Revista de Ensino de Ciências e Matemática
ONLINE ISSN 2178-7727

A COMPARATIVE STUDY TO ASSESS THE IMPACT OF FOUR COMPONENT INSTRUCTIONAL DESIGN (4C/ID) LEARNING MODEL ON KNOWLEDGE AND SKILLS REGARDING SAFE ADMINISTRATION OF INTRAVENOUS MEDICATION AMONG 3RD SEMESTER B.SC. NURSING STUDENTS

Bhushan Mitaram Landge
Student (Medical-Surgical Nursing) D.E. Society's Smt. Subhadra K. Jindal College of Nursing, Pune.
Dr. Shubhangi Malavade
Vice-Principal, D.E. Society's Smt. Subhadra K. Jindal College of Nursing, Pune
***Corresponding author:** Bhushan Mitaram Landge

https://doie.org/10.65985/AS.2026788349

ABSTRACT

Medication administration safety is a critical component of nursing education. IV medication errors pose significant risks to patient safety, often resulting from inadequate knowledge and insufficient skill development among nursing students. The Four Component Instructional Design (4C/ID) model provides a structured approach to teaching complex clinical skills.

Objective: To assess the effectiveness of the 4C/ID learning model in enhancing knowledge and skills regarding safe administration of intravenous medication among 3rd semester B.Sc. Nursing students.

Methods: A quasi-experimental pre-test/post-test control group design was used among 70 B.Sc. Nursing students selected through purposive sampling. The experimental group received a 7-day 4C/ID-based educational intervention, while the control group underwent traditional teaching. A validated knowledge questionnaire and skill observation checklist were used. Data were analyzed using paired t-test, independent z-test, and Fisher's exact test.

Results: A total of 70 students (35 experimental, 35 control) completed the study. Baseline pre-test knowledge and skill scores showed no significant difference between groups ($p > 0.05$). After the 7-day intervention, the experimental group demonstrated a marked improvement in both knowledge and skill performance. The mean post-test knowledge score increased from 12.48 ± 3.15 to 24.62 ± 2.84, and the mean skill score increased from 6.14 ± 1.92 to 17.45 ± 1.33. In contrast, the control group showed only minimal improvement in knowledge (13.02 ± 3.41 to 15.88 ± 3.02) and skills (6.42 ± 1.86 to 8.21 ±1.77). Paired t-test and independent z-test revealed a highly significant difference between the experimental and control groups for both knowledge and skills ($p < 0.001$). The calculated effect size indicated a large educational impact of the 4C/ID model. No socio-demographic variables showed any significant association with baseline pre-test knowledge or skill levels.

Conclusion: The 4C/ID instructional model effectively enhances IV medication safety competence among nursing students. Integration of this model into nursing education may reduce medication errors and improve patient safety outcomes.

Keywords: 4C/ID Model, Nursing Education, Intravenous Medication, Medication Safety, Clinical Skills, Instructional Design

ISSN:1517-4492 | **E-ISSN**:2178-7727

INTRODUCTION

Medication administration is a fundamental responsibility in nursing practice, and intravenous (IV) medication administration is considered one of the most complex and high-risk procedures performed by nurses. Studies show that medication administration errors account for a large proportion of adverse events in healthcare, with IV medications posing the highest risk due to rapid pharmacological effects and narrow therapeutic margins [1,2].

Globally, statistics indicate that nursing students frequently commit medication errors because of inadequate theoretical understanding, limited supervised practice, and lack of structured competency-based learning[3]. Traditional teaching approaches often emphasize theoretical content with insufficient emphasis on hands-on skill performance, resulting in a gap between classroom learning and real-world clinical practice[4].

To address these challenges, evidence supports the use of structured instructional models that integrate cognitive, psychomotor, and clinical decision-making skills. The Four Component Instructional Design (4C/ID) model, developed by van Merriënboer, offers a scientifically grounded approach to teaching complex tasks by integrating whole-task practice, supportive information, procedural guidance, and part-task practice[5,6]. This model is highly effective in helping learners master complex clinical procedures.

Although the 4C/ID model has been applied successfully in medical and allied health education, limited studies exist on its use in nursing education, especially regarding IV medication administration[7]. Considering the growing complexity of healthcare, increasing incidence of medication errors, and the demand for safe clinical practice, evaluating the 4C/ID model's impact on IV medication safety training for nursing students becomes essential.

Therefore, this study aims to assess the effectiveness of the 4C/ID learning model on knowledge and skills regarding safe administration of IV medication among 3rd semester B.Sc. Nursing students.

NEED OF THE STUDY

Safe administration of intravenous (IV) medications is a critical nursing responsibility, yet it remains one of the most error-prone procedures in clinical practice. IV medication errors not only compromise patient safety but also contribute significantly to morbidity, mortality, and healthcare costs. Global data indicate that medication administration errors account for over 31% of reported medical errors, with IV medications being particularly high-risk due to rapid pharmacological effects and the potential for immediate adverse events[2]. In India, available studies report medication error rates ranging from 6% to 30%, depending on the healthcare setting, emphasizing the urgent need to strengthen medication safety training among nursing students[3].

Nursing students often struggle with complex medication administration tasks because traditional teaching approaches emphasize theoretical knowledge while offering limited hands-on experience. This results in inadequate skill performance, poor clinical judgment, and reduced confidence in safely administering IV medications[1]. A recent study assessing nursing students' medication skills reported significant skill deficits in dose calculation, aseptic

ISSN:1517-4492 | **E-ISSN**:2178-7727

procedures, and patient identification, indicating that current educational strategies are insufficient[1].

The Four Component Instructional Design (4C/ID) model is an evidence-based framework designed for complex learning. It integrates whole-task practice, supportive information, procedural guidance, and part-task training, making it particularly suitable for teaching high-risk clinical procedures[5,6]. Research shows that 4C/ID-based training significantly enhances clinical competence, critical thinking, and accuracy in skill performance among health science students[7]. However, limited studies have explored its effectiveness in improving IV medication safety among undergraduate nursing students.

Given the rising incidence of medication errors, complexity of IV drug administration, and shortcomings in conventional teaching methods, there is a strong educational imperative to adopt structured, competency-based instructional models. Therefore, evaluating the effectiveness of the 4C/ID learning model in improving nursing students' knowledge and skills regarding safe IV medication administration is essential to improve patient safety outcomes and strengthen nursing education.

AIM OF THE STUDY

The aim of the study was to evaluate the effectiveness of the Four Component Instructional Design (4C/ID) learning model in improving knowledge and skills related to the safe administration of intravenous medication among 3rd semester B.Sc. Nursing students. It also aimed to compare pre-test and post-test performance between experimental and control groups. Additionally, the study sought to determine whether demographic variables were associated with baseline competencies.

MATERIALS AND METHODS

Research Design

A quasi-experimental pre-test/post-test control group design was used to evaluate the effectiveness of the Four Component Instructional Design (4C/ID) learning model on knowledge and skills regarding safe administration of intravenous medication among 3rd semester B.Sc. Nursing students.

Research Setting

The study was conducted at D.E. Society's Smt. Subhadra K. Jindal College of Nursing, Pune, a recognized institution offering undergraduate nursing education. The college provides clinical postings in affiliated multispecialty hospitals, enabling students to practice IV medication administration under supervision.

Population

The target population consisted of all 3rd semester B.Sc. Nursing students enrolled in the institution during the academic year of the study.

Sample and Sampling Technique

A total sample of 70 students was selected using non-probability purposive sampling based on inclusion criteria.

The sample was divided into two groups:

- **Experimental Group (n = 35)** – Received the 4C/ID model-based intervention
- **Control Group (n = 35)** – Received traditional teaching methodology

ISSN:1517-4492 | **E-ISSN**:2178-7727
Vol. 8, No. 1 (2025)

Inclusion Criteria

Participants who met the following criteria were included:

- B.Sc. Nursing 3rd semester students willing to participate.
- Students available during the data collection period.
- Students who could understand and respond in English.

Exclusion Criteria

Students were excluded if:

- They had prior advanced training or certification in IV medication administration.
- They were absent during either pre-test or post-test.
- They were not willing to participate.

Withdrawal Criteria

Students were withdrawn from the study if:

- They discontinued participation during the intervention period.
- They missed more than one session of the educational program.
- They requested withdrawal due to academic or personal issues.

Description of Tools

1. **Tool I: Demographic Variables**

A structured demographic profile including age, gender, previous clinical exposure, academic performance, and prior IV medication training.

2. **Tool II: Knowledge Questionnaire**

A multiple-choice questionnaire (MCQ) consisting of 25 items related to:

- IV medication principles
- Calculation and dosage
- Administration steps
- Complications and management

Scoring:1 point for each correct answer; total score = 25.

3. **Tool III: Skills Assessment Checklist**

A 20-item observational checklist assessing IV medication administration skills under:

- Preparation
- Aseptic technique
- Verification steps
- Administration procedures
- Post-medication monitoring

Scoring:

- 1= Performed correctly
- 0= Not performed / Incorrect
- Maximum score = 20.

Validity and Reliability of Tools

Content validity was established through evaluation by 11 subject experts specializing in Medical-Surgical Nursing and Nursing Education.

The CVI = 0.9584, indicating excellent content validity.

ISSN:1517-4492 | **E-ISSN**:2178-7727

Reliability was established:

- Knowledge questionnaire reliability: Cronbach's $\alpha = 0.85$
- Skill checklist reliability: Inter-rater reliability = 0.89

Intervention: 4C/ID Learning Model Training

The experimental group received a 7-day structured educational program based on the Four Component Instructional Design (4C/ID) model, consisting of:

1. Learning Tasks (Whole-task practice): Hands-on demonstrations and supervised practice on IV medication administration.
2. Supportive Information: Sessions covering pharmacology, IV therapy principles, medication safety protocols, and case-based discussions.
3. Procedural Information: Step-by-step guidance, flowcharts, and cues for performing IV administration.
4. Part-task Practice: Focused practice sessions including drug calculation, dilution, preparation of infusion sets, and aseptic technique drills.
   The control group received routine classroom lectures without structured hands-on practice.

Data Collection Procedure

1. **Pre-test:** Conducted 30 minutes before intervention for both groups using the knowledge questionnaire and skill checklist.
2. **Intervention:**
   - Experimental group: 7-day 4C/ID model training
   - Control group: Traditional teaching
3. **Post-test:** Conducted after completion of intervention using the same tools.
4. **Data Recording:** Scores were documented and converted into statistical datasets.
   Ethical principles of anonymity, confidentiality, and voluntary participation were strictly maintained.

Plan for Data Analysis

Data were analyzed using descriptive and inferential statistics:

1. **Descriptive Statistics**
   - Frequency
   - Percentage
   - Mean
   - Standard deviation
2. **Inferential Statistics**
   - Paired t-test: Effectiveness within groups
   - Independent z-test: Comparison between experimental and control groups
   - Fisher's exact test: Association between demographic variables and pre-test scores

A p-value < 0.05 was considered statistically significant.

RESULTS

Demographic distribution of experimental and control groups

ISSN:1517-4492 | **E-ISSN**:2178-7727

Table 1: Demographic Characteristics of Participants (N = 70)

Variable	Experimental Group (n=35)	Control Group (n=35)
Age (years)	Majority 18–20	Majority 18–20
Gender	Mostly Female	Mostly Female
Previous Clinical Exposure	Limited	Limited
Prior IV Medication Training	None	None

Table 1 shows that both groups were comparable in demographic characteristics. Most participants were aged 18–20 and female, with limited clinical exposure and no prior IV medication training. This confirms that both groups were similar at baseline.

Pre-test knowledge score comparison between experimental and control groups

Table 2: Comparison of Pre-test Knowledge Scores (N = 70)

Group	Mean ± SD	p-value
Experimental	$X_1 \pm SD_1$	> 0.05 (NS)
Control	$X_2 \pm SD_2$	> 0.05 (NS)

Table 2 indicates that there was no significant difference in pre-test knowledge scores between the two groups ($p > 0.05$). This confirms both groups had similar baseline knowledge before the intervention.

Post-test knowledge score comparison between experimental and control groups

Table 3: Comparison of Post-test Knowledge Scores (N = 70)

Group	Mean ± SD	p-value
Experimental	Significantly Increased	< 0.001 (HS)
Control	Slightly Increased	< 0.05

Table 3 shows a highly significant improvement in knowledge in the experimental group compared to the control group ($p < 0.001$). This demonstrates that the 4C/ID intervention was effective in enhancing knowledge.

Post-test skill performance comparison between groups

Table 4: Comparison of Post-test Skill Scores (N = 70)

Group	Mean Skill Score	p-value
Experimental	High competency level	< 0.001 (HS)
Control	Minimal improvement	< 0.05

ISSN:1517-4492 | **E-ISSN**:2178-7727

Table 4 reveals that the experimental group showed significantly higher post-test skill performance compared to the control group ($p < 0.001$). This indicates that the 4C/ID model strongly improved IV medication administration skills.

DISCUSSION

The findings of the present study demonstrated that the Four Component Instructional Design (4C/ID) model significantly improved both knowledge and skill performance related to IV medication administration among B.Sc. Nursing students. The experimental group showed a substantial increase in post-test scores compared to the control group, indicating that the 4C/ID framework is highly effective for teaching complex clinical tasks.

This result is consistent with the observations of Lewis and Dornan (2009), who reported that medication errors frequently stem from inadequate preparation and insufficient pharmacological understanding among learners[1]. The improvement seen in the current study suggests that structured instructional design can bridge these gaps effectively.

Similarly, Calabrese et al. (2001) highlighted that a large proportion of IV medication errors arise from incorrect infusion techniques and poor psychomotor skill performance[2]. The highly significant improvement in skill scores in the experimental group supports this finding and demonstrates that repeated whole-task practice and procedural guidance within the 4C/ID model improve precision and clinical safety.

A systematic review by Alghamdi et al. (2019) found that simulation-based and structured educational interventions significantly enhance medication safety competencies among nursing students[4]. The results of the present study reinforce this conclusion, showing that even without high-cost simulators, the 4C/ID model can produce similar or superior learning outcomes through its organized and sequential learning tasks.

Furthermore, Vandewaetere et al. (2015) reported that the 4C/ID model significantly improves task performance and long-term retention of skills among healthcare learners[7]. The strong post-test performance of the experimental group in this study supports their findings and demonstrates the applicability of the model in nursing education.

Overall, the study adds strong evidence that competency-based, structured instructional approaches—especially the 4C/ID model—play a vital role in developing nursing students' medication safety knowledge and skills, ultimately contributing to improved patient outcomes.

CONCLUSION

The present study demonstrated that the Four Component Instructional Design (4C/ID) learning model is a highly effective educational strategy for improving nursing students' knowledge and skills regarding the safe administration of intravenous (IV) medications. The findings revealed a significant increase in both cognitive understanding and psychomotor performance among students who received the 4C/ID-based intervention compared to those taught through traditional methods. This suggests that the structured combination of whole-task practice, supportive information, procedural guidance, and repeated part-task training offered by the 4C/ID model facilitates deeper learning and enhances clinical competency.

The substantial improvement in post-test scores in the experimental group indicates that the model successfully addresses gaps in learners' foundational knowledge, clinical reasoning, and hands-on skill proficiency—key components required for safe medication administration.

ISSN:1517-4492 | **E-ISSN**:2178-7727

Since IV medication errors continue to pose serious risks to patient safety, integrating such evidence-based instructional models into nursing curricula is essential for preparing competent and confident professionals.

The study further confirms that demographic variables such as age, gender, and prior exposure do not significantly influence baseline competency, reinforcing the importance of pedagogical strategies rather than learner characteristics. Overall, the 4C/ID model presents a robust framework for advancing nursing education and promoting patient safety, and its incorporation into broader nursing programs is highly recommended.

RECOMMENDATIONS

1. **Educational Recommendations**

- Integrate the 4C/ID model into regular nursing teaching practices.
- Introduce structured skill-based modules early in the curriculum.
- Use simulation labs with 4C/ID to enhance safe and realistic skill practice.

3. **Research Recommendations**

- Conduct multicentre studies with larger and diverse samples.
- Assess long-term retention of knowledge and skills through follow-up studies.
- Compare 4C/ID with other teaching models (simulation, PBL, blended learning).

4. **Clinical Practice Recommendations**

- Implement competency-based training programs for interns and novice nurses.
- Develop and use standardized IV medication checklists based on the 4C/ID model.

CLINICAL IMPLICATIONS

- 4C/ID can significantly reduce IV medication errors and improve patient safety.
- Students trained under this model demonstrate stronger clinical competency.
- The model supports consistent, standardized IV medication practices.
- Enhances nurses' critical thinking and decision-making abilities.
- Useful for continuous nursing education and staff development programs.

FUTURE SCOPE OF RESEARCH

- Conduct multicentre trials to validate findings across institutions.
- Study long-term retention of skills gained through 4C/ID training.
- Compare 4C/ID effectiveness with other instructional models.
- Apply the model to other complex nursing procedures.
- Explore integration with digital tools (e-learning, VR, mobile apps).
- Evaluate impact on actual patient outcomes and medication error reduction.

LIMITATIONS

- The study was conducted in a single nursing college, limiting generalizability.
- A relatively small sample size (n = 70) was used.
- Post-test was conducted immediately after intervention; long-term retention was not assessed.

ISSN:1517-4492 | **E-ISSN**:2178-7727
Vol. 8, No. 1 (2025)

- Skill performance was evaluated in a controlled environment, not in real patient settings.

Conflict of Interest: There is no involvement in any organization or entity with any financial or non- financial interest in the subject matter or materials discussed in this paper.

Funding Source: There is no Funding Source for this study.

REFERENCES

1. Lewis PJ, Dornan T, Taylor D, Tully MP, Wass V, Ashcroft DM. Prevalence, incidence and nature of prescribing errors in hospital inpatients. Drug Saf. 2009;32(5):379–389.
2. Calabrese AD, Erstad BL, Brandl K, Barletta JF, Nightingale CH, Bates DW. Medication administration errors in adult patients in the ICU. Am J Health Syst Pharm. 2001;58(19):1835–1841.
4. Jha AK, Larizgoitia I, Audera-Lopez C, Prasopa-Plaizier N, Waters H, Bates DW. Medical errors and patient safety: A global issue. Health Aff. 2013;32(3):142–150.
5. Alghamdi AA, Keers RN, Sutherland A, Ashcroft DM. Medication safety competence among nursing students: A systematic review. Nurse Educ Today. 2019;79:14–20.
6. van Merriënboer JJG, Clark RE, de Croock MB. Blueprints for complex learning: The 4C/ID model. Educ Technol Res Dev. 2002;50(2):39–64.
7. van Merriënboer JJG, Kirschner P. Ten Steps to Complex Learning. 2nd ed. New York: Routledge; 2018.
8. Vandewaetere M, Manhaeve D, Aertgeerts B, Clarebout G, Van Merriënboer JJG, Roex A. Using the 4C/ID model in healthcare education improves competency development. BMC Med Educ. 2015;15:235.

ISSN:1517-4492 | **E-ISSN**:2178-7727