Research Article

EDUCATIONAL POINT
An International Peer-Reviewed Journal

https://www.educationalpoint.net
ISSN: 3062-1011 (Online)

Enhancing clinical mathematics proficiency of nursing students through heuristic-based learning packets: A quantitative evaluation

Evan P. Taja-on [1*], Dennis B. Roble [1]

[1] University of Science and Technology of Southern Philippines, PHILIPPINES
* Correspondence: etajaon@gmail.com

CITATION: Taja-on, E. P., & Roble, D. B. (2025). Enhancing clinical mathematics proficiency of nursing students through heuristic-based learning packets: A quantitative evaluation. *Educational Point*, *2*(2), e122. https://doi.org/10.71176/edup/16553

ARTICLE INFO

Received: 23 Apr 2025
Accepted: 11 Jun 2025

OPEN ACCESS

ABSTRACT

Mathematics plays a vital role in nursing practice, as it supports essential tasks such as medication administration, fluid management, and the accurate interpretation of patient data. However, nursing students often struggle to apply mathematical concepts in clinical settings where quick and accurate decisions are crucial. The study explores a heuristic way to help students become more confident and capable in using mathematics to ensure safe and effective patient care. A learning intervention was conducted among nursing students using specially designed packets incorporating heuristic strategies for understanding clinical mathematics. Data collected before and after the intervention were analyzed to identify meaningful improvements in their skills, with results handled under strict ethical and privacy guidelines. The results showed significant improvements in students' performance in clinical mathematics after using heuristic-based learning materials. These gains were consistent across key areas such as unit conversion, dosage calculation, fluid balance, and data interpretation. The findings confirm that focused and contextual instruction can meaningfully support nursing students in developing the skills necessary for safe and effective patient care.

Keywords: clinical mathematics, heuristic-based education, nursing practice, nursing education, mathematical education

INTRODUCTION

Background of the Study

Mathematical skills are essential in clinical practice, especially nursing, where precise calculations can directly impact patient outcomes (Ogbonnaya & Awoniyi, 2021). Nurses are often responsible for administering medications, managing intravenous fluids, and interpreting medical data, all requiring accuracy and confidence in mathematical computations (Taja-on et al., 2024). Their role as primary caregivers places them

in constant contact with patients, making it critical for them to apply clinical mathematics quickly and correctly (Bell et al., 2020). Given the demands of healthcare settings, the ability to carry out calculations efficiently is not just a technical requirement, it is a fundamental part of safe and effective patient care.

Despite the recognized importance of mathematics in nursing, many students find it challenging to transfer mathematical concepts into clinical practice (Bell et al., 2020). Traditional mathematics teaching methods often focus on theoretical understanding, which may not translate well into the daily fast-paced and high-pressure environments that nurses face (Damar, 2022; Minty-Walker et al., 2024; Saeedi et al., 2021). The urgency of medical situations leaves little room for second-guessing or lengthy problem-solving methods, making real-time accuracy a challenge. Errors in dosage calculation or fluid management can lead to serious consequences, highlighting the need for more practical, adaptable ways of learning that fit the realities of the clinical setting (McKenna et al., 2022; Mulac et al., 2022; Stolic et al., 2022).

To address these challenges, there is a growing interest in heuristic approaches to learning, which emphasize practical strategies and simplified decision-making processes (Mousoulides & Sriraman, 2020). Heuristics are mental shortcuts, or guiding principles that help learners efficiently approach problems, especially in high-stakes situations. By focusing on common patterns and practical cues rather than abstract rules, this method can support nursing students in developing mathematical fluency that is both accurate and time-efficient (Bavar et al., 2023; Wilson et al., 2023). This approach aligns closely with the nature of clinical work, where quick judgment and practical reasoning are often required.

Although mathematics education has long been a component of nursing curricula, a notable lack of research on clinical mathematics and how best to teach it in applied settings remains. Most existing studies either generalize mathematical learning or do not account for nursing students' specific challenges in clinical environments (Du et al., 2022; Lawson et al., 2020; Lima et al., 2019; Tyo & McCurry, 2019). This gap leaves educators with limited guidance on effectively supporting the development of clinical math skills using methods aligned with real-world practice demands. Filling this gap is essential for improving academic outcomes, patient safety, and overall quality of care.

In response to this need, the current investigation explores how heuristic learning strategies can better support nursing students in mastering essential clinical calculations. Focusing on an approach that simplifies and contextualizes mathematical learning aims to build both confidence and competence among future nurses. This study emphasizes the importance of aligning educational tools with the specific demands of clinical work, ensuring that students are knowledgeable and ready to apply what they learn in the healthcare setting.

Theoretical Foundation of the Study

This study is grounded in two key educational theories: Cognitive load theory and constructivism. Cognitive load theory (Tabatabaee et al., 2024) explains how learners process and retain new information by emphasizing the limits of working memory. In clinical mathematics, this theory supports using simplified strategies and focused tasks to avoid overwhelming students, especially when learning complex or unfamiliar procedures. On the other hand, constructivism (Thompson, 2020) highlights the importance of learners actively building their understanding through experience and reflection. In this study, these theories guide the overall approach to instruction, aiming to balance clarity, relevance, and active engagement.

These two theories create a strong foundation for understanding how nursing students can develop clinical mathematics proficiency. Cognitive load theory ensures that instructional content is explicit and manageable, while constructivism supports deeper understanding through practical application and learner involvement. Combined, they provide a framework that avoids cognitive overload and encourages meaningful learning by connecting theory to clinical practice.

Objective of the Study

Despite emphasizing accuracy and safety in healthcare, many nursing students struggle with applying mathematical concepts in real-world clinical settings. In fast-paced environments where decisions must be made quickly, this gap in learning becomes a concern, as miscalculations can lead to errors in patient care. The study aims to answer the question of how nursing students' performance outcomes reflect the effectiveness of heuristic-based learning packets in enhancing clinical mathematics skills, considering achievement test scores.

REVIEW OF RELATED LITERATURE

Mathematical Competence and Approaches of Teaching Mathematics in Nursing Education

Mathematics has long been a foundational subject in nursing education, often taught as a prerequisite to clinical subjects. The current approach generally includes classroom-based instruction on basic arithmetic, algebra, and applied problem-solving exercises (Bell et al., 2020; Saeedi et al., 2021). While this method builds fundamental knowledge, it emphasizes theoretical understanding rather than clinical relevance. As a result, students may grasp mathematical concepts in isolation but struggle to apply them in actual healthcare settings (Lawson et al., 2020; Lima et al., 2019; Minty-Walker et al., 2024). This gap between learning and practice becomes evident when nursing students are placed in clinical environments where speed, accuracy, and decision-making are critical. The challenge lies in teaching mathematics in a way that connects directly to the tasks and responsibilities of nursing practice.

One of the essential components of clinical mathematics is unit conversion, which allows nurses to translate different measurement systems in the context of medication dosages, fluid volumes, and lab results (Minty-Walker et al., 2024; Ogbonnaya & Awoniyi, 2021). Despite its importance, unit conversion is often taught as a standalone skill without adequate clinical context. This limits students' ability to apply it quickly and correctly in patient care situations (Jarvis et al., 2021; Stake-Nilsson et al., 2022). In practice, improper unit conversion can result in incorrect dosages or treatment plans, posing serious risks to patient safety (Minty-Walker et al., 2021; Sienkiewicz & Megerdichian, 2024; Ware et al., 2024). Accordingly, teaching unit conversion within the framework of real nursing tasks is crucial for preparing students to perform accurately and confidently under pressure.

Another critical area in nursing mathematics is medication dosage calculation, which directly affects a nurse's ability to administer the right amount of medication at the right time (Dutra et al., 2022; Stake-Nilsson et al., 2022). Errors in this area can have life-threatening consequences, making proficiency in this skill non-negotiable. Unfortunately, students often find dosage calculations difficult, especially when multiple steps, units, or contextual variables are involved (Mulac et al., 2022; Owegi et al., 2021; Schneidereith & Barr, 2023; Wennberg-Capellades et al., 2022). Teaching this topic requires more than technical instruction, it demands practice in realistic scenarios where judgment and precision are vital.

Assessing fluid and electrolyte balance is another task that requires strong mathematical skills, particularly in monitoring input and output, calculating deficits, and interpreting lab results. This area is closely tied to maintaining patient stability, especially for those in critical care or undergoing treatments like dialysis (Madu et al., 2021; Leinum et al., 2023). A miscalculation can disrupt fluid management, leading to complications such as dehydration, overload, or imbalances that affect organ function (Goldstein et al., 2024; Jarvis et al., 2021). Integrating mathematics into teaching these assessments allows nursing students to make more informed decisions, bridging clinical reasoning with numerical accuracy.

In modern healthcare, nurses also regularly interact with patient data, whether interpreting vital signs, lab results, or monitoring charts over time. This task demands familiarity with numerical data and the ability to analyze trends, identify anomalies, and anticipate potential complications (Akbar et al., 2021; Bell et al., 2020; Taja-on et al., 2024). Teaching students to interpret this information mathematically can significantly enhance their clinical awareness and responsiveness (Alrabadi et al., 2021). It supports safer, more proactive care by enabling nurses to recognize early warning signs and take appropriate action.

Heuristic Approaches to Learning Mathematics

Heuristic approaches to learning emphasize strategies that simplify decision-making and support problem-solving through patterns, rules of thumb, and intuitive reasoning. In nursing practice, where time-sensitive decisions are common, these approaches offer practical tools for quickly working through complex calculations without losing accuracy (Dutra et al., 2022; Mousoulides & Sriraman, 2020; Wilson et al., 2023). Heuristics can make clinical mathematics less intimidating and more approachable for students, allowing them to internalize essential processes through repeated application and pattern recognition (Safitri et al., 2023; Vogel et al., 2022; Wakhata et al., 2023). This method helps develop both speed and confidence in mathematical tasks, which are critical in clinical settings.

Developing a learning packet grounded in heuristic principles allows for creating structured, practice-oriented materials focusing on essential clinical math skills. These materials provide step-by-step strategies and examples that guide students through common scenarios they will likely encounter in practice. Rather than overwhelming students with abstract rules, the packet offers simplified paths to understanding and solving problems (Batiibwe, 2020; Boschetti & Maniezzo,2022; Mousoulides & Sriraman, 2020). These supports are helping students retain and apply what they learn effectively, making their training more aligned with the demands of real-world nursing.

METHODOLOGY

Research Design

This research employed an experimental design (Garton et al., 2020) to examine the effectiveness of a heuristic-based learning approach in improving the clinical mathematics proficiency of nursing students. The design involved the administration of a pre-test and post-test to the same group of students, allowing for the measurement of changes in performance after the intervention. The test was conducted within the context of a nursing education setting, specifically targeting the application of mathematics in clinical nursing practice. The assessment items focused on key topics essential to safe and effective nursing care, including unit conversion, medication dosage calculations, fluid and electrolyte balance assessment, and patient data interpretation. Rather than assessing abstract mathematical skills in isolation, all test items were embedded within contextualized clinical scenarios to reflect real-life nursing situations and enhance relevance and applicability.

The same test was administered for both the pre-test and post-test to ensure consistency in measurement and allow for direct comparison of student performance before and after the intervention. This approach minimized variability and provided a clear baseline for evaluating the impact of the heuristic-based instructional strategy. The intervention was implemented across four separate nursing classes within a Catholic higher education institution, providing a broader sample and increasing the generalizability of the findings while maintaining adherence to the institution's academic and ethical standards. Focusing on a controlled learning environment, the study was able to isolate the effects of the instructional material from other variables, such as differences

in teaching styles, access to external tutoring, prior clinical exposure, varying levels of peer collaboration, and use of additional learning resources outside the intervention.

Sampling Method and Respondents

To ensure the intervention's inclusiveness and fairness, the study used total population sampling (Lohr, 2021). All students enrolled in the Pharmacology course were included as participants, removing the need for selection and minimizing potential biases in the results. This approach allowed every student to benefit from the heuristic-based learning packets and ensured that the findings would reflect the entire cohort. It also enhanced the integrity of the results by eliminating disparities in instructional exposure among students.

The study's respondents consisted of one hundred forty-nine nursing students enrolled across four sections of the Pharmacology course. Twenty-nine were male, and one hundred twenty were female, with ages ranging from eighteen to twenty-three. This diverse group of learners provided a balanced representation of the student population within the program. Their participation ensured that the outcomes would reflect the learning needs and capacities of male and female students within the typical age range for nursing education.

Heuristic-Based Learning Packets

The investigation was conducted within the context of a nursing education program at a Catholic higher education institution, focusing on improving students' proficiency in clinical mathematics as applied in real-world nursing scenarios. To support this goal, the researchers developed a set of learning packets tailored to address critical areas of clinical mathematics: unit conversion, medication dosage calculations, fluid and electrolyte balance assessment, and patient data interpretation. These packets were designed for use during classroom-based instructional sessions that formed the core of the heuristic-based learning intervention.

The researchers employed a structured content validation process to ensure that the instructional materials were valid and appropriate for the intended educational context. Eighteen experts across relevant fields participated in the review, including five specialists in nursing education, two in general education, three in science education, and eight in mathematics education. Each expert evaluated the clarity, relevance, and appropriateness of the content in relation to both educational standards and clinical practice. The process resulted in high content validity index (CVI) scores (Yusoff, 2019)—0.998 for unit conversion, 0.993 for medication dosage calculations, 0.998 for fluid and electrolyte balance, and 0.998 for patient data interpretation—demonstrating strong expert consensus on the quality and applicability of the materials within the context of nursing education and clinical practice (Almanasreh et al., 2019).

Research Procedures

Before the intervention began, formal approval was secured from the Catholic higher education institution, and the implementation was scheduled from March to April 2025. An orientation session was conducted with participating nursing students to explain the study's objectives, procedures, and ethical safeguards. During this session, students were asked to sign informed consent forms and were briefed on data privacy protocols, ensuring their voluntary participation and the confidentiality of their information.

The study commenced with the administration of a pre-test designed to assess students' baseline proficiency in clinical mathematics—a domain that refers to the application of mathematical concepts within nursing practice. Specifically, the test focused on key topics integral to safe and effective patient care, including unit conversion, medication dosage calculations, fluid and electrolyte balance assessment, and interpretation of patient data. Rather than testing abstract math skills, all questions were embedded in contextualized clinical scenarios, aligning closely with real-world nursing responsibilities.

The same test was used for both the pre-test and the post-test. This decision was intentional and grounded in methodological consistency: using identical items allowed the researchers to make direct comparisons of student performance before and after the intervention, ensuring that any observed improvements could be attributed to the instructional method rather than differences in test difficulty or content. The heuristic-based learning packets were then introduced and integrated into students' Pharmacology classes. A team-teaching approach was employed, with the researcher delivering the mathematical concepts and the clinical instructor demonstrating their application in clinical practice. This collaboration provided a cohesive, context-rich learning experience.

Following the instructional period, the post-test, identical in format and content to the pre-test, was administered to evaluate the effectiveness of the intervention in improving students' clinical mathematics skills. All test results were securely stored and accessed exclusively by the research team to uphold data integrity and participant confidentiality.

Data Analysis

The data gathered from the pre-test and post-test were analyzed using descriptive statistics, which involve summarizing and organizing data through measures of central tendency and variation to provide a clear overview of students' performance levels. A paired t-test was employed, which compares the means of two related groups—in this case, the same students before and after the intervention to assess the statistical significance of changes in scores. These analytical tools allowed the researchers to evaluate the impact of the heuristic-based learning packets in a clear, systematic, and objective manner.

In the treatment of data for this study, several key statistical measures were employed to evaluate the effectiveness of the heuristic-based learning packets on nursing students' clinical mathematics performance. The mean represents the average test scores of students in both the pre-test and post-test, providing a central value for performance comparison. The standard deviation measures the degree of variation or dispersion of scores from the mean, indicating whether student performance was consistent or varied widely. A paired t-test was conducted, generating a t-value that reflects the size of the difference relative to the variability in the data to assess whether the observed differences in scores before and after the intervention were statistically significant. Finally, the p-value was used to determine the likelihood that the results occurred by chance; a p-value of less than 0.05 was considered statistically significant. These statistical tools collectively enabled the researchers to determine whether the instructional intervention led to meaningful improvements in clinical mathematics skills.

This analysis directly supports the study's objective to determine how nursing students' performance outcomes reflect the effectiveness of heuristic-based learning packets in enhancing clinical mathematics skills, as measured by their achievement test scores. The researchers were able to assess whether exposure to the instructional materials led to measurable improvements in clinical mathematics proficiency within a nursing education context by comparing pre- and post-intervention results.

RESULTS AND DISCUSSION

Implementation of the Heuristic-Based Learning Packets

The implementation of the learning packets was evaluated through a single assessment administered at two points, a pre-test and a post-test, designed to measure students' performance across four key areas of clinical mathematics: unit conversion, medication dosage calculations, fluid and electrolyte balance assessments, and interpretation of patient data. These assessments provided a comprehensive view of students' proficiency in applying mathematical concepts in nursing contexts. The analysis of the pre-test and post-test results

Table 1. Comparison of the achievement test results of the implementation of the heuristic-based learning packets for unit conversion

Test	Mean	Std. Dev.	*t*	*p*
Pre-test	3.77	1.768	–29.685	0.000**
Post-test	8.81	1.195		

** p < 0.01

offered insights into students' progress after engaging with the instructional materials. The following sections present the outcomes of this evaluation, emphasizing the differences in performance observed before and after the use of the heuristic-based learning packets.

Unit conversion

Unit conversion is a foundational skill in clinical mathematics, involving the accurate transformation of values between different measurement systems such as metric, apothecary, and household units. In nursing, this skill is essential for preparing medications, interpreting lab values, and managing fluid intake/output. A clear understanding of unit conversion ensures safe and efficient patient care, reducing the risk of dosage errors due to miscalculated measurements. **Table 1** compares the nursing students' test scores between the pre-test and post-test results of implementing the developed heuristic-based learning packets on the material for unit conversion.

Table 1 indicates a significant improvement in nursing students' performance on unit conversion after using the heuristic-based learning packets. The pre-test mean score was 3.77, while the post-test mean increased sharply to 8.81. This increase, supported by a p-value less than 0.01, confirming that the intervention had a meaningful impact. Additionally, the standard deviation decreased from 1.768 in the pre-test to 1.195 in the post-test, which signifies that student scores became more closely grouped around the mean. A lower standard deviation suggests reduced variability in performance, implying that students had a more consistent understanding of the material and fewer outliers in their performance, evidence of clearer comprehension, and less confusion across the group.

The results presented in **Table 1** respond to the question of how learning materials affect students' ability to apply unit conversion in clinical settings. The substantial improvement points to the effectiveness of rule-based strategies, structured guidelines or step-by-step methods that help simplify problem-solving by using logical procedures rather than memorization or trial and error. For example, students may have followed a consistent method to convert units (e.g., milligrams to grams) using dimensional analysis, which has been shown in studies such as Stake-Nilsson et al. (2022) and Sienkiewicz and Megerdichian (2024) to improve accuracy and reduce cognitive load. This structured approach enables quicker and more accurate calculations, especially in high-pressure environments where nurses must make fast, precise decisions. These improvements are not only observed in the test results but also supported by prior findings that emphasize the importance of consistent and repeatable strategies in learning clinical math (Minty-Walker et al., 2021).

Furthermore, presenting unit conversion tasks within familiar clinical contexts, such as adjusting medication dosages or converting IV fluid volumes, helped students relate the abstract mathematical content to real nursing responsibilities. Research by Jarvis et al. (2021) and Ware et al. (2024) confirms that embedding math instruction in real-world scenarios enhances student engagement and retention. In this study, when students recognized the practical use of unit conversions in patient care, they were more motivated to understand the steps involved and better able to internalize the relevance of what they were learning. This contextual connection allowed them not just to solve math problems but to see their clinical importance, which further strengthened their comprehension and confidence. The result implies that the shift from abstract instruction to applied, student-centered learning supports comprehension and retention, especially in complex, detail-sensitive tasks like unit conversion.

Table 2. Comparison of the achievement test results of the implementation of the heuristic-based learning packets for medication dosage calculations

Test	Mean	Std. Dev.	*t*	*p*
Pre-test	3.60	2.936	–20.116	0.000**
Post-test	8.79	0.977		

** $p < 0.01$

The positive shift in students' ability to perform unit conversions holds significant implications for nursing practice and patient safety. In clinical settings, the timely and correct conversion of units is vital to tasks. The improvement of this skill, nurses are better equipped to make sound clinical decisions, minimizing the risk of errors and improving overall patient outcomes (Akbar et al., 2021; Bell et al., 2020; Minty-Walker et al., 2024; Ogbonnaya & Awoniyi, 2021; Taja-on et al., 2024). The results suggest that instructional strategies grounded in real practice—those that foster mental efficiency and active meaning-making—are effective in academic environments and crucial for preparing students to deliver safe and competent patient care.

Medication dosage calculations

Medication dosage calculation is a critical competency for nurses, ensuring the safe and accurate administration of drugs. It involves determining the correct dosage based on factors such as patient weight, prescribed concentration, and route of administration. Mastery of this skill minimizes medication errors, supports effective treatment, and safeguards patient well-being, making it a core focus of clinical mathematics training in nursing education. **Table 2** compares the nursing students' test scores between the pre-test and post-test results of implementing the developed heuristic-based learning packets on the material for medication dosage calculations.

Table 2 indicates a notable improvement in nursing students' performance on medication dosage calculations following the use of heuristic-based learning packets. The mean score increased from 3.60 in the pre-test to 8.79 in the post-test, with a p-value less than 0.01, signifying that the improvement was statistically significant. Furthermore, the reduction in standard deviation from 2.936 to 0.977 suggests a more consistent level of performance across the cohort. These results imply that the structured instructional design helped students understand and master multi-step dosage problems, which often require conversions between units, interpreting labels, and computing accurate dosages based on weight and time. Without support, such processes can overwhelm learners by placing too many demands on working memory simultaneously, leading to errors and anxiety (Mulac et al., 2022; Owegi et al., 2021).

By presenting the content in smaller, logically ordered steps, the learning materials made the topic less cognitively demanding and easier to approach, especially for students who may struggle with multi-variable calculations. For instance, instead of presenting dosage problems as lengthy word problems, the packets broke them down into sequences such as identifying the correct formula, converting units, plugging in values, and checking for accuracy, allowing students to concentrate on one step at a time. This stepwise approach helped reduce extraneous cognitive load and promoted focused learning on the essential mathematical operations needed for clinical accuracy. As a result, students became more confident and accurate in their computations, aligning with findings from Stake-Nilsson et al. (2022) and Schneidereith and Barr (2023), who emphasize the effectiveness of simplified, practice-based instruction in dosage calculation training.

Moreover, the results support the notion that bridging classroom content with real clinical tasks enhances comprehension and retention. When students recognized that the mathematical problems they solved mirrored actual nursing responsibilities, such as administering the correct medication dose based on a doctor's prescription, they were more engaged in the learning process. This relevance to their future professional role not only made learning more meaningful but also encouraged deeper cognitive processing, allowing them to internalize the logic behind dosage calculations. According to Wennberg-Capellades et al.

Table 3. Comparison of the achievement test results of the implementation of the heuristic-based learning packets for fluid and electrolyte balance assessment

Test	Mean	Std. Dev.	*t*	*p*
Pre-test	2.80	1.351	–28.430	0.000**
Post-test	7.70	1.795		

** p < 0.01

(2022), such contextual learning approaches increase application accuracy and long-term understanding, providing strong evidence that the materials used in this study were both practical and educationally effective.

The improved ability to calculate medication dosages accurately has direct implications for patient safety and nursing efficiency. Nurses must make quick and correct calculations to ensure proper medication administration; even minor errors can have serious consequences. The students' improved performance suggests they are better prepared to carry out this responsibility in clinical settings. Applying these skills consistently under pressure can reduce the risk of medication errors and improve the overall quality of care (Akbar et al., 2021; Bell et al., 2020; Dutra et al., 2022; Taja-on et al., 2024). The result reinforces the importance of teaching strategies that improve test performance and prepare students for the real-life demands of patient care.

Fluid and electrolyte balance assessment

Fluid and electrolyte balance assessment involves evaluating a patient's hydration status and the levels of key electrolytes such as sodium, potassium, and calcium. Nurses use mathematical reasoning to calculate fluid intake/output and interpret lab values to detect imbalances. These assessments are vital for maintaining physiological stability and guiding interventions in both acute and long-term care settings. **Table 3** compares the nursing students' test scores between the pre-test and post-test results of implementing the developed heuristic-based learning packets on the material for fluid and electrolyte balance assessment.

Table 3 indicates the results of the student's performance in fluid and electrolyte balance assessment before and after using the learning packets. The mean score of the pre-test was 2.80, which significantly increased to 7.70 in the post-test. This improvement is supported by a statistically significant p-value less than 0.01, indicating that the change was not due to chance. The high t-value and the reduction in the standard deviation from 1.351 to 1.795 show a marked enhancement in performance and consistency among the students. These results suggest that the structured and focused learning approach made it easier for students to understand a topic that typically involves complex and interrelated numerical calculations.

The marked increase in test scores demonstrates that simplifying the content and connecting it to clinical experiences allowed students to better grasp the principles behind fluid and electrolyte balance. Specifically, the mean score rose from 2.80 in the pre-test to 7.70 in the post-test, supported by a statistically significant p-value of less than 0.01. This substantial gain suggests that the instructional design, focused on reducing cognitive complexity and presenting information in digestible steps, was instrumental in improving student understanding. This topic often challenges students due to the need to interpret lab values, calculate fluid input and output, and assess patient symptoms holistically. By offering clear strategies and step-by-step methods within realistic nursing scenarios, the learning materials reduced confusion and gradually helped students build their understanding. As students engaged with the materials in a way that allowed them to discover meaning through guided practice, they became more confident in applying the concepts to real-life clinical tasks, showing that the method effectively enhanced essential competencies (Madu et al., 2021; Jarvis et al., 2021; Leinum et al., 2023).

Accurate fluid and electrolyte balance assessment is essential in preventing complications such as dehydration, fluid overload, or electrolyte imbalances, all of which can significantly impact patient outcomes. Improving students' abilities suggests they are better prepared to make accurate assessments and sound

Table 4. Comparison of the achievement test results of the implementation of the heuristic-based learning packets for patient data interpretation

Test	Mean	Std. Dev.	*t*	*p*
Pre-test	3.52	1.455	–34.320	0.000**
Post-test	8.44	1.254		

** $p < 0.01$

decisions when caring for patients, particularly those in critical or high-risk conditions. The result strengthens the capacity of future nurses to deliver safe and responsive care, reducing the likelihood of error and supporting more efficient clinical workflows (Akbar et al., 2021; Bell et al., 2020; Goldstein et al., 2024; Taja-on et al., 2024). As these skills are vital for maintaining patient stability, the results underline the importance of practical, application-based instruction in nursing education.

Patient data interpretation

Patient data interpretation refers to the nurse's ability to analyze quantitative and qualitative clinical information, such as vital signs, laboratory results, and health records, to make informed care decisions. This process often involves mathematical analysis to identify trends, abnormalities, or changes in patient status, reinforcing its importance as part of clinical mathematics proficiency. **Table 4** compares the nursing students' test scores between the pre-test and post-test results of implementing the developed heuristic-based learning packets on the material for patient data interpretation.

Table 4 indicates a substantial improvement in nursing students' performance in interpreting patient data after using the learning materials. The pre-test mean score was 3.52, which significantly increased to 8.44 in the post-test. The high t-value and the p-value less than 0.01 confirm that the improvement is statistically significant. A lower standard deviation in the post-test also indicates more consistent performance across the group, suggesting that the students understood the concepts better and applied them more uniformly. These results suggest that the structured layout of the learning packets, featuring visual data representations, stepwise guides for trend analysis, and repeated practice in reading and evaluating patient charts, enabled students to better organize and process large sets of clinical data. This design approach aligns with existing research, which shows that simplifying complex information into manageable steps supports cognitive clarity in data-heavy environments (McKenna et al., 2022; Wilson et al., 2023).

The improvement in performance shows that the learning materials helped students interpret a variety of patient data types, including vital signs, lab reports, and observation charts, by guiding them through scenarios they are likely to encounter in clinical practice. These scenarios incorporated familiar patterns, such as reading blood pressure trends over time or identifying abnormal glucose levels, which allowed students to apply what they learned in meaningful ways. Studies have shown that when learners engage with realistic simulations or problem sets, they gain a deeper understanding and are better able to recall and transfer knowledge (Alrabadi et al., 2021; Bavar et al., 2023). This form of applied engagement, reinforced through repeated exposure to context-based tasks, helped bridge the gap between abstract instruction and actual clinical responsibility, contributing to students' growing confidence in handling patient data.

Accurate interpretation of patient information plays a key role in the delivery of safe and responsive nursing care. The improvement in students' test performance suggests they are better prepared to assess, evaluate, and act on patient trends, skills that are foundational to effective clinical decision-making. These findings support the integration of math-based clinical reasoning tasks in nursing education and highlight the need for teaching methods that focus not just on computation but on clinical relevance and critical thinking. The results underscore the benefit of connecting mathematical concepts directly to patient care responsibilities, reinforcing how mathematical understanding supports everyday nursing practice (Akbar et al., 2021; Bell et al., 2020; Taja-on et al., 2024).

Table 5. Comparison of the achievement test results of the implementation of the heuristic-based learning packets

Test	Mean	Std. Dev.	*t*	*p*
Pre-test	13.68	6.135	–34.930	0.000**
Post-test	32.48	2.404		

** p < 0.01

Nursing students' performance in clinical mathematics

Clinical mathematics encompasses the application of mathematical principles in nursing contexts, including dosage calculation, unit conversion, and data interpretation. Evaluating nursing students' performance in clinical mathematics provides insight into their readiness to deliver safe and accurate care. **Table 5** compares the nursing students' test scores between the pre-test and post-test results of implementing the developed heuristic-based learning packets.

Table 5 presents the overall improvement in students' clinical mathematics proficiency after engaging with the learning packets. The mean score in the pre-test was 13.68, which increased significantly to 32.48 in the post-test, with a p-value less than 0.01, indicating that the change was statistically significant. The increase in scores and the decrease in standard deviation suggest that the students gained a stronger grasp of the topics and performed more consistently. The overall result aligns with the improvements seen in Tables 1 to 4, where individual topics such as unit conversion, medication dosage calculations, fluid and electrolyte balance, and patient data interpretation all showed similar positive trends. The data reflect a broad enhancement in mathematical skills across all key clinical areas covered.

The improvement demonstrates that the learning packets effectively enhanced students' clinical mathematics skills. The structured, simplified content helped students process complex topics without becoming overwhelmed, while the contextual approach supported deeper understanding through active engagement (Dutra et al., 2022; Mousoulides & Sriraman, 2020; Safitri et al., 2023; Vogel et al., 2022). By gradually building knowledge through practical, real-life examples, students could connect new information with prior knowledge, making it easier to recall and apply. The consistency of improvement across all measured areas indicates that the instructional method supported individual comprehension and collective learning success (Bell et al., 2020; Taja-on et al., 2024; Wakhata et al., 2023; Wilson et al., 2023). These outcomes show that students responded well to clear, purposeful learning and connected to their future professional responsibilities.

The positive changes in students' proficiency have meaningful implications for the quality of nursing practice and patient care. Clinical settings demand accuracy, speed, and sound judgment, especially in calculations and data interpretation tasks. With improved mathematical skills, students are better prepared to carry out these responsibilities confidently and precisely. This reduces the risk of errors and enhances their ability to make timely decisions, ultimately contributing to safer and more effective care (Batiibwe, 2020; Bavar et al., 2023; Boschetti & Maniezzo,2022; Mousoulides & Sriraman, 2020). The findings emphasize the importance of teaching strategies that prioritize understanding and application, ensuring that future nurses are well-equipped for the demands of the healthcare environment.

SUMMARY AND CONCLUSION

The results directly address the objective of examining how nursing students' performance outcomes reflect the effectiveness of heuristic-based learning packets in enhancing clinical mathematics skills. Across all key areas, unit conversion, medication dosage calculation, fluid and electrolyte balance assessment, and patient data interpretation, students demonstrated significant improvement in post-test scores compared to their pre-

test results. These statistically significant gains confirm that the learning packets effectively supported both comprehension and application of clinical mathematics. The structured, heuristic-based format of the materials minimized cognitive overload by presenting content in simplified, step-by-step formats aligned with actual nursing tasks. The material enabled students to process, understand, and retain essential concepts more effectively, fulfilling the aim of the study to evaluate the instructional method's impact on measurable learning outcomes.

Furthermore, the study revealed that using realistic examples and problem-solving strategies helped bridge theoretical knowledge and practical application, preparing students for real-world clinical responsibilities. As students were able to engage more deeply with mathematical concepts in a context that mirrors professional nursing practice, they developed not only academic competence but also the confidence to apply these skills in high-pressure environments. These findings confirm that the intervention successfully empowered learners with the mathematical proficiency required for clinical accuracy and decision-making. The results, therefore, affirm the value of using practical, heuristic-based learning tools as a strategy to improve nursing education and prepare students for the demands of modern healthcare.

RECOMMENDATIONS

Based on the findings, it is recommended that nursing programs could integrate heuristic-based learning materials into their mathematics instruction, particularly those designed with clear steps and clinical relevance. Institutions may also benefit from incorporating more contextual problem-solving activities in core subjects to help students transfer knowledge to practice. These steps can help improve students' readiness for clinical duties where accuracy, efficiency, and sound judgment are essential.

It is further recommended that future instructional designs provide detailed implementation guides that outline how heuristic-based learning can be systematically applied across specific clinical areas such as medication administration, fluid management, and patient monitoring. These guides could include example lesson plans, heuristic strategies tailored to clinical scenarios, and step-by-step teaching frameworks that educators can adopt or adapt. Integrating simulation activities, case-based discussions, and reflective exercises alongside heuristic instruction may also enhance the transfer of mathematical knowledge to real-world practice. Professional development programs for nurse educators could be developed to train them in heuristic-based teaching techniques, ensuring that the method is applied consistently and effectively in diverse classroom and clinical teaching settings.

Future research may explore the long-term retention of clinical mathematics skills after exposure to strategy-based learning methods to assess their impact beyond immediate performance. Investigating the approach's effectiveness across different year levels and in other healthcare-related programs would also be beneficial. Comparative studies involving control groups or different teaching formats may offer deeper insights into the relative strengths of various instructional models. Additionally, examining student perceptions and learning experiences can help refine the design and delivery of future instructional materials.

LIMITATIONS OF THE STUDY

The study was limited to a single institution and included only students enrolled in one course during the second semester of the academic year 2024–2025, which may restrict the generalizability of the findings. This specific academic term refers to the period from March to April 2025, during which the intervention and data collection were conducted. The results reflect the outcomes of a short-term intervention within that timeframe and do not account for long-term knowledge retention or the application of skills in clinical settings beyond the classroom. Additionally, while the study employed a robust validation process for the learning materials,

individual teaching styles and classroom dynamics may have influenced student engagement and outcomes. These factors should be considered when interpreting the results and applying them to broader educational settings.

Acknowledgements

The authors would like to thank the students who participated in the study and the experts for reviewing the article and their valuable insights and advice for the improvement of the paper.

REFERENCES

Akbar, S., Lyell, D., & Magrabi, F. (2021). Automation in nursing decision support systems: A systematic review of effects on decision making, care delivery, and patient outcomes. *Journal of the American Medical Informatics Association*, *28*(11), 2502–2513. https://doi.org/10.1093/jamia/ocab123

Almanasreh, E., Moles, R., & Chen, T. F. (2019). Evaluation of methods used for estimating content validity. *Research in Social and Administrative Pharmacy*, *15*(2), 214–221. https://doi.org/10.1016/j.sapharm.2018.03.066

Alrabadi, N., Shawagfeh, S., Haddad, R., Mukattash, T., Abuhammad, S., Al-rabadi, D., Farha, R. A., AlRabadi, S., & Al-Faouri, I. (2021). Medication errors: A focus on nursing practice. *Journal of Pharmaceutical Health Services Research*, *12*(1), 78–86. https://doi.org/10.1093/jphsr/rmaa025

Madu, A., Asogan, H., & Raoof, A. (2021). Education and training as key drivers for improving the quality of fluid balance charts: Findings from a quality improvement project. *British Medical Journal Open Quality*, *10*(3), Article e001137. https://doi.org/10.1136/bmjoq-2020-001137

Batiibwe, M. S. K. (2020). Developing mathematical thinking through activity based heuristic approach: A case of making connections between patterns, sequences and graphs. *European Journal of Education Studies*, *6*(12), 284–310. https://doi.org/10.5281/zenodo.3692059

Bavar, A., Bavar, A., Gholian-Jouybari, F., Hajiaghaei-Keshteli, M., & Mejía-Argueta, C. (2023). Developing new heuristics and hybrid meta-heuristics to address the bi-objective home health care problem. *Central European Journal of Operations Research*. https://doi.org/10.1007/s10100-023-00862-4

Bell, A., Galligan, L., & Latham, J. (2020). Numeracy in paramedicine education: A literature review. *Adults Learning Mathematics*, *15*(1), 6–18.

Boschetti, M. A., & Maniezzo, V. (2022). Matheuristics: Using mathematics for heuristic design. *4OR*, *20*(2), 173–208. https://doi.org/10.1007/s10288-022-00510-8

Damar, M. (2022). What the literature on medicine, nursing, public health, midwifery, and dentistry reveals: An overview of the rapidly approaching metaverse. *Journal of Metaverse*, *2*(2), 62–70. https://doi.org/10.57019/jmv.1132962

Du, L., Zhao, L., Xu, T., Wang, Y., Zu, W., Huang, X., Nie, W., & Wang, L. (2022). Blended learning vs traditional teaching: The potential of a novel teaching strategy in nursing education: A systematic review and meta-analysis. *Nurse Education in Practice*, *63*, Article 103354. https://doi.org/10.1016/j.nepr.2022.103354

Dutra, S. V. O., Kumar, K., & Clochesy, J. M. (2022). Instruction strategies for drug calculation skills: A systematic review of the literature. *Nurse Education Today*, *111*, Article 105299. https://doi.org/10.1016/j.nedt.2022.105299

Garton, E. O., Ratti, J. T., & Giudice, J. H. (2020). Research and experimental design. In: N. J. Silvy (Ed.), *The wildlife techniques manual: Volume 1: Research* (8th ed., pp. 1–40). JHU Press.

Goldstein, C., Woods, N., MacKinnon, R., Fazelzad, R., Gill, B., Giuliani, M. E., Papadakos, T., Wei, Q., & Papadakos, J. (2024). Numeracy education for health care providers: A scoping review. *Journal of Continuing Education in the Health Professions*, *44*(1), 35–43. https://doi.org/10.1097/CEH.0000000000000504

Jarvis, D. H., McCullough, K. D., & McParland, T. R. (2021). Nurse education and mathematical competency: Implementation of an online, self-directed, prerequisite model. *International Journal of Environmental Research and Public Health*, *18*(24), Article 13106. https://doi.org/10.3390/ijerph182413106

Lawson, D., Grove, M., & Croft, T. (2020). The evolution of mathematics support: A literature review. *International Journal of Mathematical Education in Science and Technology*, *51*(8), 1224–1254. https://doi.org/10.1080/0020739X.2019.1662120

Leinum, L. R., Krogsgaard, M., Tantholdt-Hansen, S., Gögenur, I., Baandrup, A. O., & Azawi, N. (2023). Quality of fluid balance charting and interventions to improve it: A systematic review. *British Medical Journal Open Quality*, *12*(4), Article e002260. https://doi.org/10.1136/bmjoq-2023-002260

Lima, P. D. S. N., das Almas Silva, L., Félix, I. M., & de Oliveira Brandão, L. (2019). Difficulties in basic concepts of mathematics in higher education: A systematic review. In *2019 IEEE Frontiers in Education Conference* (pp. 1–7). IEEE. https://doi.org/10.1109/FIE43999.2019.9028658

Lohr, S. L. (2021). *Sampling: Design and analysis*. Chapman and Hall/CRC. https://doi.org/10.1201/9780429298899

McKenna, L., Johnston, J., Cross, R., Austerberry, J., Mathew, T., & McKenzie, G. (2022). Mathematics anxiety and associated interventions in nursing: A scoping review. *Nurse Education Today*, *112*, Article 105335. https://doi.org/10.1016/j.nedt.2022.105335

Minty-Walker, C., Wilson, N. J., Rylands, L., Hunt, L., & Pettigrew, J. (2024). Numeracy teaching for undergraduate nursing students: A scoping review. *Journal of Nursing Education*, *63*(4), 218–227. https://doi.org/10.3928/01484834-20240207-03

Minty-Walker, C., Wilson, N. J., Rylands, L., Hunt, L., & Pettigrew, J. (2021). Undergraduate nursing curricula: Numeracy and accreditation. *Collegian*, *28*(5), 559–564. https://doi.org/10.1016/j.colegn.2020.10.006

Mousoulides, N., & Sriraman, B. (2020). Heuristics in mathematics education. In S. Lerman (Ed.), *Encyclopedia of mathematics education* (pp. 331–333). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-15789-0_172

Mulac, A., Hagesaether, E., & Granas, A. G. (2022). Medication dose calculation errors and other numeracy mishaps in hospitals: Analysis of the nature and enablers of incident reports. *Journal of Advanced Nursing*, *78*(1), 224–238. https://doi.org/10.1111/jan.15072

Ogbonnaya, U. I., & Awoniyi, F. (2021). Mathematics in the nursing profession: Student and professional nurses' perspective. *Journal of Holistic Mathematics Education*, *5*(2), 125–138. https://doi.org/10.19166/johme.v5i2.4631

Owegi, R., Burdick, K., Cannon, E., McQuiston, L., & Arvin, S. (2021). Medication math dosage assessment anxiety in undergraduate nursing students: A systematic review. *Journal of Professional Nursing*, *37*(4), 735–740. https://doi.org/10.1016/j.profnurs.2021.05.003

Saeedi, M., Ghafouri, R., Tehrani, F. J., & Abedini, Z. (2021). The effects of teaching methods on academic motivation in nursing students: A systematic review. *Journal of Education and Health Promotion*, *10*(1). https://doi.org/10.4103/jehp.jehp_1070_20

Safitri, N. D., Darmayanti, R., Usmiyatun, U., & Nurmalitasari, D. (2023). 21st century mathematics learning challenges: Bibliometric analysis of trends and best practices in Shinta indexed scientific publications. *JEMS: Jurnal Edukasi Matematika Dan Sains*, *11*(1), 136–152. https://doi.org/10.25273/jems.v11i1.14283

Schneidereith, T., & Barr, E. (2023). A national survey of medication dosage calculation teaching methods and competency criteria on nursing student success: Recommendations for nurse educators. *Nursing Education Perspectives*, *44*(1), 11–17. https://doi.org/10.1097/01.NEP.0000000000001044

Sienkiewicz, S., & Megerdichian, S. (2024). *Clinical nursing calculations with navigate advantage access*. Jones & Bartlett Learning.

Stake-Nilsson, K., Almstedt, M., Fransson, G., Masoumi, D., Elm, A., Toratti-Lindgren, M., & Björkman, A. (2022). Medication dosage calculation among nursing students: Does digital technology make a difference? A literature review. *BioMed Central Nursing*, *21*(1), Article 123. https://doi.org/10.1186/s12912-022-00904-3

Stolic, S., Ng, L., Southern, J., & Sheridan, G. (2022). Medication errors by nursing students on clinical practice: An integrative review. *Nurse Education Today*, *112*, Article 105325. https://doi.org/10.1016/j.nedt.2022.105325

Tabatabaee, S. S., Jambarsang, S., & Keshmiri, F. (2024). Cognitive load theory in workplace-based learning from the viewpoint of nursing students: Application of a path analysis. *BioMed Central Medical Education*, *24*(1), Article 678. https://doi.org/10.1186/s12909-024-05664-z

Taja-on, E. P., Roble, D. B., & Lomibao, L. S. (2024). Mathema Asclepius: A systematic review of mathematics shaping medical frontiers. *Journal of Innovations in Teaching and Learning*, *4*(1), 37–43. https://pubs.sciepub.com/jitl/4/1/6/index.html

Thompson, P. W. (2020). Constructivism in mathematics education. In S. Lerman (Ed.), *Encyclopedia of mathematics education* (pp. 127–134). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-15789-0_31

Tyo, M. B., & McCurry, M. K. (2019). An integrative review of clinical reasoning teaching strategies and outcome evaluation in nursing education. *Nursing Education Perspectives*, *40*(1), 11–17. https://doi.org/10.1097/01.NEP.0000000000000375

Vogel, F., Kollar, I., Fischer, F., Reiss, K., & Ufer, S. (2022). Adaptable scaffolding of mathematical argumentation skills: The role of self-regulation when scaffolded with CSCL scripts and heuristic worked examples. *International Journal of Computer-Supported Collaborative Learning*, *17*(1), 39–64. https://doi.org/10.1007/s11412-022-09363-z

Wakhata, R., Mutarutinya, V., & Balimuttajjo, S. (2023). Relationship between active learning heuristic problem-solving approach and students' attitude towards mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(2), Article em2231. https://doi.org/10.29333/ejmste/12963

Ware, A., Blumke, T., Hoover, P., & Arreola, D. (2024). Calculating optimal patient to nursing capacity: Comparative analysis of traditional and new methods. *JMIR Nursing*, *7*, Article e59619. https://doi.org/10.2196/59619

Wennberg-Capellades, L., Fuster-Linares, P., Rodríguez-Higueras, E., Fernández-Puebla, A. G., & Llaurado-Serra, M. (2022). Where do nursing students make mistakes when calculating drug doses? A retrospective study. *BioMed Central Nursing*, *21*(1), Article 309. https://doi.org/10.1186/s12912-022-01085-9

Wilson, S., Rixon, A., & Brown, C. (2023). Non-clinical intuitions and adaptive heuristics in emergency care: A scoping review. *International Emergency Nursing*, *71*, Article 101371. https://doi.org/10.1016/j.ienj.2023.101371

Yusoff, M. S. B. (2019). ABC of content validation and content validity index calculation. *Education in Medicine Journal*, *11*(2), 49–54. https://doi.org/10.21315/eimj2019.11.2.6