A Follow-up Study on the Pedagogical Development of Rational Drug Use in Bachelor of Nursing Science Programs

Kamolrat Turner[1], Matanee Radabutr[2], Sukjai Charoensuk[3], Kanoklekha Suwannapong[4], Suntharawadee Theinpichet[5]

[1] Faculty of Nursing, Paboromarajchanok Institute

[2] Boromarajonani College of Nursing, Changwat Nonthaburi, Faculty of Nursing, Paboromarajchanok Institute

[3] Paboromarajchanok Institute, [4] Royal Thai Navy College of Nursing, [5] Thailand Nursing and Midwifery Council

Correspondence: Matanee Radanutr, E-mail: matanee@bcnnon.ac.th

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Abstract

Rational Drug Use (RDU) is critical because it maximizes patient benefits, enhances safety, and reduces healthcare costs. This follow-up study, which applied a research and development approach, aimed to 1) follow up on RDU competencies and identify educational factors associated with RDU competencies; 2) develop innovative RDU teaching media; and 3) evaluate RDU knowledge after learning through innovative RDU teaching media of nursing students. This study was conducted in three phases. Phase I was conducted to assess RDU competencies among nursing graduates: the sample comprised 1,388 graduates in Academic Year (AY) 2018 and 1,428 in AY 2019 from Bachelor of Nursing Science programs across Thailand. The data were analyzed using descriptive statistics and Pearson's correlation. Phase II was conducted to develop innovative RDU teaching media based on Phase I. Phase III was conducted to evaluate nursing students' RDU knowledge after learning through the innovations developed in Phase II. The sample comprised 40 who learned through a virtual reality simulation and 88 who learned through an interactive video, with 44 in each experimental and control group. Paired and independent t-tests were used to analyze the data. The results showed that 1) the nurses who graduated in AY 2019 achieved high RDU competency scores across domains and significantly higher overall competencies than graduates in AY 2018. RDU competencies were positively correlated with attitudes toward RDU, didactic management, and instructors' support. 2) The two innovative RDU teaching media developed showed E1/E2 efficiency criteria scores of 64.94/72.96 and 97.27/90.00, respectively. 3) The innovative RDU teaching media significantly increased nursing students' knowledge of RDU. This study indicates that RDU curriculum reforms improve nursing graduates' RDU competencies. Instructors' support in creating innovative RDU teaching can enhance nursing students' RDU knowledge.

Keywords: competencies; innovative teaching media; nursing students; rational drug use

การติดตามผลการพัฒนาการจัดการเรียนการสอน RDU ในหลักสูตรพยาบาลศาสตรบัณฑิต

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กมลรัตน์ เทอร์เนอร์[1], เมทณี ระดาบุตร[2], ศุกร์ใจ เจริญสุข[3], กนกเลขา สุวรรณพงษ์[4], สุนทราวดี เธียรพิเชฐ[5]

[1]คณะพยาบาลศาสตร์ สถาบันพระบรมราชชนก

[2] วิทยาลัยพยาบาลบรมราชชนนี จังหวัดนนทบุรี คณะพยาบาลศาสตร์ สถาบันพระบรมราชชนก

[3]สถาบันพระบรมราชชนก, [4]วิทยาลัยพยาบาลกองทัพเรือ, [5]สภาการพยาบาล ประเทศไทย

Correspondence: Matanee Radanutr, E-mail: matanee@bcnnon.ac.th

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บทคัดย่อ

การใช้ยาอย่างสมเหตุผล (Rational Drug Use: RDU) มีความสำคัญเพราะช่วยให้ผู้ป่วยได้รับประโยชน์สูงสุด ปลอดภัย และลดค่าใช้จ่าย การศึกษานี้มีวัตถุประสงค์เพื่อ 1) ติดตามสมรรถนะและระบุปัจจัยด้านการจัดการศึกษาที่สัมพันธ์กับสมรรถนะ RDU 2) พัฒนานวัตกรรมสื่อการสอน RDU และ 3) ประเมินความรู้ RDU ของนักศึกษาพยาบาลหลังเรียนผ่านนวัตกรรม แบ่งเป็น 3 ระยะ: ระยะที่ 1) ติดตามสมรรถนะ RDU ของบัณฑิตพยาบาล ปีการศึกษา 2561 จำนวน 1,388 คน และปีการศึกษา 2562 จำนวน 1,428 คน จากหลักสูตรพยาบาลศาสตรบัณฑิตทั่วประเทศ วิเคราะห์ด้วยสถิติเชิงพรรณนาและสหสัมพันธ์เพียร์สัน ระยะที่ 2) พัฒนานวัตกรรมสื่อการสอนด้าน RDU จากผลของระยะที่ 1 และระยะที่ 3) ประเมินความรู้ของนักศึกษาพยาบาลหลังใช้สื่อนวัตกรรมฯ ที่พัฒนาขึ้นจากระยะที่ 2 กลุ่มตัวอย่าง ได้แก่ นักศึกษาพยาบาลที่เรียนผ่านสื่อสถานการณ์จำลองเสมือนจริง 40 คน และเรียนผ่านสื่อวีดิทัศน์เชิงโต้ตอบ 88 คน กลุ่มทดลองและควบคุม กลุ่มละ 44 คน ข้อมูลวิเคราะห์โดยสถิติ paired t-test และ independent t-test ผลการวิจัยพบว่า 1) บัณฑิตปีการศึกษา 2562 มีสมรรถนะ RDU ในระดับสูงทุกมิติ และคะแนนรวมสูงกว่าปีการศึกษา 2561 อย่างมีนัยสำคัญ สมรรถนะ RDU มีความสัมพันธ์เชิงบวกกับทัศนคติ RDU การจัดการเรียนการสอน และการสนับสนุนจากผู้สอน 2) นวัตกรรมที่ผลิตขึ้นมีประสิทธิภาพตามเกณฑ์ E1/E2 เท่ากับ 64.94/72.96 และ 97.27/90.00 ตามลำดับ และ 3) สื่อสถานการณ์จำลองเสมือนจริงและสื่อวีดิทัศน์เชิงโต้ตอบช่วยเพิ่มพูนความรู้ RDU แก่นักศึกษาพยาบาลอย่างมีนัยสำคัญ แสดงให้เห็นว่าการปฏิรูปหลักสูตร RDU ของสภาการพยาบาลช่วยพัฒนาสมรรถนะ RDU ในบัณฑิตพยาบาล และการสนับสนุนจากอาจารย์ในการสร้างสรรค์นวัตกรรมสามารถเพิ่มพูนความรู้ RDU ของนักศึกษาพยาบาลได้

คำสำคัญ: การใช้ยาอย่างสมเหตุผล; นักศึกษาพยาบาล; สมรรถนะ; สื่อนวัตกรรมการสอน

INTRODUCTION

Irrational drug use is a significant global health issue influenced by various factors. The World Health Organization (WHO) estimates that approximately 50% of all drug use is inappropriate, highlighting systemic issues in the prescribing, dispensing, and selling of medications. Economic factors also play a role, as the misuse of medicines can lead to significant financial burdens on healthcare systems and patients alike[2]. Addressing these factors requires a collaborative effort among healthcare providers, policymakers, and the public to promote rational drug use (RDU) and enhance global health outcomes[3]. The WHO has identified RDU as a key component in mitigating the risks associated with AMR and improving patient care outcomes globally[4]. Addressing these challenges requires targeted measures to improve communication, enhance public awareness, and implement stricter regulations to mitigate the adverse effects of irrational antibiotic use[5-6].

In Thailand, irrational drug use, particularly of antibiotics, raises a critical public health challenge, exacerbated by the COVID-19 pandemic, which increased access to and misuse of medicines[5]. Several factors, such as poor communication between dispensers and users, misconceptions about antibiotics, and economic factors, contribute to this issue[6]. The economic burden of antimicrobial resistance (AMR) is substantial, with costs from in-hospital infections reaching approximately THB 66.4 billion (USD 2.1 billion) over five years, primarily due to mortality and hospitalization[7]. Furthermore, a lack of understanding of the proper use of antibiotics leads to inappropriate treatment practices, which not only prolong hospital stays but also increase the risk of drug-resistant infections[8]. Promoting RDU competencies among healthcare providers in Thailand is crucial for enhancing and improving the quality of health services and ensuring patient safety. Research suggests that training interventions can significantly enhance healthcare providers' competencies by equipping them with the knowledge and skills to effectively use technology in service delivery[9]. A systematic review also highlighted the importance of defining competencies and ensuring their consolidation throughout the careers of healthcare professionals, which is essential for integrated care[10].

In response, the nursing workforce plays a central role in these efforts; therefore, the Thai Nursing and Midwifery Council has been diligently formulating educational standards to integrate RDU principles into the Bachelor of Nursing Science program in Thailand since 2018[11]. Despite increased awareness of RDU education, gaps in knowledge regrading its effectiveness in nursing curricula persist. While previous studies have emphasized the importance of RDU in nursing practice, there is little research on the actual impact of RDU-related educational interventions on nursing graduates' competencies[4,12]. Traditional lecture-based approaches often fail to fully engage students or equip them with the practical skills needed to apply RDU principles in real-world clinical settings[11]. The integration of interactive media and virtual reality (VR) into nursing curricula is a relatively innovation, and there is limited research on how these tools impact student learning outcomes, particularly in areas such as drug administration and patient safety[4].

Even when curriculum reforms have been implemented, there is a lack of comprehensive longitudinal studies that track the effectiveness of these interventions over time, particularly in the context of Thai nursing programs[9]. Although there are national RDU rules and recent changes to include RDU in Bachelor of Nursing Science programs, significant knowledge gaps remain. It remains uncertain whether these educational modifications have genuinely enhanced RDU competencies in subsequent cohorts of nursing graduates, which predisposing, enabling, and reinforcing educational factors are most significantly correlated with elevated RDU competence, and how innovative teaching modalities are used. The integration of interactive media can effectively cultivate RDU-related knowledge and decision-making skills among undergraduate nursing students. Furthermore, there is a paucity of literature on the assessment of innovative pedagogical tools in nursing education, particularly those designed to enhance students' understanding of complex concepts, such as RDU. It is important to ensure that nursing graduates receive consistent, high-quality RDU education at all institutions in Thailand. The lessons from the Thai experience can serve as a valuable model for developing and implementing effective RDU educational programs across diverse cultural and healthcare contexts. This study addresses a critical national need and contributes to the broader global effort to improve patient safety, reduce healthcare costs, and mitigate the risks associated with irrational drug use.

OBJECTIVES

This follow-up study aimed to enhance the pedagogical development of RDU in Bachelor of Nursing Science programs in Thailand. The specific objectives included:

1) to follow up on RDU competencies by assessing and comparing RDU competencies among nursing graduates between the AY 2018 and 2019, and identify predisposing, enabling, and reinforcing educational factors associated with RDU competencies among nursing graduates in AY 2019

2) to develop innovative RDU teaching media for nursing students

3) to evaluate nursing students' knowledge after learning through innovative RDU teaching media

METHODOLOGY

The follow-up study applied a research and development approach to enhance the pedagogical development of RDU in Bachelor of Nursing Science programs in Thailand, which comprises three phases:

Phase I: The follow-up on RDU competencies among nursing graduates was conducted by assessing and comparing RDU competencies between AY 2018 and 2019, and by identifying predisposing, enabling, and reinforcing educational factors associated with RDU competencies among nursing graduates in AY 2019, using descriptive approaches.

Phase II: The development of innovative RDU teaching media for nursing students based on the RDU competencies resulting from Phase I. Two prototypes were developed, including 1) a VR simulation on drug administration and 2) an interactive video on RDU in psychiatric nursing for nursing students. These media were developed through expert consultation and iterative refinement.

Phase III: The evaluation of nursing students' knowledge after learning using innovative RDU teaching media developed in Phase II, including VR simulation and interactive video, was conducted through a quasi-experimental study. Third-year nursing students were randomly allocated to an experimental group. The VR study used a one-group pre-post-test design, while the interactive VDO used a two-group design.

Population and Sample

Phase I: The sample of the follow-up on RDU competencies among nursing graduates to assess and compare nursing graduates' RDU competencies between AY 2018 and 2019, and to identify factors associated with nursing graduates' RDU competencies in the AY 2019 consisted of 9,503 and 9,249 nursing graduates from 86 nursing institutions in Thailand between AY 2018 and 2019, respectively. The samples were the nursing graduates who completed the questionnaires: 1,388 in AY 2018 and 1,428 in AY 2019. The accessible population consisted of graduates for whom current contact information was available via institutional records. These responses were used to assess and compare RDU competencies across the two academic years and to identify educational factors associated with predisposing, enabling, and reinforcing variables.

Phase II: Three experts, comprising a psychiatric nurse, an instructional designer, and an educational technologist, validated the content, learning objectives, and technological functions of innovative RDU teaching media. Thirty nursing students whose characteristics were similar to those of the target samples in phase III were assessed in pilot studies to evaluate the instruments' effectiveness.

Phase III: The samples in quasi-experimental studies of RDU knowledge among nursing students regarding the use of innovative RDU teaching media, VR simulation, and interactive video were third-year nursing students enrolled in the Bachelor of Nursing Science program in the AY 2020. A random sample was used to select two institutions from the 86 nursing institutes. Both institutions agreed to implement innovative RDU teaching media, with one selecting an interactive video and the other a VR simulation. The VR cohort included 40 students, while the interactive video comprised 88 students, who were then randomly assigned to experimental and control groups (n = 44 per group). The students were stratified by cumulative grade point average (GPA) into three categories: high (≥3.00), medium (2.50-2.99), and low (<2.50). Within each stratum, a matching-pairs procedure was used to assign participants to the experimental and control groups. The criteria for inclusion were as follows:

1. The samples were third-year nursing students enrolled in the Bachelor of Nursing Science program in the academic year 2020.

2. The samples were required to participate in the study and provide written informed consent voluntarily.

3. The samples had to be able to engage with the innovative RDU teaching media developed in line with the RDU concepts within the specified timeframe.

4. The samples that were unable to participate in the innovative RDU teaching media within the designated timeframe were excluded from the study.

Research instruments

The research instruments were organized into 3 phases, including:

Phase I: The research instruments of the follow-up on RDU competencies among nursing graduates for data collection comprised four questionnaires to elicit participant responses relevant to the study objectives, consisting of a five-point Likert scale ranging from 1 (very low) to 5 (very high), including 1) the RDU competencies assessment questionnaire for nursing graduates, which comprised 46 items, 2) the attitudes towards RDU questionnaire, which consisted of 10 items, 3) the RDU didactic management questionnaire, which comprised 12 items, and 4) the instructors' support questionnaire consisted of 12 items. All instruments were content-validated by five experts, and internal consistency was assessed in pilot studies to evaluate the instruments' effectiveness. All questionnaires had an index of item-objective congruency (IOC) ranging from .67 to 1.00. The Cronbach's alpha coefficient of the instrument of six questionnaires was .96, .91, .94, and .96, respectively.

Phase II: The research instruments to develop prototypes of innovative RDU teaching media were used to validate the content, learning objectives, and technological functions. The content and scenarios of both media were developed based on the RDU competencies framework, the results of Phase I, and relevant clinical guidelines. All instruments were content-validated by three experts, and internal consistency was confirmed. The initial Item-Objective Congruence (IOC) of innovative RDU teaching media for nursing students, including a VR simulation on drug administration and an interactive video on RDU in psychiatric nursing, were .60 and .70, respectively. The media were revised in accordance with the experts' recommendations and re-evaluated, resulting in a final IOC value of 1.00.

Phase III: The research instruments of a quasi-experimental study to evaluate the RDU knowledge among nursing students after learning through innovative RDU teaching media, including:

1) Two prototypes of innovative RDU teaching media for nursing students were developed from Phase II, including a VR simulation on drug administration and an interactive video on RDU in psychiatric nursing. All instruments were content-validated by three experts, and internal consistency was assessed in pilot studies to evaluate the instruments' effectiveness. The initial Item-Objective Congruence (IOC) index for these innovative RDU teaching media was 0.60 and 0.70, respectively. The media were revised in accordance with the experts' recommendations and re-evaluated, resulting in a final IOC value of

1.00. The instructional efficiency indices (E1/E2), representing process and outcome efficiency, were 64.94/72.96 and 97.27/90.00 for the two media, respectively, indicating that both met the predetermined efficiency criteria.

2) Two questionnaires evaluated knowledge of RDU of nursing students who learned through innovative RDU teaching media, including 1) the questionnaire assessing knowledge of RDU of nursing students on drug administration, consisting of 9 multiple-choice questions, and 2) the questionnaire on the evaluation of the knowledge of RDU in psychiatric nursing, consisting of 10 items. All instruments were content-validated by five experts, and internal consistency was assessed in pilot studies to evaluate the instruments' effectiveness. All questionnaires had IOC indices ranging from 0.67 to 1.00. Cronbach's alpha coefficient of the instrument of six questionnaires was .93 and .95, respectively.

Ethical Consideration

The Institutional Review Board of the TNMC granted ethics approval for this research endeavor on 26 January 2021. The IRB approval number is TNMC-IRB 01/2020.1007. The samples were informed of the study's details and could withdraw at any time. The samplws were required to read and understand the information in the informed consent statement. The data were securely stored on a computer protected by a private password.

Data Collection

The data collection was organized into three phases.

Phase I: The follow-up on RDU competencies among nursing graduates aligned with the study objectives to assess nursing graduates' RDU competencies and compare the competencies between AY 2018 and AY 2019, and identify educational factors associated with these competencies in AY 2019. The online questionnaires were distributed to all nursing graduates across 86 nursing institutions in Thailand during the AY 2018 and 2019 academic years. The samples comprised 1,388 and 1,428 graduates who completed the questionnaires in AY 2018 and 2019, respectively. The survey links were unique to each nursing graduate, enabling de-identified linkage and preventing duplicate submissions.

Phase II: The innovative RDU teaching media were developed as a result of Phase I. Three experts evaluated RDU content specialists and educational technology specialists for validation. Experts evaluated the content for accuracy, relevance, clarity, and the technical quality and usability of the media. The experts informed revisions, and the IOC were developed until satisfactory values were achieved. The innovative RDU teaching media were piloted with 30 nursing students who were similar to those of the target sample in phase III. Nursing students who learned through the innovative RDU teaching media for self-directed practice outside the classroom to enhance their knowledge of RDU. The E1/E2 efficiency indices were computed from students' in-process performance (E1) and post-test scores (E2) to verify that the innovative RDU teaching media met the established efficiency standards.

Phase III: Evaluation of RDU knowledge among nursing students who learned through innovative RDU media developed in Phase II, using quasi-experimental studies. The VR simulation conducted a one-group pre-post test research design. The sample comprised 40 nursing students who met the inclusion criteria. They completed a pre-test to assess their knowledge of RDU, then learned independently through the VR simulation, and completed a post-test. Meanwhile, the samples that learned through the interactive VDO employed a two-group design. The samples comprised 88 nursing students who met the eligibility criteria and were randomly assigned to experimental and control groups (n=44 per group). The experimental group then engaged in self-directed learning through interactive VDO, while the control group received traditional instruction during the study period. Subsequently, both groups completed a post-test.

Data Analysis

Phase I: Descriptive studies were used to assess nursing graduates' RDU competencies. The data was analyzed using descriptive statistics, including means and standard deviations. Independent t-tests were used to compare the nursing graduates' RDU competencies between AY 2018 and 2019. Meanwhile, Pearson's correlation coefficients were used to identify the factors associated with the RDU competencies of nursing graduates in AY 2019.

Phase II: The innovative RDU teaching media were examined using the E1/E2 efficiency index, which was analyzed based on students' participation during the learning process (E1) and post-test (E2), and compared with the determined efficiency criteria.

Phase III: The quasi-experimental studies conducted paired t-tests to compare nursing students' RDU knowledge before and after using VR simulations. Meanwhile, an independent t-test was conducted to compare nursing students' knowledge after undertaking interactive VDO between the experimental and control groups.

RESULTS

This follow-up study applied research and development in three phases that were consistent with the research objectives.

Phase I: The results of the follow-up in alignment with the RDU competencies among nursing graduates were as follows.

1.1 Overall RDU competencies of nursing graduates in the academic year 2019 were high across all domains. The highest three competencies included correct administration of medication (M=4.45, SD=.50), multidisciplinary collaboration to promote RDU (M=4.41, SD=.59), and provision of sufficient drug information (M=4.39, SD=0.54). Item-level analysis showed that assessing patients' medical problems, chronic disease history, and allergy history had the highest score (M=4.58,

SD=.59). The lowest score was for considering patient-specific information for prescribing, dose adjustment, discontinuation, or medication change (M=4.11, SD=.73)[13].

1.2 A cohort comparison of nursing graduates' RDU competencies between AY 2018 and 2019 found that the nursing graduates in AY 2019 scored significantly higher in overall RDU competencies than those in 2018 ($p<.05$). However, there were no significant differences observed for five items including 1) assessment of medical problems/chronic disease/allergy history, 2) participation in appropriate drug selection, 3) monitoring treatment outcomes and reporting potential adverse drug reactions, 4) appropriate medication use aligned with professional knowledge, skills, and ethics, and (5) multidisciplinary collaboration to promote RDU. These findings indicated that the RDU competencies of nursing graduates have continuously improved through sustained curricular, supervisory, and practice-based approaches that foster and maintain these competencies[13].

1.3 The findings identifying the educational factors associated with their RDU competencies of the nursing graduates in the AY 2019 showed that the overall RDU competencies (M=4.35), attitudes toward RDU (M=4.60), didactic management (M=4.43), and instructors' support score (M=4.36) of the nursing graduates in AY 2019 were high. Moreover, there were positive associations between RDU competencies and attitudes toward RDU ($r=.65$, $p<.00$), didactic management ($r=.63$, $p<.00$), and instructors' support ($r=.55$, $p<.00$). Analytically, these consequences indicated that attitudes and pedagogical conditions correlated with competence when attitudes were immersed in purposefully didactic management, and received instructor support, nursing graduates were more likely to apply knowledge in RDU competencies[14].

Phase II: The results of the development of innovative RDU teaching media for nursing students based on the RDU competencies resulting from Phase I, related to the predisposing, enabling, and reinforcing educational factors on RDU competencies, including attitudes toward RDU, didactic management, and instructors' support. Additionally, these innovative RDU teaching media were developed in alignment with new technologies and the learning preferences of digital-era nursing students, through expert consultation and iterative refinement. Two prototypes were developed, including 1) a VR simulation on drug administration and 2) an interactive video on RDU in psychiatric nursing for nursing students. Two innovative RDU teaching media were revised in accordance with experts' recommendations and re-evaluated, resulting in a final IOC value of 1.00. Two innovative RDU teaching media achieved satisfactory instructional efficiency. The VR simulation showed E1/E2 efficiency indices of 64.94/72.96, and the interactive video showed indices of 97.27/90.00, indicating that both exceeded the predetermined efficiency criteria.

Phase III: The results of evaluating RDU knowledge among nursing students after learning through innovative RDU teaching media.

1. A comparison of nursing students' RDU knowledge before and after learning through innovative RDU teaching media showed that VR simulation use was associated with a significant increase in knowledge. The mean score after learning through VR simulation was higher than before, and this difference was statistically significant ($p < .05$). The score increased by 0.47 points (approximately 8.4%), indicating that learning through VR simulation increased nursing students' RDU knowledge[15] (Table 1).

Table 1 A comparison of nursing students' RDU knowledge before and after learning through VR Simulation (n= 40)

	Post-test		Pre-test		df	t	p-value
	Mean	SD	Mean	SD			
RDU knowledge	6.05	.99	5.58	1.6	39	3.219	.002

2. The comparison of nursing students' RDU knowledge between the experimental group after learning through interactive VDO and the control group demonstrated a statistically significant difference ($p<.05$). The results indicated that the experimental group's knowledge was higher than that of the control group. Nursing students' RDU knowledge increased by 1.00 points, representing about a 13.8% improvement. This analysis suggests that this interactive VDO can enhance nursing students' RDU knowledge, resulting in higher knowledge gains than conventional learning[16] (Table 2).

Table 2 The comparison of nursing students' RDU knowledge between the experimental group after learning through interactive VDO and the control group

	n	Mean	SD	t	p-value
Experimental group	44	8.23	1.11	3.710	.0001
Control group	44	7.23	1.33		

DISCUSSION

This follow-up study applied a research and development approach to connect nursing graduates' RDU competencies with the development of innovative RDU teaching media and the evaluation of nursing students' RDU knowledge.

The sustained curricular, supervisory, and practice-based approaches are starting to generate measurable improvements at the cohort level. Simultaneously, item-level results revealed relatively lower performance in considering patient-specific information for prescribing, dose adjustment, discontinuation, or medication change, indicating a persistent gap in higher-order therapeutic decision-making. According to progress in RDU teaching and learning management, descriptive studies showed a positive trend, with increased overall RDU competencies across successive cohorts, strong attitudes toward RDU, effective didactic management, and ongoing instructor support. These factors confirm that

RDU competencies are more influenced by an educational environment characterized by aligned stewardship values, structured learning activities, and guided reflection, rather than by isolated knowledge acquisition. This finding aligns with contemporary scholarship, indicating that programs aiming to improve the quality of clinical decisions must create constructive alignment among intended outcomes, learning activities, and evaluations that authentically assess decision-making rather than mere recall of pharmacological information[17-18]. Consequently, pedagogical approaches must evolve from traditional evaluations to a holistic assessment framework that integrates innovative instructional media with designated RDU competencies, facilitating structured feedback. This alignment leverages existing strengths in the RDU situation, such as positive attitudes, effective didactic management, and active instructor support, while also directly addressing the reasoning gap.

This direction is consistent with broader efforts to improve academic programs, which have been shown to foster undergraduate nursing success[19]. Therefore, the assessment program is centered on individualized decision-making. Align RDU competencies with corresponding performance assessment that evaluates patient-specific decisions, incorporating clear criteria and feedback in accordance with the Ottawa consensus on technology-enhanced assessment[17]. Nursing instructors should point out risks, which encourage the use of trade-off reasoning rather than mere memorization[18]. Additionally, nursing instructors should support clinical coaching by disseminating standardized prompts and feedback rubrics to enhance clinical practice while emphasizing patient safety and stewardship values[19]. Therefore, a diagnostic stage identified both strengths and gaps in graduates' RDU competencies, as well as key predisposing, enabling, and reinforcing educational factors. This evidence directly informed the design of innovative media, turning outcome data into input for the next cycle of pedagogical development. Nursing instructors should use analytical teaching methods to support the pedagogical development of RDU competencies to simulate decision-making for competency level learning analytics and targeted feedback[17,20]. Additionally, fostering nursing students' confidence is essential. Nursing instructors should use simulation-based learning as the standard for broad accessibility and reserve high-quality virtual reality for skills that require embodied workflow practice, thereby improving cost-effectiveness without compromising outcomes[21]. Nursing instructors can enhance knowledge outcomes by using guideline-concordant administration to reduce adverse drug reaction rates and demonstrate their application in clinical performance through innovative media[17].

An innovative RDU teaching media. Both media were intentionally developed to move beyond didactic pharmacology teaching toward simulation-based learning that better reflects real clinical decision-making. Contents were aligned with national RDU policies, nursing competency frameworks, and the specific cognitive and behavioral components identified as needing further strengthening in Phase I. The findings of the two quasi-experimental studies indicated that innovative RDU teaching media, including VR simulation on drug administration and interactive videos designed for psychiatric scenarios,

resulted in significant knowledge gains both within groups (pre-post) and between groups (post-test). These results are consistent with recent syntheses demonstrating that VR and simulation-based learning improve knowledge, skills, and learner confidence in medication administration in nursing education[20,21]. The findings also support recommendations to use technology-enhanced assessment and learning that prioritize authentic tasks and actionable feedback[17]. Additionally, transforming teaching methods through clinically based instruction can enhance decision-making variability, moving beyond content rehearsal to adaptable therapeutic reasoning[22].

Consequently, the two phases show how RDU education can be organized as an ongoing R&D cycle. At the system level, national policies and standards define RDU as an essential graduate competency, consistent with nurses' central role in medication management and antimicrobial stewardship (AMS)[4-5,18-19]. At the program level, systematic follow-up of graduates provides empirical feedback on current teaching and learning practices[6-7]. At the classroom and skills-laboratory levels, targeted innovations such as VR and interactive video translate this evidence into concrete learning experiences that allow students to practice RDU-related decisions in safe yet realistic environments [12,15-17.] The study also reinforces that RDU involves more than pharmacological knowledge. It requires integrating patient assessment, ethical judgment, interprofessional collaboration, and patient-centered communicatio[18-20.] Furthermore, integrating these innovative instructional media into an assessment program should be implemented to evaluate decision-making, thereby authentically enhancing knowledge. These enhancements are more likely to translate into the routine practice of nurses and improved patient safety outcomes[17,19-23].

CONCLUSION

This follow-up study demonstrated that evaluating nursing graduates' RDU competencies can drive targeted pedagogical innovations. Descriptive analyses showed that RDU competencies improved in the 2019 cohort compared with the 2018 baseline, while highlighting remaining gaps in higher-order, patient-specific decision-making and using these findings as diagnostic input. Consequently, the developed and evaluated VR simulation and interactive video media significantly enhanced third-year nursing students' RDU knowledge, particularly compared with conventional teaching, and led to significant knowledge gains, with the greatest benefit when these tools were integrated into a structured assessment program. However, persistent gaps remain in the rationale for the ongoing development of RDU pedagogy in Bachelor of Nursing Science programs in Thailand. This ongoing process translates knowledge into durable practice behaviors that enhance patient safety and stewardship outcomes in nursing students.

RECOMMENDATIONS

1. Nursing institutions in Thailand should continue to refine and expand RDU education in their curricula to cover all aspects of rational drug use comprehensively.

2. Ongoing faculty development programs are crucial for maintaining high teaching standards and adapting to emerging trends in nursing education in Thailand.

3. The use of innovative teaching media, such as virtual reality and interactive media, should be expanded to ensure that nursing students receive a dynamic and engaging learning experience.

4. Further research should assess the long-term impact of RDU education on nursing practice and patient care outcomes.

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