#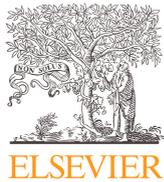 Student satisfaction and self-confidence in learning through pharmacology virtual reality simulations: A mixed methods evaluation
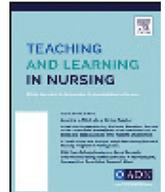
Research

# Student satisfaction and self-confidence in learning through pharmacology virtual reality simulations: A mixed methods evaluation

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ABSTRACT

Background: Pharmacology remains challenging in preregistration nursing education. Virtual reality (VR) may support learning by visualizing medication mechanisms within patient scenarios. This study evaluated preregistration nursing students' satisfaction and self-confidence when learning pharmacology through 3 patient-based VR simulations.
Methods: A sequential exploratory mixed-methods design was conducted at a university in the United Kingdom. Phase 1 explored usability and learning experience through focus groups to inform iterative refinements to the simulations. Phase 2 evaluated student satisfaction and self-confidence using the National League for Nursing Student Satisfaction and Self-Confidence in Learning questionnaire. Qualitative data were analyzed using reflexive thematic analysis, and quantitative data were descriptively summarized.
Results: Phase 1 identified themes of presence, flow, usability, learning consequences, and technology adoption. Phase 2 demonstrated high levels of student satisfaction and self-confidence.
Conclusions: Patient-based VR pharmacology simulations were associated with high levels of student satisfaction and self-confidence. Immersive visualization embedded within a structured learning sequence may support pharmacology education in preregistration nursing programs. Future research should examine knowledge retention, clinical performance, and transfer to practice.

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## Introduction

Medication errors remain a significant threat to patient safety and are linked to gaps in pharmacology knowledge, low confidence in clinical decision-making, and insufficient critical thinking (Barton et al., 2021; Manias et al., 2020; Schneidereith, 2021; Tomas & Fillipus, 2024). Across international nursing curricula, medication management competence is regarded as a core component of preregistration education, with medication safety and pharmacology knowledge embedded as essential learning outcomes (World Health Organization, 2011). In the United Kingdom (UK), this expectation is further formalized in regulatory standards, where medication management is part of the requirements for registration (Nursing & Midwifery Council, 2023). However, persistent gaps remain in students' understanding of medication mechanisms and in their ability to transfer this knowledge into clinical practice (Barton et al., 2021; Tomas & Fillipus, 2024). In pharmacology education, traditional lecture-based delivery can lead to rote memorization of medication mechanisms rather than the conceptual understanding required for clinical practice (Phillips & Ford, 2021). This challenge is particularly pronounced because the interactions between medications and receptors, as well as the underlying physiologic mechanisms, are difficult to visualize. Consequently, evidence-based, experiential strategies are required to bridge the theory−practice gap and strengthen students' preparedness for safe medication administration.

Simulation-based education (SBE) provides structured, supervised learning in realistic yet safe environments and is associated with gains in competence, clinical reasoning, and learner confidence (Alinier & Oriot, 2022; Chernikova et al., 2020). A recent systematic review in nursing programs also reports consistent improvements in knowledge and skills with SBE, while noting limited data on long-term retention (Alharbi et al., 2024). Within SBE, virtual reality (VR) extends learning through immersive, 3-dimensional visualization and repeatable practice, enabling students to connect theoretical knowledge to patient care. Prior studies demonstrate VR's educational benefits across health and nursing education (Chen et al., 2020; Liu et al., 2023); however, few have explicitly focused on pharmacology, where visualizing complex physiologic and pharmacologic processes poses distinctive pedagogical challenges. Recent research indicates that immersive or interactive digital visualization can

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enhance understanding of medication mechanisms and other complex pharmacologic concepts (Aronsson et al., 2015; Rayamajhi et al., 2024), highlighting the potential value of VR in this domain. Given the increasing use of immersive approaches in preregistration programs, it is essential to consider how VR-based activities align with current regulatory expectations for simulation in nursing education.

The Nursing and Midwifery Council (2023) in the UK distinguishes between SBE and simulated practice learning (SPL). Both may be delivered within academic settings; however, SPL must meet the NMC's standards for practice learning. This includes explicit mapping of proficiencies, appropriate student supervision, and assessment processes equivalent to those in clinical practice. Although evaluated as SBE, the VR simulations align with these requirements and could be considered SPL in future implementations.

This mixed-methods evaluation examined preregistration nursing students' satisfaction and self-confidence in learning pharmacology through 3 patient-based VR simulations (child with asthma, adult with psychosis, and adult with a fractured femur). Phase 1 qualitatively explored usability and learning experience to inform refinements, and Phase 2 quantitatively assessed the refined simulations using satisfaction and self-confidence measures.

*Research questions*

- What are preregistration nursing students' experiences of learning pharmacology through virtual reality simulations?
- How do preregistration nursing students rate their satisfaction and self-confidence in learning following VR pharmacology simulations?

## Methods

### Design

This study adopted a sequential exploratory mixed-methods design comprised of 2 phases, informed by comparable VR evaluations in nursing education (Chen et al., 2020). Phase 1 involved qualitative focus groups that explored students' experiences with the VR simulations, including their perceptions of usability and learning. Insights from this phase informed technical and pedagogical refinements to the simulations before the broader evaluation. Phase 2 assessed a larger cohort using the National League for Nursing Student Satisfaction and Self-Confidence in Learning (NLN-SSSCL) instrument, which evaluates learners' perceptions of the educational value of simulation through 2 validated subscales, *satisfaction with learning* and *self-confidence in learning*. Scores on these subscales were used to describe students' perceptions following participation in the VR simulations. Integration occurred during interpretation through meta-inferences, with Phase 1 themes used to explain and contextualize Phase 2 findings.

### Ethical considerations

Ethical approval was obtained from an institutional research ethics panel for both phases of the study (Phase 1: HS23240018-R, January 2024; Phase 2: HS24250012, October 2024). Participation was voluntary, all data were anonymized, and focus groups were facilitated and analyzed by colleagues at an external university to maintain separation from the teaching staff and reduce any perception of coercion.

### Setting and participants

The study took place at a UK higher education institution offering a preregistration nursing program across the fields of practice in adult, child, and mental health. The 3 patient-based VR simulations were delivered in a simulation suite with standard pre-brief and debrief arrangements. Inclusion and exclusion criteria were designed to ensure participant safety, particularly with respect to visual or vestibular sensitivity to VR. Students were eligible to participate if they were enrolled in a preregistration nursing program within the adult, child, or mental health field of practice and provided informed consent. Students were excluded if they had significant visual impairment, a neck or head injury, a history of nausea or dizziness associated with VR use, epilepsy or seizure disorder, or a current ear infection. Sample sizes were set pragmatically within cohort constraints, consistent with small-to-moderate cohorts commonly reported in VR nursing education studies (Chen et al., 2020; Liu et al., 2023). Recruitment was via university email and short in-class announcements by faculty with no teaching or assessment responsibilities. Interested students received an information sheet and provided written consent to the same neutral contact. Participation was voluntary and unrelated to academic progression.

### Intervention

The development of the 3 patient-based VR simulations was undertaken in collaboration with an extended-reality developer. Each simulation followed a structured sequence comprising a pre-brief, VR experience, and debrief. Within the VR environment, learners conducted a branching virtual patient assessment with guided dialogue to practice clinical reasoning and decision-making skills. A concise animation illustrated each medication's route of administration, distribution, and mechanism of action and was supported by on-screen labels and narration to strengthen visual−verbal integration. Embedded multiple-choice questions provided immediate feedback and reinforcement. Brief scenario vignettes illustrating the intervention are provided below.

*Childhood asthma scenario:* Learners conducted an annual asthma review for a child in a general practitioner setting, assessing symptoms, triggers, and inhaler use. Pharmacologic content focused on how inhaled bronchodilators and corticosteroids exert their effects in the airways, linking medication mechanisms to pediatric asthma management.

*Adult with psychosis scenario:* Learners supported an adult initiating community-based clozapine after a limited response to previous antipsychotics. Students took a brief history, obtained consent, and discussed early side effects. The scenario emphasized the medication's mechanism of action and key safety considerations to support safe administration.

*Adult with fractured femur scenario:* Learners assessed pain in an adult awaiting surgery for a fractured femur and conducted a structured pain assessment to inform intravenous paracetamol administration. Pharmacologic content focused on the medication's mechanism of action in acute pain management.

### Data collection

Qualitative and quantitative data were collected sequentially across 2 phases. Phase 1 involved collecting qualitative data through 2 online focus group discussions conducted via Microsoft Teams, each lasting approximately 60 minutes. Discussions were guided by a semi-structured topic guide designed to explore participants' experiences with VR simulations in nursing education, including usability, perceived learning, realism, and any adverse effects, such as nausea or fatigue. Open-ended prompts were used to elicit further detail and clarification. To maintain anonymity within a small sample, participant characteristics were limited to program stage (second-year preregistration nursing students), with no additional demographic data

collected. Findings from Phase 1 informed iterative technical and pedagogical refinements to the VR simulations.

The childhood asthma scenario was selected for Phase 1 testing because it was the first completed simulation and served as a representative pharmacology case. It incorporated the same interactive structure, learning objectives, and pedagogical design as the subsequent scenarios, thereby enabling consistent refinements across all simulations.

Phase 2 collected quantitative data using the NLN-SSSCL questionnaire. The instrument comprises 13 items: 5 assessing *satisfaction with learning* (e.g., perceived effectiveness, relevance, and enjoyment of the simulation) and 8 items assessing *self-confidence in learning* (e.g., confidence in understanding content, applying learning, and seeking assistance when needed). All items are rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), with higher scores indicating greater satisfaction or confidence. The NLN-SSSCL was developed within the NLN/Laerdal national simulation study and has demonstrated strong internal consistency, with subscale reliability coefficients exceeding 0.85 (Franklin et al., 2014; Jeffries & Rizzolo, 2006). Permission to use the instrument was obtained from the NLN before the start of data collection.

*Data analysis*

Qualitative data were audio recorded, transcribed verbatim, and analyzed using reflexive thematic analysis (Braun & Clarke, 2006, 2019), which involved familiarization, coding, theme generation, review, definition, and reporting. Findings from Phase 1 informed refinements to the VR simulations, which guided the interpretation of quantitative results. Quantitative data from the NLN-SSSCL questionnaire were analyzed using descriptive statistics, including item frequencies and percentages. Due to occasional missing responses, item-level denominators were reported where appropriate. Quantitative findings were interpreted descriptively to reflect students' self-reported satisfaction and self-confidence in learning. For reporting purposes, Likert-scale responses were collapsed into 3 categories (agree, neutral, and disagree), with strongly agree combined with agree and strongly disagree combined with disagree.

Integration occurred during interpretation through meta-inferences, with qualitative themes used to explain and contextualize patterns observed in the quantitative data (Creswell & Plano Clark, 2018). Trustworthiness was addressed by considering transferability, dependability, and confirmability (Lincoln & Guba, 1985). Transferability was supported through a detailed description of the study context and VR intervention. Dependability was enhanced by a transparent analytic process consistent with reflexive thematic analysis (Braun & Clarke, 2006, 2019). Confirmability was strengthened through independent facilitation of focus groups by colleagues external to the teaching team and reflective memoing during analysis, in line with recommended practices for maintaining rigor in qualitative thematic research (Nowell et al., 2017).

## Results

*Qualitative findings—Phase 1:* Seven second-year nursing students participated in online focus group discussions to explore usability and learning in the VR pharmacology simulations. Reflexive thematic analysis identified 4 themes: engagement and presence, usability, consequences for the learning experience, and technology adoption. Students described the VR simulations as enjoyable and immersive, reporting a strong sense of presence and focus during the activity. They noted that both a brief technical orientation to the headset and clear preparatory guidance enhanced focus and flow during the simulations. Early usability challenges included clunky scene transitions, uncertainty about next steps, and difficulty locating information

**Table 1**
Participant demographics (*n* = 52).

| Variable | Category | *n* (%) |
|---|---|---|
| Gender | Female | 46 (88) |
| | Male | 6 (12) |
| Age group (years) | 18−25 | 17 (33) |
| | 26−44 | 25 (48) |
| | 45−59 | 10 (19) |
| Previous VR experience | Yes | 48 (92) |
| | No | 4 (8) |

Note. Percentages rounded to the nearest whole number; totals may not equal 100% due to rounding.

under time pressure. These issues led students to suggest more explicit on-screen cues and a more measured pace. No adverse events were reported; however, students identified motion sensitivity, headset availability, and equipment cost as important considerations for inclusivity. Students reported that VR made medication mechanisms more concrete and strengthened connections between theoretical pharmacology and clinical practice. However, some participants found it challenging to articulate specific knowledge gains immediately after the simulations, suggesting that brief consolidation activities may support reflection and learning. Students recommended wider adoption of VR within the curriculum but emphasized the importance of reliable equipment and sufficient time to become familiar with the controls. They also highlighted the need for structured sequencing of preparation, VR activity, and debriefing to support learning. These findings informed refinements to the simulations before Phase 2.

*Quantitative findings—Phase 2:* Student characteristics are summarized in Table 1, which indicates a predominantly female sample with a broad age range and high levels of previous VR exposure. Responses to the SSSCL items are presented in Tables 2 and 3, respectively. Across satisfaction items, most responses fell within the "agree" category, indicating positive evaluations of the VR learning experience. Similarly, responses to the self-confidence items showed high levels of agreement, reflecting students' self-reported confidence in engaging with the pharmacology content. As student satisfaction and confidence reflect perceptions rather than observed performance, these findings should be interpreted as indicators of learning experiences rather than as evidence of learning effectiveness or competence.

## Discussion

This mixed-methods evaluation explored preregistration nursing students' experiences of learning pharmacology through patient-based VR simulations, using student satisfaction and self-confidence to characterize their perceptions of the learning experience. Findings

**Table 2**
Distribution (%) of responses for student satisfaction items.

| Item | Agree | Neutral | Disagree |
|---|---|---|---|
| The teaching methods used in this simulation were helpful and effective (*n* = 52) | 88% (46) | 8% (4) | 4% (2) |
| The simulation provided a variety of learning materials and activities to promote my learning (*n* = 51) | 92% (47) | 6% (3) | 2% (1) |
| I enjoyed how my instructor taught the simulation (*n* = 52) | 90% (47) | 8% (4) | 2% (1) |
| The teaching materials used in this simulation were motivating and helped me learn (*n* = 52) | 88% (46) | 8% (4) | 4% (2) |
| The way my instructor(s) taught the simulation was suitable for the way I learn (*n* = 52) | 81% (42) | 15% (8) | 4% (2) |

Note. Agree = strongly agree + agree; disagree = disagree + strongly disagree. One response was missing for Item 2 (*n* = 51). Percentages are based on item-level responses and are rounded to the nearest integer.

**Table 3**
Distribution (%) of responses for student self-confidence items.

| Item | Agree | Neutral | Disagree |
|---|---|---|---|
| I am confident that I am mastering the content of the simulation activity ($n = 52$) | 81% (42) | 13% (7) | 6% (3) |
| I am confident that this simulation covered critical content necessary for mastery of the pharmacology curriculum ($n = 52$) | 88% (46) | 6% (3) | 6% (3) |
| I am confident that I am developing the skills and obtaining the required knowledge to perform necessary tasks in a clinical setting ($n = 51$) | 86% (44) | 10% (5) | 4% (2) |
| My instructors used helpful resources to teach this simulation activity ($n = 51$) | 90% (46) | 10% (5) | 0% (0) |
| It is my responsibility as a student to learn what I need to know from this simulation activity ($n = 51$) | 90% (46) | 10% (5) | 0% (0) |
| I know how to get help when I do not understand the concepts covered in the simulation ($n = 49$) | 88% (43) | 8% (4) | 4% (2) |
| I know how to use simulation activities to learn critical aspects of these skills ($n = 50$) | 86% (43) | 12% (6) | 2% (1) |
| It is the instructor's responsibility to tell me what I need to learn from the simulation activity content ($n = 51$) | 71% (36) | 25% (13) | 4% (2) |

Note. Agree = strongly agree + agree; disagree = disagree + strongly disagree. Item-level response totals vary due to missing responses ($n = 49–52$). Percentages are based on item-level responses and are rounded to the nearest integer.

from the qualitative and quantitative phases converged to suggest that VR may offer an engaging and meaningful approach to pharmacology education in preregistration nursing. This was particularly evident when the simulations were embedded within a structured learning sequence of preparation, simulation activity, and debriefing. Students' satisfaction and self-confidence ratings were closely aligned with qualitative accounts of immersion, clarity, and perceived relevance to practice, indicating that design features and learner experience are central to the educational value of VR. Together, these findings suggest that the value of VR in pharmacology lies less in the technology itself and more how immersive visualization is pedagogically designed and integrated.

These findings align with prior SBE research demonstrating improved engagement, clinical reasoning, and confidence in nursing and health professions education (Alinier & Oriot, 2022; Chernikova et al., 2020; Chen et al., 2020; Liu et al., 2023). In the present study, students' self-reported confidence may be interpreted through a self-efficacy lens (Bandura, 1997), informed by qualitative accounts suggesting that usability and clear visualization of medication mechanisms supported engagement with complex pharmacological content (Barton et al., 2021; Phillips & Ford, 2021). By visualizing medication mechanisms within patient-based scenarios, the VR simulations appeared to support students' perceived conceptual understanding, consistent with prior evidence that 3-dimensional, interactive visualization can aid learning of complex pharmacological concepts (Richardson et al., 2013; Rayamajhi et al., 2024).

However, as highlighted in the literature and reflected in this study's reliance on perceptual measures, confidence should not be interpreted as a direct proxy for competence. Persistent concerns remain regarding nursing students' preparedness for safe medication administration (Ali et al., 2024; Tomas & Fillipus, 2024), reinforcing the importance of interpreting confidence as a component of readiness for learning rather than as evidence of mastery. In this respect, the present findings extend existing work by demonstrating how immersive visualization can be applied specifically to pharmacology teaching, a domain characterized by abstract and difficult-to-visualize mechanisms, while also supporting the broader caution that positive learner experience should not be conflated with demonstrable clinical competence.

Qualitative findings help explain how students experienced the VR simulations and why these experiences were associated with positive ratings of satisfaction and self-confidence. Students emphasized the importance of seamless interaction with the VR environment, with clear prompts and a manageable pace supporting focus and reducing cognitive load. This aligns with immersive learning research, which identifies usability and instructional scaffolding as critical to effective educational experiences (Tcha-Tokey et al., 2018). Early usability challenges disrupted engagement, whereas subsequent refinements improved coherence and flow, suggesting that the educational impact of VR depends as much on implementation quality as on the immersive medium itself. This may help explain variability in outcomes reported across VR studies and highlights the importance of careful instructional design in translating immersive technologies into meaningful learning experiences.

Integration of qualitative and quantitative findings also highlights several implementation considerations. Students emphasized the value of a clear learning sequence comprising a short technical orientation to the VR interface, the VR activity itself, and a structured debrief to support consolidation of learning and medication-related clinical reasoning. Phase 1 feedback identified 3 priorities for implementation: rapid familiarization with the VR interface; effective visual−verbal integration through labels and concise narration; and dependable access to equipment with appropriate technical support. These findings align with recommendations in the broader immersive learning literature, which emphasize managing cognitive load and supporting learners' navigation of virtual environments (Tcha-Tokey et al., 2018; Makransky & Petersen, 2021). Accessibility considerations, including motion sensitivity, headset availability, and equipment costs, were also noted and are consistent with reported challenges in the adoption of immersive technologies in health professions education (Radianti et al., 2020). Although vestibular effects were uncommon in this study, mitigations such as short sessions, optional breaks, and clear opt-out pathways remain essential to ensure inclusive participation. More broadly, sustainable implementation depends on adequate infrastructure, faculty development, and scheduling to ensure VR complements rather than displaces existing teaching; without this support, VR risks remaining confined to small pilot initiatives rather than achieving wider adoption.

### Implications for nursing education

For nurse educators, these findings suggest that VR can complement existing pharmacology instruction by providing opportunities to visualize mechanisms of action in realistic patient contexts. Rather than replacing traditional approaches, VR appears most effective when integrated alongside lectures, case-based learning, and skills teaching. Standardized pre-briefs, a technical orientation to the headset, and structured debriefing can be implemented with minimal additional burden and are likely to be critical for consolidating learning.

Within the UK context, these findings also have relevance for programs considering how immersive simulations align with regulatory expectations. Although evaluated here as SBE, the VR activities incorporated features that may support future alignment with SPL, including patient-based scenarios, explicit pharmacology learning outcomes, and facilitated debriefing ((Nursing & Midwifery Council, 2023)). Careful mapping of proficiencies, along with appropriate supervision and assessment processes, would be required if VR were to contribute to practice-learning hours.

### Strengths, limitations, and future directions

This study's strengths include its iterative mixed-methods design, which allowed qualitative insights to inform refinements before the

quantitative evaluation, thereby enhancing relevance to real-world teaching contexts.

Several limitations should be acknowledged. This was a single-site evaluation, and participation was self-selected, which may limit transferability. Although potential perceived coercion was mitigated by separating teaching and research roles, residual self-selection bias cannot be entirely excluded. Excluding students with a history of nausea or motion sensitivity may further limit applicability to all learners. The qualitative sample in Phase 1 was small and did not aim to achieve data saturation; rather, it was intended to generate focused insights to inform iterative refinement of the VR simulations. In line with contemporary qualitative guidance, emphasis was placed on information power, defined as the relevance, specificity, and richness of the data relative to the study aim (Malterud et al., 2021). Nevertheless, the qualitative findings should be interpreted as exploratory and context-specific.

Although prior VR exposure was high among participants, novelty effects related to immersive use cannot be entirely excluded. Novelty effects may temporarily elevate engagement or positive perceptions due to the newness of a technology rather than its pedagogical features. In addition, the study relied on self-reported measures of satisfaction and confidence and did not assess pharmacology knowledge or clinical performance, limiting inferences about learning effectiveness or competence.

Future research would benefit from stronger design rigor to support inference, including comparative designs (e.g., VR compared with non-immersive digital tools or standard teaching), and preregistered protocols, consistent with the call for improved methodological rigor and comparative approaches in health professions education research (Cook et al., 2015). Further work should examine underlying mechanisms, including presence and cognitive load, as well as potential moderators such as prior VR familiarity, digital literacy, and motion sensitivity, which may influence the experience of immersive learning environments (Tcha-Tokey et al., 2018; Makransky & Petersen, 2021).

Beyond these pedagogical considerations, questions of implementation and value also warrant attention. Cost, staff time, and student throughput are likely to be significant considerations for programs considering scale-up, and mixed-methods implementation studies and economic evaluations could inform sustainable adoption (Zendejas et al., 2013). Equity-focused analyses will be essential to ensure access across sites and student groups, particularly when co-designed work with practice-learning partners is intended to support mapping to SPL in line with regulatory expectations (Nursing & Midwifery Council, 2023).

## Conclusion

This study demonstrates that patient-based VR simulations can provide an engaging approach to pharmacology education for preregistration nursing students, as evidenced by high levels of reported student satisfaction and self-confidence. By visualizing medication mechanisms in realistic patient scenarios, VR appeared to support students in connecting pharmacologic concepts to clinical decision-making.

Importantly, the findings indicate that the educational value of VR lies not in the technology itself, but in its pedagogical design and integration within a structured learning sequence that includes preparation, technical orientation, and debriefing. When thoughtfully implemented, immersive visualization may offer a useful strategy for addressing the conceptual challenges inherent in pharmacology teaching.

Future research should examine whether these positive learning experiences translate into sustained knowledge development, safe clinical performance, and effective transfer to practice. Further work

is needed to identify the conditions under which VR can be implemented at scale in preregistration nursing programs in ways that are pedagogically sound, feasible, and equitable.

## Declaration of competing interest

The authors declare that they have no known competing personal relationships or financial interests that may have influenced the study reported in this paper.

## CRediT authorship contribution statement

**Samantha Rogers:** Writing − review & editing, Investigation. **Kirsty Wedgbury:** Writing − review & editing, Investigation. **Sarah Wilson:** Writing − review & editing, Investigation. **Amy Read:** Writing − review & editing, Investigation. **Hilary Mairs:** Writing − review & editing, Investigation, Formal analysis, Conceptualization.

## Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used *ChatGPT* (OpenAI, San Francisco, CA, USA) to assist with language refinement, formatting, and clarity. After using this tool, the authors reviewed and edited the content as needed and assumed full responsibility for the publication.

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