of measurement
- Critically evaluate answers





Medication Calculation Ability

Critically Evaluate

- Evaluate answer and the process
- Does the answer make sense?

Conceptualize

- Ability to set-up a drug calculation problem

Convert

- Within and between system of measurements

Compute

- Perform Elementary math functions
- Add, subtract, divide, multiple
- Simple Algebraic equations



Reciprocal Interaction

Student Factors

- ▶ Basic Math Skills
- ▶ Perceived Self-Efficacy
- ▶ Anxiety
- ▶ Motivation

Program Factors

- ▶ Teaching Methods
- ▶ Curriculum
- ▶ Faculty Support
- ▶ Faculty Attitudes



Program Factors



- ▶ Teaching strategy is purported to impact student outcomes
- ▶ Outcome set at 100% passage rate on calculation exams. Anything less could cost a patient their life.
- ▶ Practice problem solving
- ▶ Seeing and handling documents, supplies, and equipment



Hypothesis

Baccalaureate nursing students exposed to an experiential teaching strategy will have higher medication calculation scores compared to those exposed to a traditional teaching strategy.



Methodology

- ▶ Pretest-Posttest Control group design with random blind assignment into groups
- ▶ Sample Size $N = 76$
- ▶ The sample size was generated by a power analysis where at least 30 students were needed for each group with power set at .80 with $p = \leq .05$.
- ▶ Response rate = 100%
- ▶ No attrition from the study
- ▶ Nursing Policy followed
 - ▶ Pass medication calculation 10-item exam with 100% accuracy
 - ▶ Pass medication administration competencies
 - ▶ Calculators not permitted

Sample Characteristics $N = 76$





Comparison of Teaching Strategies

Control Group

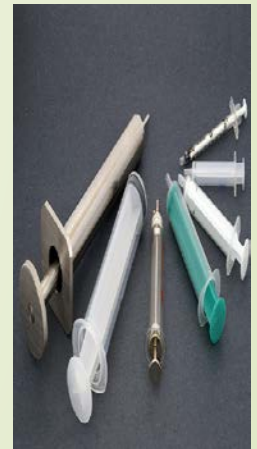
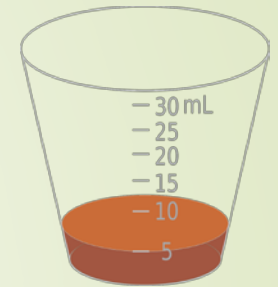
- ▶ Basic Math and Pretest (classroom)
- ▶ Traditional Methodology (Skills Lab)
 - ▶ Calculations taught using textbook and white boards with focus on using formulas)
 - ▶ Medication Administration taught by demonstration and return demonstration

Experimental Group

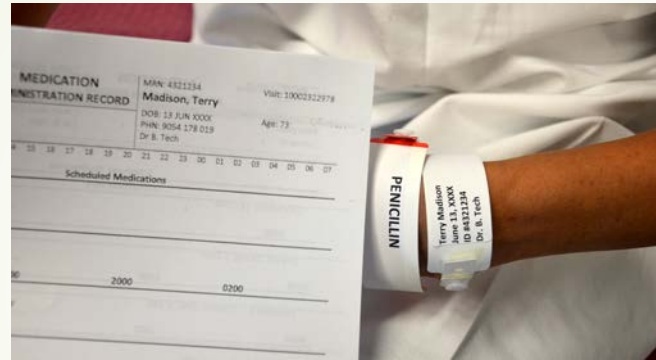
- ▶ Basic math and Pretest (classroom)
- ▶ Experiential Real Life (Skills Lab)
 - ▶ Provider orders, MAR, ; drug calculations ab values, pre-assessments, determining if drugs should be given, post-assessments, documentation
 - ▶ Simple math, Mental math, and formula choice per consistent accuracy
 - ▶ Simulation using drugs (pills, capsules, tablets, liquids, vials, ampoules, IV's, syringes, medication cups etc.).

Experiential Teaching

- Providers orders
- MAR
- Medication Cart
- Pre-assessments
- Dosage Calculations
- Dosage Preparation
- Assessment at Bedside
- Determining if drug should be given
- Administration
- Post-Assessments
- Documentation



Keeping within Clinical Context





Test Example

1. The provider orders Heparin Units subcutaneously this morning. You have on-hand a vial of Heparin 10,000 Units/mL. How much will you give?
2. The IV order reads to give 1500 mL of 0.9% Normal Saline in 10 hours. The drop factor is 12gtts/mL. How many gtts/min will you run the IV?
3. The provider orders Digoxin 0.25 mg PO stat. You have on hand 0.5 mg tablets. The tablets are scored. How much will you give?
4. The provider orders Morphine gr ss. Every four hours IM for pain. You have available Morphine 15 mg/mL. How much will you give?
5. The provider orders Regular Insulin U-50 , 16 Units every morning. After breakfast. On hand you have Regular Insulin U-50 units/mL. How much will you give.



Test Example

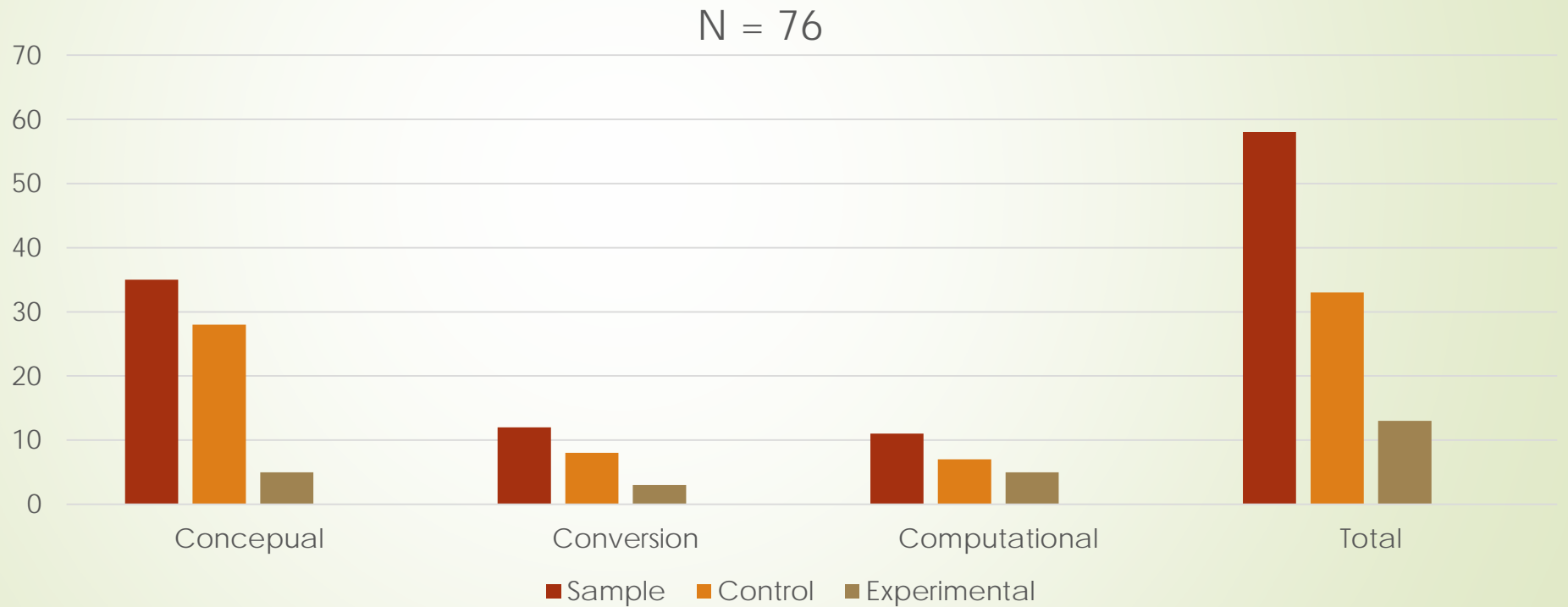
6. The provider orders Tagamet 300 mg IVPB in 50 mL D5W to infuse over 30 minutes. The drop factor is 60 gtt/mL. How many gtt/min will you run th?
7. The provider order Tazidime 400 mg IM every 8 hours. You have available 280 mg/mL vial. How much will you give the client?
8. The client is to recive an intermittent tube feeding. The provider orders 490 mL of $\frac{3}{4}$ strength Ensure by nasogastric tube every eight hours. How would you make the $\frac{3}{4}$ strength tube feeding?

How many mL of Ensure? _____

Hoe many mL of water? _____

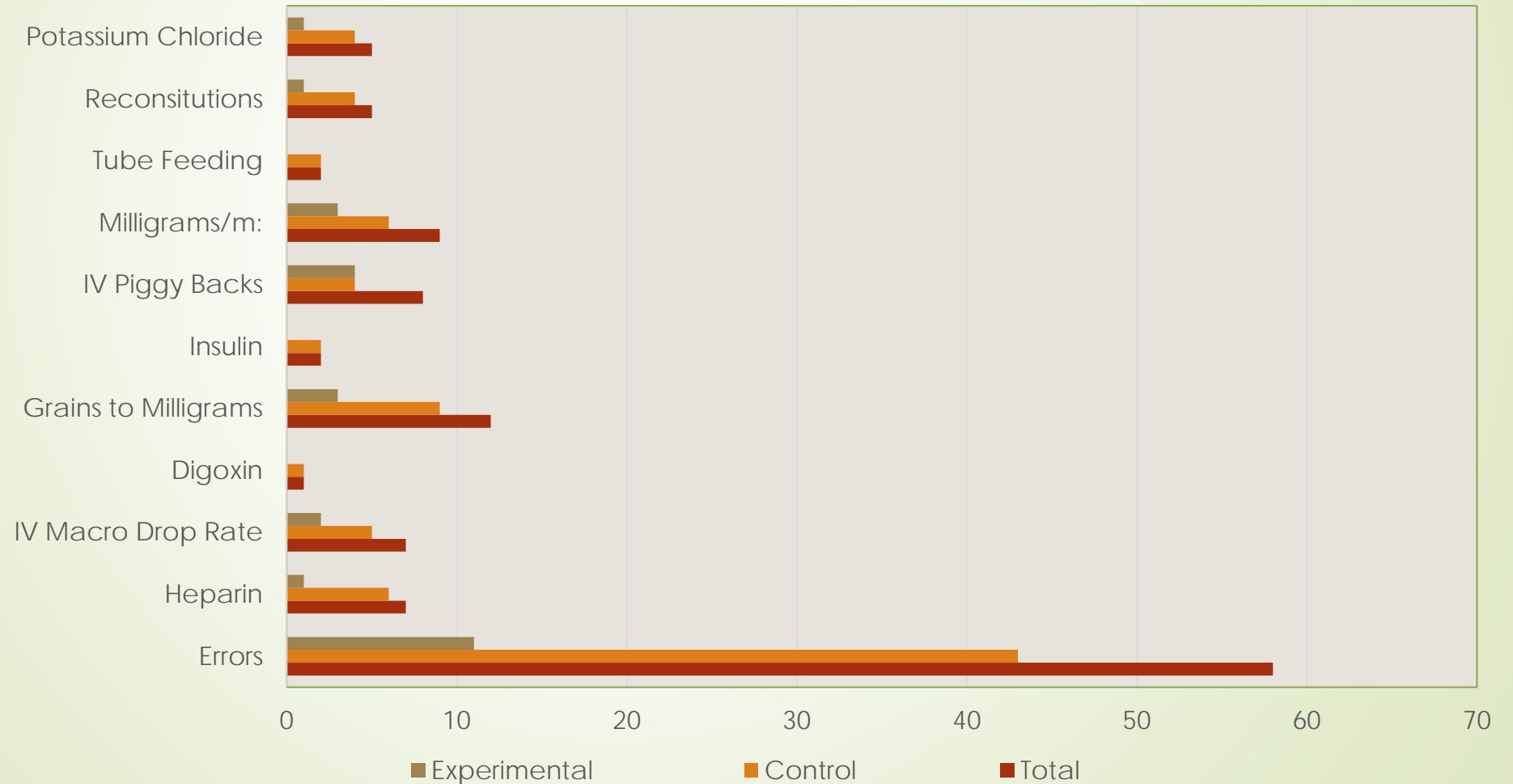
9. The client has a provider's order for Cefadyl 700 mg IV every 6 hours. You have on hand a 1 g vial with the directions to reconstitute with 10 mL of sterile water to give you 0.1 g/mL. How much will you give?
10. The provider has ordered Potassium Chloride 10 mEq by mouth every morning. You have on hand 5 mEq/5 nL. How much will you give the client?

Comparison Between Control and Experimental Groups Posttest Scores

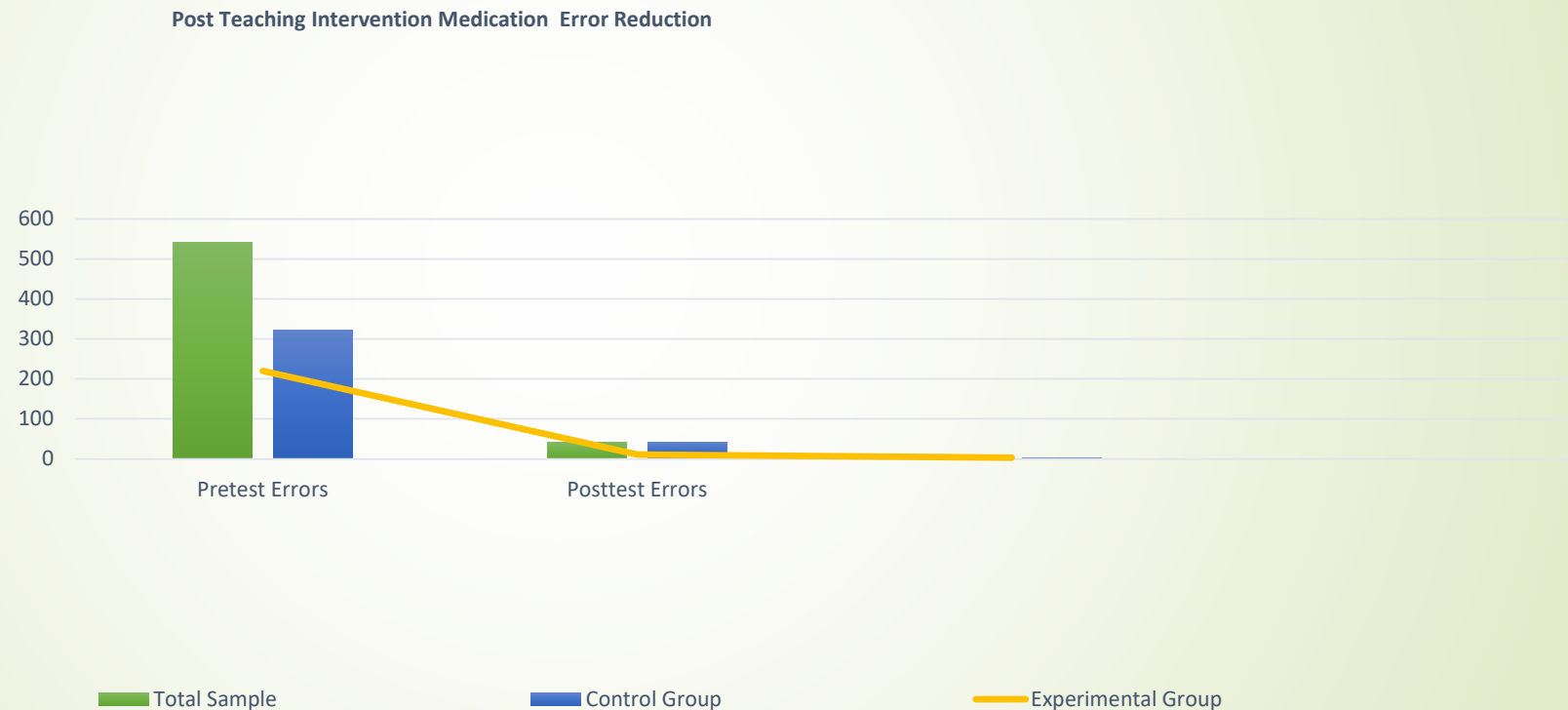


Posttest Medication Calculation Scores

Potentially Life Threatening Errors



Null Hypothesis was rejected. Differences found at $t = 3.1$, $df = 37$, $p = .004$, $CI = 95\%$.



Medication Error Category

Error Type	Compute	Conceptualize	Convert	Critically Evaluate
Heparin mL/unit	5	2	0	7
IV Drops/Minute	5	2	0	7
Digoxin	1	0	0	1
Insulin	0	2	0	2
Grams to Milligrams	0	1	11	12
IV Piggy Back	3	5	0	8
Tube Feedings	0	2	0	2
Reconstitution	1	4	0	5
KCL mEq/mL	1	4	0	5
Total	16	22	11	58

Error Reductions from 544 to 58 = 89%

Control Group

n = 24 with 43 errors

- ▶ 75% decrease in errors
- ▶ 14 achieved 100% on first attempt
- ▶ Errors were from 1 to 6
 - ▶ Conceptual 28
 - ▶ Conversion 8
 - ▶ Computational 7

Course medication Calculation Exam four weeks later:

- ❑ 64% (24) did not pass on first attempt; scores were 40% to 90% with 52 potentially life threatening errors;
- ❑ 2nd attempt 13 students failed with 18 errors,
- ❑ and 3rd attempt 1 failed and was withdrawn from the next course

Experimental Group

n = 11 with 15 errors

- ▶ 93% decrease in errors
- ▶ 27 (71%) achieved 100% on first attempt
 - ▶ Conceptual 5
 - ▶ Conversion 3
 - ▶ Computational 5
 - ▶ 100% passed the course medication calculation exam on the first attempt 4 weeks later

Long Term 10 weeks later 100% passed medication calculation test

Example: Heparin ordered 64 units from a 10,000 unit/mL vial

- ▶ Dimensional Analysis
- ▶ Ratio and proportion
- ▶ Set-up incorrectly 1,000%
- ▶ Misplaced decimal = 6.4 ml = 64,000 units a 10 million percent overdose Heparin = 64,000 units of heparin 10 million percent more than ordered



Intravenous Calculation Errors



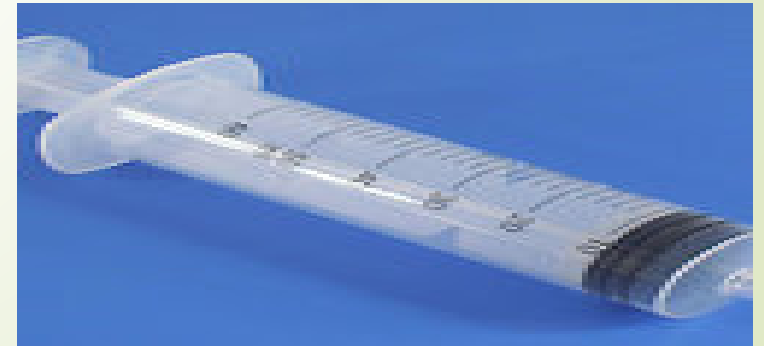
- Set-up problem incorrectly which resulted in 1,000 drops/minute or 2.5 drops/min instead of 38 drops/min
- \ Misplaced Decimal = drops/min
- Set up problem incorrectly using ordered amount of medication of 300 milligrams instead of the amount of solution = 50mL = 60 instead of 100 drops/min

Insulin Errors: Order 16 units Regular Insulin U-50

- ▶ Ratio and Proportion
- ▶ Dimensional Analysis



- ▶ 50 units = 31.3% over the ordered dose
- ▶ Calculated a dosage of 16 mL = 800 units = 5,000% over ordered dose

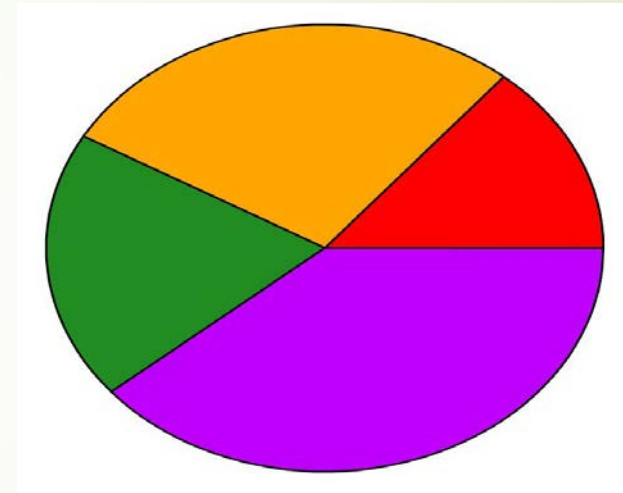




Conversion of Grams to Milligrams

- ▶ Morphine Sulfate
- ▶ Potassium Chloride order = 10 mEq. On hand 5mEq/5mL
- ▶ 6 mL I over dosage = 67% more than ordered
- ▶ 0.5 mL = under dosage = 50% less than ordered
- ▶ Dimensional Analysis set up the problem resulted in 10 mEq/1ml which was 90% under dosage

Posttest Calculations by Experimental Group



Key Factors



Rote memorization of a formula does not foster conceptual understanding



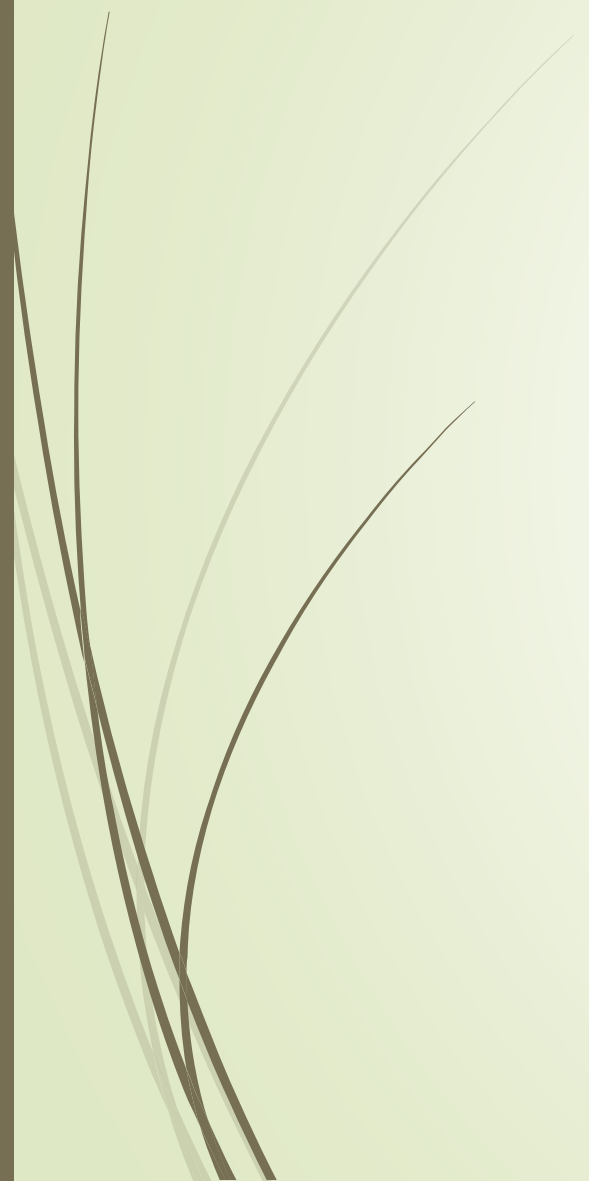
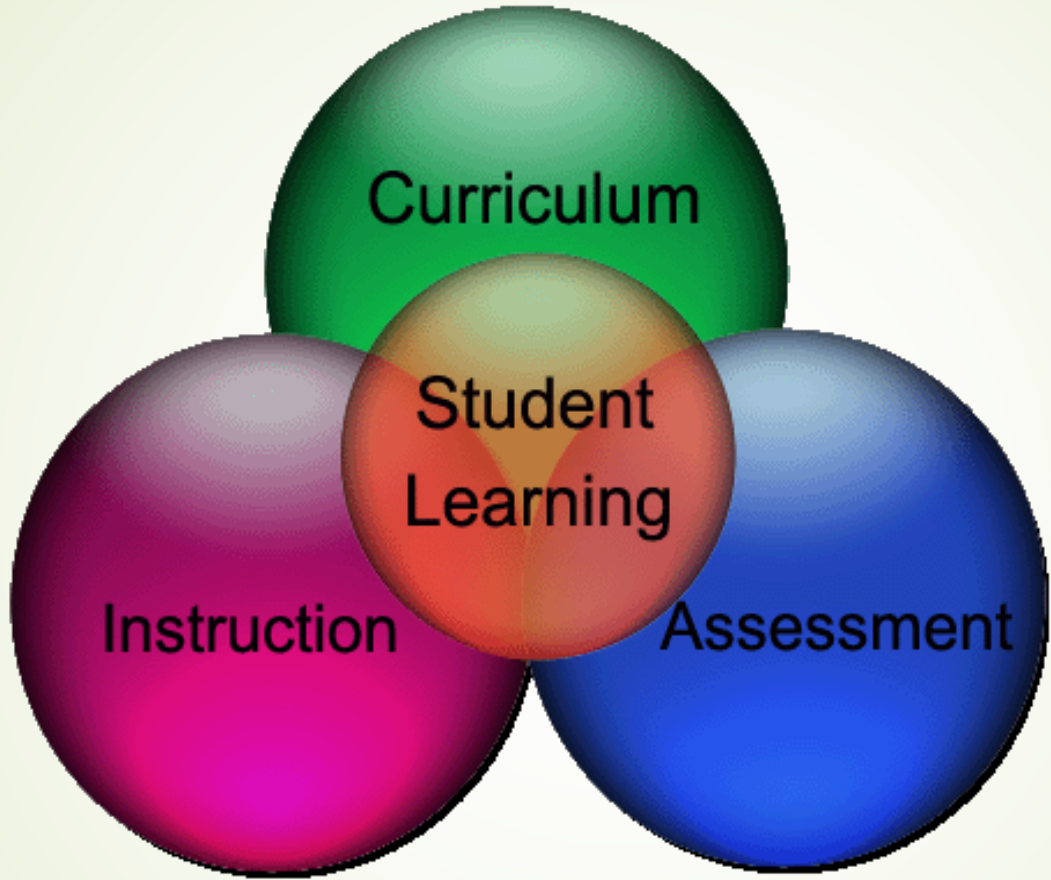
The formula does not give the correct answer but the ability of the students to critically think and make clinical judgements. Keep the numbers within a clinical context.

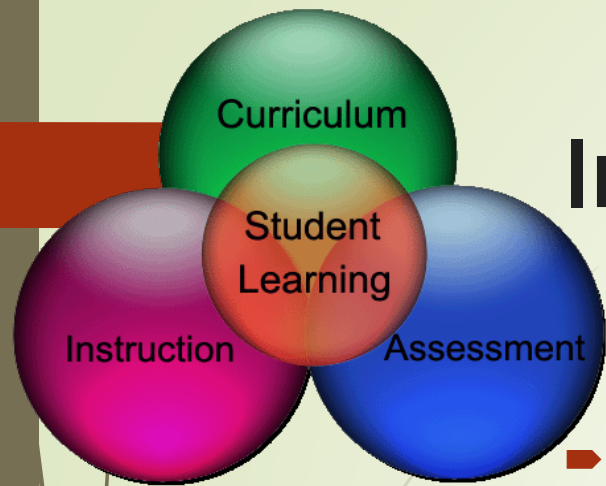


Dependence on calculators does not lead to correct answers if the student does not know how to set-up a problem. Once the numbers are removed from the clinical content with or without a calculator, the incidence of an error increases (Wright, 2007). The numbers



Stress mental and simple math first then the use of a formula that consistently produces a correct dosage.





Implications for Nursing Curriculum

- Assess academic preparedness using standard tests that have validity and reliability such as the Test of Essential Academic Skills by Assessment Technology Institute (math, reading, English Language use, and science predicted medication calculation ability). Please see Appendix B
- Use a patient-centered approach
- Active use of materials, supplies, and technological resources
- Foster long-term medication accuracy through experiential strategies throughout the curriculum
- Collaborate with other divisions to provide interdisciplinary education on medication accuracy such as pre-med, pre-dentistry, pre-law, and medical ethics.



THANK YOU





References


ACT (2014). *Condition of college and career students*. Retrieved from:
<http://www.org/newsroom/data/index.html/>

Faddis, M. (1939). Eliminating errors in medication. *American Journal of Nursing*, 39, 1217.

Institute of Medicine (2000). *To err is human: Building a safer health care system*, Washington, DC: national Academies Press.

Johnson, S. A. & Johnson, L. J. (2002). The 4CCs: A model for teaching dosage calculations. *Nurse Educator*, 27(2), 79-83.

National Center for Education Statistics (2015). *Program for international student statistics* Retrieved from: <http://nces.gov?surveys/pisa/>



National Mathematics Advisory Council (2008). *Foundations for success: The final report of the national Advisory Panel*. Washington, DC: U.S. Department of Education. Retrieved from: http://www.gov.about/bdsconun/list/mthpanel/report/final_reprt.pdf

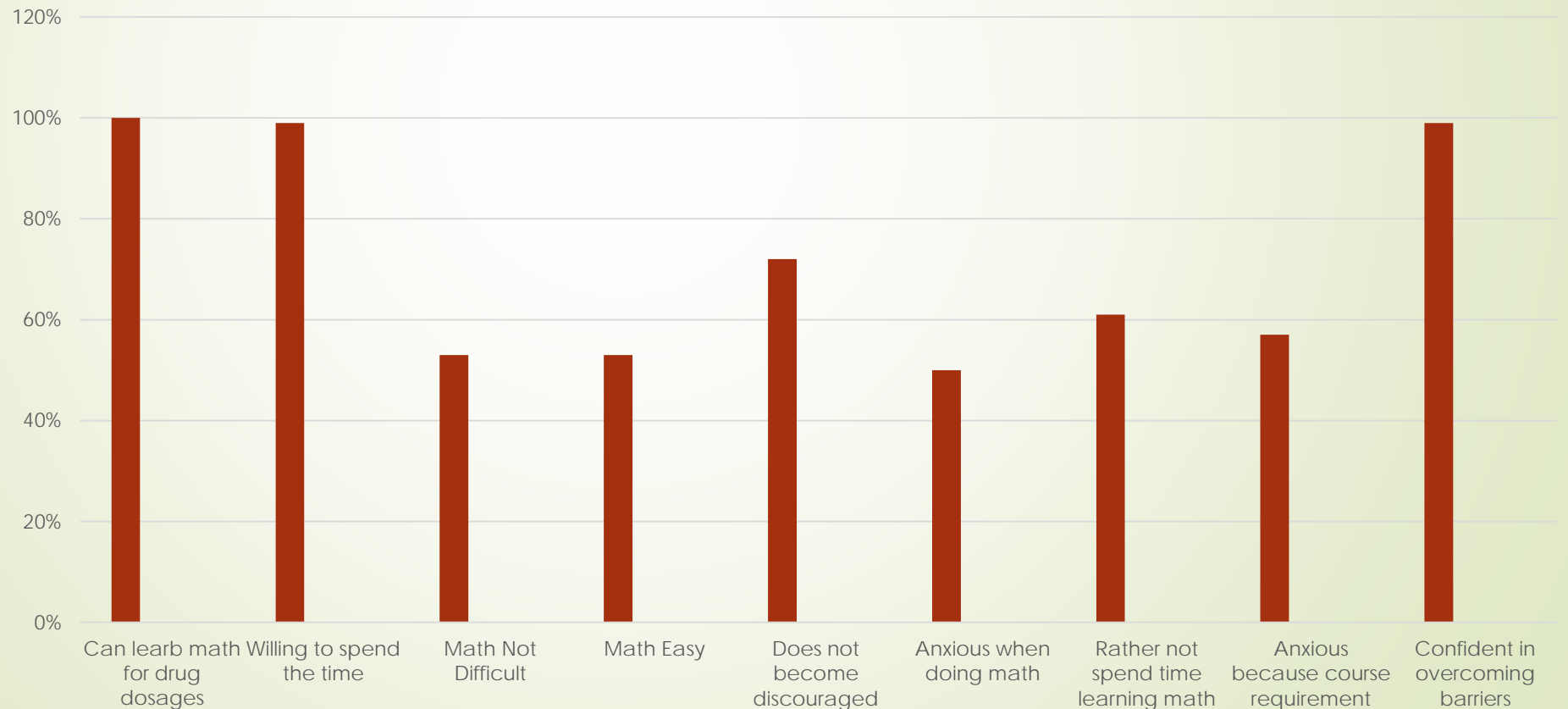
The Joint Commission International (2010). *WHO collaborating centre for patient safety solutions*. Retrieved from: <http://www.ccforpatientsafety.org/patient.safety.solutions/>

Wright, K. (2007). Student nurses need more than maths to improve their calculation skills. *Nurse Education Today*, 27. 278-285.



Appendix A

Pre-Course Survey on Math Perceptions Anxiety, Self-Efficacy, and Motivation





Appendix B

Experimental Group Evaluation

- ▶ **I liked how we were able to use the medication and pills to help us see what exactly we would be dealing with in practice.**
- ▶ **Getting the knowledge I need to perform my duties and the time spent with students to build their confidence.**
- ▶ **Reading the questions carefully before attempting to solve them and practicing solving problems in a critical manner.**
- ▶ **The hands on activity.**
- ▶ **Different teaching methods**
- ▶ **Being shown a variety of ways to do math and choosing the easiest way for me.**
- ▶ **It helped that the instructor could give med cases that were real examples.**
- ▶ **Professor and teaching techniques**



Experimental Group Comments

- ▶ I liked taking practice med. calculation exams. It helped me show my progress throughout the course and my strengths and weaknesses in my math ability.
- ▶ I enjoy that what I once looked at as alien I now understand
- ▶ Actually learning how to do med calcs. My instructor showed us many ways to do them and explained everything great.
- ▶ I liked that we were given many examples to practice from and learned what meds can do to the body if wrong calc. done.
- ▶ The textbook was very clear and easy to follow. The practice questions during skills lab were very helpful.
- ▶ I liked learning the different ways to calculate.




Experimental Group Comments

- ▶ Actually using meds while calculating. The math book had everything we needed to learn and explained it well.
- ▶ Instructor was always helpful and gave knowledgeable information.
- ▶ I actually had no idea how to do med calcs before this course.
- ▶ Being able to understand and pick apart problems in order to do the problem..
Doing practice problems
- ▶ The teacher of the program. I knew nothing and didn't have much confidence. Now I have a little more and know so much and am confident.
- ▶ The instructor helped me to believe in myself 😊. It's by a 100% better than when I started (math ability) 😊 The practice exams really helped me track my progress and pinpoint exactly which problems I needed to work on.



Experimental Group Comments

- ▶ Allowing me to understand the different methods of calculating meds
- ▶ Loved the lab time.
- ▶ I enjoyed how it related to real life scenarios.
- ▶ Learning different ways to solve problem without a calculator.am a hands on person and this course was definitely hands on.
- ▶ It prepared us for life settings. The course gave me the opportunity to learn in a real clinical setting by providing materials during lab.
- ▶ The course gave me the opportunity to learn in a real clinical setting by providing materials during lab.



Appendix C

Control Group Evaluation

- ▶ Doing practice problems
- ▶ Clarifying problems
- ▶ More practice tests
- ▶ Nothing really I liked about the course.
- ▶ Less self-teaching
- ▶ More homework
- ▶ Need to learn different ways---not just one (dimensional Analysis)
- ▶ Problems in the book were helpful.
- ▶ Problems for homework with tests next week.