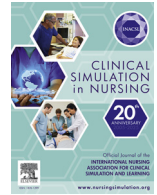




ELSEVIER

Contents lists available at ScienceDirect

# Clinical Simulation in Nursing

journal homepage: [www.elsevier.com/locate/ecns](http://www.elsevier.com/locate/ecns)

## Research Article

# An objective exit exam to assess nursing students' knowledge and skills in vital sign detection: A cross-sectional study

Kristiina Rosqvist, MNSc<sup>a,\*</sup>, Jaana-Maija Koivisto, PhD<sup>a,b</sup>, Janne Engblom<sup>c</sup>,  
Elina Haavisto, PhD<sup>a</sup>

<sup>a</sup> Faculty of Social Sciences/Health Sciences, Tampere University, Tampere, Finland

<sup>b</sup> Faculty of Medicine, Department of Public Health, University of Helsinki, Helsinki, Finland

<sup>c</sup> University of Turku, Turku, Finland



## ARTICLE INFO

**Keywords:**  
Clinical  
Educational measurement  
Knowledge  
Nursing  
Skill  
Students  
Vital signs

## ABSTRACT

**Background:** The ability of graduating nursing students to detect changes in vital signs varies globally, posing potential life-threatening risks. This underscores the critical need to rigorously assess these competencies at graduation. However, objective exit exams that assess both knowledge and skills remain uncommon. The study aimed to assess nursing students' knowledge and skills in vital signs through an objective exit exam and to evaluate the usability of a simulation game platform as a skill test in the exit exam.

**Methods:** A cross-sectional study using the Vital Signs Knowledge Test (VSKT,  $n = 159$ ) and Vital Signs Skill Test (VSST,  $n = 187$ ) was conducted. The P-SUS survey gathered feedback on the VSST's usability as a skill test. Data were analyzed using univariate descriptive analysis and Pearson correlation with significance tests. Multivariate models estimated mean differences between categories.

**Results:** Variation in knowledge and skills was found, particularly in nursing procedures and interpreting electrocardiogram changes. Participants who performed well on the VSKT also performed well on the VSST. The P-SUS survey indicated good usability of the game.

**Conclusions:** This study emphasizes the importance of assessing both knowledge and skills to fully gauge the competence of graduating nursing students.

© 2025 International Nursing Association for Clinical Simulation and Learning. Published by Elsevier Inc. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>)

## Introduction

Nursing education aims to develop students' theoretical knowledge, critical thinking, and clinical skills, which are assessed throughout their studies. At graduation, nursing students must be able to recognize changes in a patient's clinical condition, interpret vital signs (VS), and initiate appropriate actions, including consulting physicians. These competencies require the integration of theoretical knowledge with clinical decision-making (Clemett et al., 2021).

Despite standardized competency frameworks, such as the American Association of Colleges of Nursing, AACN (2021), and the EU directive 2013/55/EU, variation in graduating nursing students' competence remains a concern (Kajander-Unkuri et al., 2021), particularly in clinical reasoning and decision-making (Clemett et al., 2021). Previous research has examined specific areas of compe-

tence, including e.g. critical care (Lakanmaa et al., 2014), medication safety (Saastamoinen, 2022; Sulosaari et al., 2015), cultural competence (Repo et al., 2017), and acute coronary syndrome (ACS) management (Liou et al., 2020; Turjamaa et al., 2022). However, these studies often focus on isolated skill sets rather than comprehensive assessments of integrated knowledge and clinical performance at the point of graduation.

Cardiovascular diseases (CVDs), including ACS, remain the leading cause of death worldwide (European Commission, 2021; WHO, 2021). Effective nursing care in ACS cases requires timely recognition of vital sign (VS) deviations and ECG interpretation, as changes in respiratory rate, blood pressure, heart rate, consciousness, and temperature are critical indicators of patient deterioration. (Elliott, 2021; Mok et al., 2015; Norton, 2017.) The ABCDE approach (Airway, Breathing, Circulation, Disability, Exposure) is internationally recommended for early detection of clinical decline (Resuscitation Council UK, 2021). Despite high self-assessed competence, graduating nursing students often lack sufficient knowledge of ACS and ECG interpretation skills (Goldsworthy et al., 2022;

\* Corresponding author.

E-mail address: [kristiina.rosqvist@tuni.fi](mailto:kristiina.rosqvist@tuni.fi) (K. Rosqvist).

Liou et al., 2020; Turjamaa et al., 2022), underscoring the need for more robust assessment methods.

Competence assessment at graduation typically involves theoretical exams and, less frequently, clinical evaluations such as Objective Structured Clinical Examinations (OSCE) and Bedside Oral Exams (BOE), which can assess decision-making and practical skills but are resource-intensive and not widely adopted (Siddaram & Sharma, 2018). Concerns about fairness and subjectivity in these methods persist (Strickland et al., 2017). The use of virtual assessment tools has increased significantly in recent years, showing potential in evaluating both theoretical knowledge (Cant et al., 2023) and clinical competence (Finn & Bradley, 2023; Sharoff, 2022).

Self-assessment instruments like the Nurse Competence Scale (NCS) are commonly used (Kajander-Unkuri et al., 2021; Kiekkas et al., 2019), yet they may not fully reflect students' readiness for professional practice. Exit exams in higher education often emphasize theoretical knowledge, with limited integration of clinical skill assessment (Alizadeh ym., 2023; Presti ym., 2019). This imbalance may hinder comprehensive competence evaluation, which should encompass knowledge, skills, attitudes, and values (Jacob et al., 2019). Consequently, there is a clear need for integrated assessment tools that evaluate both knowledge and skills prior to graduation.

## Aim

The study aimed to assess nursing students' knowledge and skills in vital signs through an objective exit exam, and to evaluate the usability of a simulation game platform as a skill test in the exit exam.

The research questions were:

- What kind of knowledge of vital signs do nursing students have in the exit exam?
- What kind of skills concerning vital signs do graduating nursing students have in the exit exam?
- What is the usability of the simulation game platform as a skill test in the exit exam?
- What is the difference in student performance between the knowledge test and the skill test in the exit exam?

## Methods

### Design

A cross-sectional study was conducted in Finland.

### Sample

The target group consisted of graduating nursing students collected from three University of Applied Sciences (UASs) from different parts of Finland. A convenience sampling method was used to invite all the graduating students from selected UASs to participate in the study. The course instructor acted as the local contact person and organized the data collection as part of the students' scheduled coursework. The inclusion criteria for the participants were (a) studying for a bachelor degree in the nursing program and (b) having completed 180 ECTS. Participation was voluntary, provided as a supplementary component of the clinical course, and did not influence the students' assessments or the education received. The sample size for the VSKT test was 159; for the VSST test, it was 187. Altogether, 153 participants participated in both tests. Although the tests were administered consecutively, the number of participants differed due to the voluntary nature of participation and technical challenges encountered during the testing process. Sample size calculations were

conducted for correlation analysis. With a statistical power of 90% and a significance level of 5%, the minimum sample size was 112 participants, when a correlation of 0.3 was considered clinically significant.

### Data collection

The study employed the Vital Signs Knowledge Test (VSKT) and the Vital Signs Skill Test (VSST), which were developed concurrently in an earlier phase of the research following DeVellis's (2017) scale development framework. To ensure content validity, the development process was multiphased and included two rounds of expert panel evaluations, medical verification, calculation of the item-level content validity index (I-CVI ranging from 0.91 to 1.00), the scale-level content validity index (S-CVI/Ave = 0.96), and a pilot test. The VSKT, based on the ABCDE protocol (Resuscitation Council UK, 2021), consists of 51 questionnaire items, while the VSST was implemented as a simulation game to maintain consistency. The tests were administered consecutively. Data were collected in the spring of 2023. The VSKT, a 51-item knowledge test with yes/no answers, and the VSST, a simulation game scenario in the simulation game platform, evaluated the ability to recognize changes in VSs in ACS patients. The maximum achievable score in VSKT was 51, with each correct answer earning one point. Both tests incorporated the ABCDE approach for systematic patient assessment (Resuscitation Council UK, 2021). The data were collected in a classroom environment under the researcher's supervision. Initially, each student completed a questionnaire, which included informed consent and demographic questions (age, gender, educational background, work experience in social and health services, and prior gaming activity) and VSKT. At the end, they were asked about the difficulty level of each subscale of VSKT (ABCDE) to assess the questionnaire's overall difficulty. Participants rated the difficulty level using a Likert scale ranging from 1 to 5 (1 = easy, 2 = quite easy, 3 = neutral, 4 = quite difficult, 5 = difficult). The questionnaire combined subscales A and B, while subscales C, D, and E were assessed separately.

After completing the VSKT, the participants took the VSST. The VSST utilized the simulation game platform (Koivisto et al., 2018). The patient scenario involving an ACS situation for the simulation game platform was developed in the study's previous stage. The game environment is set in a 3D hospital ward, featuring a 3D virtual patient representing a 60-year-old male. Authenticity and realism were achieved using graphics depicting real medical equipment and animations that showed the patient's realistic reactions, gestures, and facial expressions (Koivisto et al., 2024). Key actions in the game included interviewing the patient, assessing his clinical condition by recognizing changes in vital signs and performing nursing interventions (Figure 1). The student had to proceed systematically to gain a sufficient understanding of the patient's condition and then decide on the appropriate nursing interventions. Students received 1 to 5 points for each correct choice. The maximum possible score for the VSST was 134. Table 1 presents the patient scenario.

Following the VSST, participants completed the Positive System Usability Scale (P-SUS), a validated tool for assessing user experience and perceived usability of digital systems (Brooke, 2017), to evaluate the usability of the simulation game in assessing graduating nursing students' skills during exit exams. The P-SUS included 12 questions, each rated on a Likert scale from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). At the end of the questionnaire there were two open-ended questions to gauge the difficulty level of the simulation scenario and the overall usability of the game as a skill test. The entire exit exam, encompassing the VSKT and VSST, took about 40-45 minutes.



Figure 1. Screenshot of the game.

### Data analysis

The analysis was conducted using the SAS statistical package, version 9.4. The data of VSKT and VSST were analyzed using univariate descriptive analysis and Pearson correlation with tests of significance. Multivariate models were used to estimate differences in VSKT between categories. Furthermore, the data of the VSST was evaluated using the performance in the simulation game stored in the game data. Data analysis was performed in collaboration with a statistician, strengthening the reliability of the findings.

### Ethical considerations

The study adhered to ethical research principles throughout (Finnish National Board on Research Integrity, 2019). Ethical approval was granted by the Regional Ethical Review Committee in Finland, and permission was obtained from the University of Applied Sciences (UASs) research directors. Participation was voluntary, with informed consent collected via the questionnaire's front page. Students were informed in advance and assured of their right to withdraw at any time. Confidentiality was guaranteed. All data were de-identified and reported in aggregate. Participation had no impact on assessments or instruction. Data analysis was conducted in collaboration with a statistician to ensure reliability.

## Results

### Participants

Most students (61%,  $n = 93$ ) were under 30 years old. Over half (59%) had completed high school, while 35% had a practical nurse background. Work experience in social and healthcare varied, with the majority (38.2%) reporting one to five years. Students were most familiar with digital gaming, while board and educational games were less common.

### The knowledge of VS among nursing students in the exit exam

A total of 159 participants completed the VSKT, with scores ranging from 34 to 49 (mean = 42.2, SD = 3.03) out of 51 points.

The distribution of scores was approximately normal. In the *Airway and Breathing* subscale, 76% of participants were aware of updated oxygen therapy guidelines for ACS. While responses varied in confirming adequate respiration and recommending oxygen therapy, the difficulty level was generally rated as easy to moderate.

In subscale *Circulation*, just over half the participants (57.6%) correctly identified that any cardiac rhythm other than sinus rhythm is classified as an arrhythmia. Additionally, 88% of the participants were familiar with the guidelines for ECG lead placement in acute coronary syndrome (ACS) situations. Most participants rated the difficulty level of *Circulation* as moderate to quite difficult. The highest standard deviations were observed in subscale *Circulation* (SD = 1.33) and subscale *Exposure/environment/extra* (SD = 1.86), indicating the greatest variability in scores and, consequently, in the participants' knowledge.

The most significant score variation was observed in subscales *Disability* and *Exposure/environment/extra*, which also focused on the treatment of ACS patients. ACS was correctly identified by 75.6% of the participants. Additionally, most participants knew to contact a medical doctor (MD) if there were changes in the ECG. Notably, there was considerable variation in scores related to pain management, with 80% accurately calculating the prescribed dosage of strong opiates. The recommendation for percutaneous coronary intervention (PCI) was known by 85% of the participants. Most participants rated the difficulty level of subscales *Disability* and *Exposure/environment/extra* as moderate to quite difficult.

Statistically significant positive correlations were found between all ABCDE subscales and overall VSKT scores ( $p < .05$ ). Notably, *Circulation* had significantly positive correlation with *Exposure/environment/extra* ( $r = 0.19$ ,  $p < .05$ ) and slight correlation with *Disability* ( $r = 0.15$ ,  $p = .05$ ), suggesting that proficiency in one area was associated with competence in others. Younger participants performed better overall, while no other demographic variables showed significant correlations (Table 2).

Participants completed the test in approximately 10 minutes. The overall difficulty of the VSKT was rated as moderate by 44% and quite difficult by 47%. Over 93% considered the VSKT an effec-

**Table 1**  
Patient Scenario.

Description of the Patient	
<p>- Patient, 60 years old man</p> <p>- Anamnesis: coronary artery disease (CAD), angina pectoris symptoms on exertion, dyslipidemia, hypertension, Diabetes Mellitus II, obesity. The patient is a smoker (1 box a day).</p> <p>- Status: The patient is admitted to the hospital (internal medicine ward) because of chest pain that didn't relief at rest and nitroglycerin mouth spray that he had taken at home in the morning. He has been treated in emergency unit and no specific cardiac findings couldn't have been found (ECG+troponin blood sample have been taken), so the patient was transmitted to the internal medicine ward. He has been there for four hours and feels again chest pain. The nurse begins to do the clinical assessment to the patient following ABCDE-protocol.</p> <p>- Home medication: Acetylsalicylic acid 100 mg 1 × 1 p.o., Bisoprolol 2,5mg 1 × 2 p.o., Amlodipine 5mg 1 × 1 p.o., Atorvastatin 20mg 1 × 1, Metformin hydrochloride 500mg 1 × 2)</p> <p>References: Käypä Hoito. 2021. <i>Sepelvaltimotauti. Duodecim Terveyskirjasto.</i> <a href="https://www.terveyskirjasto.fi/dlk00077">https://www.terveyskirjasto.fi/dlk00077</a>; Käypä Hoito. 2020. <i>Tyyppin 2 diabetes. Duodecim Terveyskirjasto.</i> <a href="https://www.kaypahoito.fi/hoi50056">https://www.kaypahoito.fi/hoi50056</a>; Thim, T., Krarup, N., Grove, E., Rohde, C. &amp; Löfgren, B. 2012. <i>Initial assessment and treatment with the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach. International Journal of General Medicine</i> 2012, 5: 117-121.</p>	
The Content of the Patient Scenario Which is Embedded in VSKT and VSST	
<p>A/ Airways (Subscale A + B)</p> <p>References: Karjalainen, M., Norrgård, M., Peltomaa, M., Pineskoski, J., Rantala, H. &amp; Tirkkonen, J. 2018. <i>Suositus peruselintointojen arvioinnista ja seurannasta. Lääkärilehti</i> 2018, 12-13 (73): 786-988. Thim, T., Krarup, N., Grove, E., Rohde, C. &amp; Löfgren, B. 2012. <i>Initial assessment and treatment with the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach. International Journal of General Medicine</i> 2012, 5: 117-121.</p>	<p>Confirming that the airways are open and the patient is breathing</p> <ul style="list-style-type: none"> <li>- The easiest way to confirm that the airways are open, is that the patient answers to the nurse</li> <li>- In this scenario the patient is breathing and answers</li> </ul>
<p>B/ Breathing (Subscale A + B)</p> <p>References: Kuisma, M., Holmström, P., Nurmi, J., Porthan, K. &amp; Taskinen, T. 2017. <i>Ensihoito. Sanoma Pro. Käypä Hoito. 2019. Hengenahdistus. Duodecim Terveyskirjasto.</i> <a href="https://www.terveyskirjasto.fi/dlk00020">https://www.terveyskirjasto.fi/dlk00020</a> Käypä Hoito. 2011. <i>ST-nousuinfarkti. Duodecim Terveyskirjasto.</i> <a href="https://www.kaypahoito.fi/hoi50091">https://www.kaypahoito.fi/hoi50091</a> Käypä Hoito. 2014. <i>Sydäninfarktin diagnostiikka. Duodecim Terveyskirjasto.</i> <a href="https://www.kaypahoito.fi/hoi04050">https://www.kaypahoito.fi/hoi04050</a> Resuscitation Council UK. 2021. <i>The ABCDE -approach.</i> retrieved from <a href="https://www.resus.org.uk/library/abcde-approach">https://www.resus.org.uk/library/abcde-approach</a> Thim, T., Krarup, N., Grove, E., Rohde, C. &amp; Löfgren, B. 2012. <i>Initial assessment and treatment with the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach. International Journal of General Medicine</i> 2012, 5: 117-121.</p>	<p>Systematic assessment of the respiration</p> <ul style="list-style-type: none"> <li>- Calculating the respiration rate (which is 30, high due to the pain, fear, and shortness of breath)</li> <li>- Placing the pulse oximeter to patient's finger (The oxygen saturation level is 87% without oxygen supplement at the first)</li> <li>- The student should start oxygen therapy for the patient (3 liters per minute) and continuously follow the response (the oxygen therapy can be used in chest pain if the SpO2 is &lt;90%, the purpose is to achieve SpO2 level &gt;90%). Supplemental oxygen should not be used without a substantiated indication.</li> <li>- Placing the patient to half sitting position</li> <li>- To do the clinical check for the patient if the patient is cyanotic</li> </ul>
<p>C/ Circulation (Subscale C)</p> <p>References: Käypä Hoito. 2014. <i>Sydäninfarktin diagnostiikka.</i> <a href="https://www.kaypahoito.fi/hoi04050">https://www.kaypahoito.fi/hoi04050</a> Käypä Hoito. 2011. <i>ST-nousuinfarkti.</i> <a href="https://www.kaypahoito.fi/hoi50091">https://www.kaypahoito.fi/hoi50091</a> Thim, T., Krarup, N., Grove, E., Rohde, C. &amp; Löfgren, B. 2012. <i>Initial assessment and treatment with the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach. International Journal of General Medicine</i> 2012, 5: 117-121.</p>	<p>Systematic assessment of circulation</p> <ul style="list-style-type: none"> <li>- Calculating the pulse rate (it's a little bit high due to the ACS, 118)</li> <li>- Palpating the pulse: is it regular or irregular, If the radial pulse can be felt, the systolic blood pressure is generally more than 80 mmHg.</li> <li>- Taking the blood pressure and recognize that it's high due to the ACS situation (NIBP 179/102)</li> <li>- Checking the temperature of the periphery (hands, legs)</li> <li>- Taking the 15-16 -lead ECG and recognize that there is changes in ECG</li> </ul> <p>The student must report about the findings immediately to the medical doctor (MD)</p>
<p>D/ Disability (Subscale D)</p> <p>References: Thim, T., Krarup, N., Grove, E., Rohde, C. &amp; Löfgren, B. 2012. <i>Initial assessment and treatment with the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach. International Journal of General Medicine</i> 2012, 5: 117-121. Käypä Hoito. 2020. <i>Tyyppin 2 diabetes. Duodecim Terveyskirjasto.</i> <a href="https://www.kaypahoito.fi/hoi50056">https://www.kaypahoito.fi/hoi50056</a></p>	<p>Systematic assessment of consciousness - Confirming whether the patient is oriented or disoriented (The patient is oriented, awake and answers to the questions rationally, but using short answers. Difficulties to speak due to the shortness of breath), - Calculating Glasgow Coma Scale (GCS) = 15, normal - Checking the basic neurological status - Asking the strength of the pain using the pain subscale NRS (0-10), asking what kind of the pain is (patient describes) and asking where the pain is (patient shows the pain area) - Checking the rate of blood sugar = 11,9 (this should be checked because patient has DM II and the stress reaction in the body can increase the level of blood sugar)</p> <p>Systematic assessment of patient body (exposure), environment, other notifications of the patient situation (no abnormalities)- To expose the patient (this should be done already in phase C when taking ECG), check the body (any marks e.g. trauma, the skin color and temperature)-Order the blood samples which have been prescribed:</p> <ul style="list-style-type: none"> <li>- Troponin, creatine kinase (CKMb), Thromboplastin time, Basic blood count, Potassium, Sodium, Creatinine (fluid balance markers), inflammation marker (CRP). Increased troponin can be seen reliably in 2-4 hours from the beginning of the symptoms.</li> </ul> <p>-The treatment line (MD's order)</p> <ul style="list-style-type: none"> <li>- Administer the i.v. line to the patient (large cannula, maintenance hydration, prefer to be left hand; then right hand is available for examinations)</li> <li>- To administer Nitroglycerin infusion if the patient is hypertensive (can be administered if the systolic blood pressure is over 100mmHg), Acetylsalicylic acid 250mg (chewing), Morphine i.v. for pain management (the student have to calculate the right amount), Ondansetron for possible nausea 4 mg i.v., Enoxaparin</li> <li>- Oxygen therapy continues (monitoring the response from pulse oximeter)</li> <li>- To prepare the patient for coronary angiography and angioplasty</li> </ul>
<p>E / Exposure Environment, Extra (Subscale E)</p> <p>References: Karjalainen, M., Norrgård, M., Peltomaa, M., Pineskoski, J., Rantala, H. &amp; Tirkkonen, J. 2018. <i>Suositus peruselintointojen arvioinnista ja seurannasta. Lääkärilehti</i> 2018, 12-13 (73): 786-988. Kuisma, M., Holmström, P., Nurmi, J., Porthan, K. &amp; Taskinen, T. 2017. <i>Ensihoito. Sanoma Pro. Käypä Hoito. 2014. Sydäninfarktin diagnostiikka.</i> <a href="https://www.kaypahoito.fi/hoi04050">https://www.kaypahoito.fi/hoi04050</a> Käypä Hoito. 2011. <i>ST-nousuinfarkti.</i> <a href="https://www.kaypahoito.fi/hoi50091">https://www.kaypahoito.fi/hoi50091</a> Mok, W., Wang, W. &amp; Liaw, S. 2013. <i>Vital signs monitoring to detect patient deterioration: An integrative literature review. International Journal of Nursing Practice</i> 2015, 21: 91-98. Watkins, T., Whisman, L. &amp; Booker, P. <i>Nursing assessment of continuous vital sign surveillance to improve patient safety on the medical/surgical unit. Journal of Clinical Nursing.</i> Lambe, K., Currey, J. &amp; Considine, J. 2016. <i>Frequency of vital sign assessment and clinical deterioration in an Australian emergency department. Australasian Emergency nursing Journal.</i> 19 (2016): 217-222. Thim, T., Krarup, N., Grove, E., Rohde, C. &amp; Löfgren, B. 2012. <i>Initial assessment and treatment with the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach. International Journal of General Medicine</i> 2012, 5: 117-121.</p> <p>The student should master in VSKT and simulation scenario</p>	<p>Systematic assessment according ABCDE, taking vital signs of the patient and recognize if there are changes in VSS</p> <p>To understand that the ECG with right amount of leads must be taken always if the patient is complaining chest pain</p> <p>To recognize changes in ECG (interpretation)</p> <p>To ask the relevant questions from the patient concerning the situation and patient's condition</p> <p>The student understand that he/she has to report about the ECG findings immediately to the medical doctor</p> <p>To understand that the patient needs continuous monitoring and not to be left alone (the patient goes to Angiography and angioplasty, PCI)</p> <p>To understand the possible deterioration in patient's condition</p> <p>To understand that patient has to be in bed rest (not able to go e.g. to the toilet, even if the patient wants to go in simulation scenario)</p> <p>To understand patient's distress and fear and find the way to help/ relief the distress and fear</p> <p>To understand that the family members have to be informed of the changes of patient's condition. To understand nurse's responsibility in that; not to tell the diagnosis but nursing diagnosis e.g. that the condition has changed and examinations will be done, to calm down the family members.</p>

**Table 2**  
Pearson Correlation Coefficients (*p*-Value) of the Subscales and Total Scores.

	A + B/Airways and Breathing	C/Circulation	D/Disability	E/Exposure/Environment/Extra (Incl. Treatment of ACS)	ABCDE (The Complete VSKT)
<b>A + B/Airways and breathing</b>		0.07	-0.13	0.09	0.41
<b>C/Circulation</b>	0.07	0.38	0.11	0.26	< 0.0001***
<b>D/Disability</b>	0.38		0.15	0.19	0.63
<b>E/Exposure/environment/Extra (incl. treatment of ACS)</b>	-0.13	0.15	0.06	0.01	< 0.0001***
	0.11	0.06		0.12	0.38
	0.09	0.19	0.12	0.14	< 0.0001***
	0.26	0.01	0.01		0.76
					< 0.0001***

Note: Subscales: 1 & 2 = A/Airways and breathing, 3 = C/Circulation, 4 = D/Disability, 5 = E/Exposure, environment, extra (including treatment line of ACS).

Pearson correlation coefficients (*P*-value) of the subscales and total scores.

\**p*<0,05, \*\**p*<0,01, \*\*\**p*<0,001

0.10-0.39 Weak correlation

0.40-0.69 Moderate correlation

0.70-0.89 Strong correlation

0.90-1.00 Very Strong correlation.

tive tool for assessing vital signs knowledge, and most supported its inclusion in nursing exit exams.

#### The skills of VS among nursing students in the exit exam

A total of 187 participants completed the VSST, with scores ranging from 12 to 112 (mean = 81.4, SD = 21.0) out of a possible 134 points. Despite the VSST and VSKT being administered consecutively, the VSST had a higher number of participants.

The highest scores in the VSST were observed in *Airway, Breathing, and Disability* subscales, while the lowest were in *Circulation* and *Exposure/Environment/Extra*, which included ACS treatment protocols. Only 42.3% correctly identified ACS complications on the ECG, notably lower than in the VSKT (75.6%). Prior gaming experience or time spent on the VSST did not correlate with higher scores (Table 3).

Participants also completed the Positive System Usability Scale (P-SUS) to evaluate the simulation platform. Over 70% reported they would use the game frequently, and more than half found it easy to use without technical support. Less than 30% found it difficult and anticipated needing assistance. Feedback varied: some found progression unclear, while others described the game as intuitive. Open responses suggested interest in testing the game with different scenarios and receiving correct answers postassessment.

About half rated the scenario's difficulty as moderate, and just over one-third as quite difficult. Over 70% considered the simulation game a suitable method for assessing skills in exit exams. The average completion time was 10 minutes.

#### The difference in student performance between the knowledge test and the skill test in the exit exam

A total of 153 participants completed both the VSKT and VSST. Skill test scores positively correlated with knowledge test scores, particularly in the *Exposure/Environment/Extra* subscale ( $r = 0.19$ ,  $p < .05$ ), which included ACS treatment protocols. Overall VSST scores also correlated with total VSKT scores ( $r = 0.17$ ,  $p < .05$ ), indicating that students who performed well in knowledge test also performed well in skill test. A negative correlation was found between time spent on the tests and scores achieved, suggesting that longer completion times were associated with lower performance (Table 2). Comparison of VSKT and VSST results revealed that the most challenging content in both tests was related to ACS treatment protocols, particularly in the *Exposure/Environment/Extra* subscale. Significant variation was also observed in recognizing

ECG changes during ACS situations, with better performance in the VSKT (75.6%) than in the VSST (42.3%).

## Discussion

This study aimed to assess nursing students' knowledge and skills in vital signs through an objective exit exam and to evaluate the usability of a simulation game platform as a skill test. The findings revealed a positive correlation between theoretical knowledge and practical performance, indicating that students with stronger conceptual understanding were better able to apply their knowledge in the simulation game. A notable finding was that younger participants performed better in both knowledge and skill tests, possibly due to recent educational experiences or greater technological fluency. This suggests a need for differentiated instruction, including digital literacy support and adaptive assessment environments for diverse learner profiles. Additionally, a significant negative correlation between response time and score implies that faster responses were associated with better performance, potentially reflecting cognitive fluency and clinical reasoning. Slower responses may indicate hesitation, anxiety, or technical challenges, consistent with previous findings on simulation-related stress and concerns about fairness (Siddaram et al., 2018).

Despite a reasonable average score, wide variation in performance, especially in ACS procedures and medication calculation, reveals uneven competence levels. Only 80% of students correctly calculated a strong opiate dosage, raising concerns about medication administration competence. This is particularly concerning given that these students are on the verge of graduating and entering professional clinical practice, where accurate medication administration is crucial for patient safety. Similar gaps have been reported in earlier studies (Elonen et al., 2021; Sulosaari et al., 2015; Turjamaa et al., 2022), suggesting that theoretical instruction alone is insufficient. More hands-on training, simulation, and skill assessments are needed to strengthen practical competence.

Although students demonstrated theoretical knowledge of ECG changes, their ability to identify these changes in skill test was weaker. This discrepancy may stem from cognitive load, performance anxiety, or lack of real-time feedback during simulation game. The exam-like design of the simulation game, which withheld feedback until completion, may have limited students' ability to self-correct and reflect. These results highlight the pedagogical value of integrating theory and practice in both teaching and assessment. (Goldsworthy et al., 2022.) These findings align with Turjamaa et al. (2022), who reported limited understanding of ACS

**Table 3**  
Differences of Least Squares Means.

VSKT Total Scores				
Categorical Independents	Mean Score****			
	Estimate	p	95% Confidence Interval of the Difference	
			Lower	Upper
Age <20-30 years	2.20	0.19	-0.78	5.18
Age 31-45 years	1.57	0.43	-1.43	4.56
(Age>46 years)				
Gender: Female	-0.05	0.95	-1.79	1.69
(Gender: Male)**				
Education: High school	-1.34	0.26	-3.37	0.69
(Education: Vocational upper secondary education)				
Working experience <1year	-0.27	0.97	-3.22	2.69
Working experience 1-10 years	-0.86	0.75	-3.72	1.20
(Working experience >10 years)				
Gaming activity: Nondigital games				
Daily/Weekly	2.84	0.56	-3.74	9.42
Less than once a month	2.46	0.16	-0.70	5.61
Gaming activity: Digital games				
Daily/Weekly	-0.90	0.77	-4.00	2.20
Less than once a month	-0.22	0.95	-2.03	1.59
Gaming activity: Learning games				
Daily/Weekly	-2.21	0.52	-7.07	2.64
Less than once a month	0.01	1.00	-7.07	1.72
VSST total scores				
Numerical Independents	Mean Score *****			
			Slope**	p*
	Score	Time	0.03	.02
		-0.05	.31	

\*\*\*\* Mean score: The mean score of VSKT.

\*\*\*\*\* Mean score: The mean score of VSST.

\*\* Gender (none "other").

\* p value: Less than .05 was considered significant. Data are presented as differences in means between three phases, 95% confidence intervals in brackets together with p-values. A positive value indicates higher mean in the first category given in the beginning of each row.

\*\* Regression slopes between mean score and mean time are estimated using an interaction term of scenario and mean time.

care among nursing students, and Liou et al. (2020), who emphasized persistent challenges in ECG interpretation. To address these gaps, exit exams should incorporate realistic skill assessments that simulate clinical scenarios. Additionally, regular formative assessments can provide timely feedback and help educators identify students who require additional support.

Globally, nursing exit exams remain predominantly theoretical (Toale et al., 2023), which may limit the assessment of applied skills. In Europe, competence evaluation often relies on theoretical tests and self-assessments (Kajander-Unkuri et al., 2021; Kiekkas et al., 2019; Salminen et al., 2021; Vageriya, 2018), despite evidence that students tend to overestimate their competence (Kiekkas et al., 2019). Objective methods are needed to more accurately reflect students' readiness for clinical practice (Turjamaa et al., 2022). Studies have shown that graduating students often lack sufficient knowledge to assess vital signs, a skill essential for managing acute conditions (Lee et al., 2020; Turjamaa et al., 2022).

The use of virtual assessment tools has increased significantly in recent years, showing promise in evaluating both theoretical knowledge and clinical skills (Cant et al., 2023; Finn & Bradley, 2023; Sharoff, 2022). Simulation games have demonstrated potential in assessing knowledge (Cant et al., 2023; Koivisto et al., 2024), clinical skills (Sarvan & Efe, 2022), and reflective thinking (Açıl et al., 2024). In this study, students rated the simulation platform highly in usability, with most navigating it without technical assistance. Compared to traditional OSCEs, which are often stressful and time-consuming (Siddaram et al., 2018),

digital platforms offer a scalable and less burdensome alternative. However, further research is needed to determine whether these platforms can fully replicate the complexity of real clinical environments, including emotional stress, multitasking, and patient interaction. The combined theoretical and practical assessment method used in this study shows potential for broader application in areas such as emergency care, medication administration, and patient education. Successful implementation requires curricular alignment, technological infrastructure, and institutional readiness, including educator training and resource allocation.

Overall, this study highlights the need for comprehensive exit exams that integrate theoretical knowledge and practical skills. Diverse assessment methods, including objective tests, educator evaluations, and self-assessments, can provide a more accurate picture of student competence. Educators should use these insights to develop targeted interventions that support critical thinking and clinical reasoning. By bridging the gap between theory and practice, nursing education can better prepare students for clinical realities and enhance patient safety. Continued development of digital assessment tools, such as simulation games, may offer scalable, student-centered solutions to improve competence evaluation.

### Limitations of the study

This study has several limitations. Although participants were instructed to complete both the knowledge and skill tests consecutively, the number of respondents differed: 159 completed

the knowledge test and 187 the skill test, with 153 completed both. The knowledge test was accessible via mobile devices, whereas the skill test required a computer, which may explain the discrepancy—some participants may have faced technical challenges or forgotten their laptops. Despite this, statistical power analysis confirmed that the sample size was sufficient. Data collection was conducted in a controlled classroom setting under researcher supervision, ensuring optimal conditions for test completion.

The patient scenario focused on cardiovascular disease, one of the most prevalent global health issues (WHO, 2021a), though limited to a single clinical case. However, similar assessments could be adapted to other clinical contexts. As a cross-sectional study, the design captures data at one point in time, limiting causal interpretations. Another limitation is the lack of broader psychometric validation for the test items. Nevertheless, the development of the VSKT and VSST involved expert panels and rigorous content evaluation, supporting the reliability of the instruments.

## Conclusions

This study underscores the importance of integrating theoretical knowledge and skill assessments in nursing exit examinations. The results show that these domains are interrelated: students who performed well in the knowledge test also tended to succeed in the skill test. However, discrepancies, particularly in ECG interpretation and medication management, highlight areas where theoretical understanding does not consistently translate into clinical competence, emphasizing the need for improved training in medication safety.

As nursing student numbers grow, educators face challenges in conducting resource-intensive assessments. Simulation games offer a scalable and engaging alternative, supporting student motivation while maintaining pedagogical rigor. The assessment method used in this study could be adapted to various clinical scenarios and educational contexts. However, successful implementation requires attention to curricular alignment, technological infrastructure, and educator training. To better prepare students for clinical practice, future efforts should focus on developing and validating assessment methods that combine theoretical and practical components. Further psychometric validation of the VSKT is recommended to enhance its reliability and applicability.

## Ethics approval and consent to participate

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Finnish national ethic committee from Satakunta (Approved date: January 25, 2023). Informed consent was obtained from the participants.

The research adhered to EQUATOR guidelines and is reported according to STROBE check list.

## Consent for publication

Not applicable.

## Human face in Figure 1

The face detected in figure 1 belongs to animated patient, not a real human being.

## Availability of data and materials

The datasets created and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

## Declaration of competing interest

None.

## CRediT authorship contribution statement

**Kristiina Rosqvist:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Jaana-Maija Koivisto:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Janne Engblom:** Software, Formal analysis. **Elina Haavisto:** Writing – review & editing, Supervision, Methodology, Conceptualization.

## Acknowledgments

Authors thank all the participants for their contributions to this study.

## Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## References

- American Association of Colleges of Nursing. *The essentials: Core competencies for professional nursing education*. <https://www.aacnursing.org/Portals/0/PDFs/Publications/Essentials-2021.pdf>.
- Açıl, A., & Keçec, A. (2024). Effect of a simulation game on nursing students' reflective thinking skills: A mixed methods study. *BMN Nursing*, 23, 704. <https://doi.org/10.1186/s12912-024-02228-w>.
- Alizadeh, S., Zamanzadeh, V., Ostovar, S., Ghaffari, R., Moonaghi, H. K., Johnston, A., & Valizadeh, L. (2023). The development and validation of a standardized eight-station OSCE for registration of undergraduate nursing students: A Delphi study. *Nurse Education in Practice*. <https://doi.org/10.1016/j.nepr.2023.103817>.
- Brooke, J. (2017). SUS. A retrospective. *Journal of User Experience*, 8(2), 29–40. <https://uxpajournal.org/sus-a-retrospective/>.
- Cant, R., Ryan, C., & Kelly, M. (2023). Use and effectiveness of virtual simulations in nursing student education: An umbrella review. *CIN: Computers, Informatics, Nursing*, 41(1), 31–38. <https://doi.org/10.1097/CIN.0000000000000932>.
- Clemett, V., & Raleigh, M. (2021). The validity and reliability of clinical judgement and decision-making skills assessment in nursing: A systematic literature review. *Nurse Education Today*, 102. <https://doi.org/10.1016/j.nedt.2021.104885>.
- DeVellis, R.F. (2017). *Scale development: Theory and applications*. *applied social research methods* (4th ed.). SAGE.
- Elliott, M. (2021). The global elements of vital signs' assessment: A guide for clinical practice. *British Journal of Nursing*, 30(16). <https://doi.org/10.12968/bjon.2021.30.16.956>.
- Elonen, I., Salminen, L., Brasaité-Abromé, I., Fuster, P., Kukkonen, P., Leino-Kilpi, H., Löyttyniemi, E., Noonan, B., Stubner, J., Svavarsdóttir, M., Thorsteinnsson, H., & Koskinen, S. (2021). Medication calculation skills of graduating nursing students within European context. *Journal of Clinical Nursing*, 31, 548–558. <https://doi.org/10.1111/jocn.15908>.
- European Commission. *Causes of death statistics* Retrieved November 30, 2025. <https://ec.europa.eu/eurostat/web/health/data>.
- Finn, J., & Bradley, L. (2023). vSim® gerontology and inquiry-based learning enhancing clinical reasoning and preparation for practice. *Teaching and Learning in Nursing*, 18(4). <https://doi.org/10.1016/j.teln.2023.05.002>.
- Finnish National Board on Research Integrity. *The ethical principles of research with human participants and ethical review in the human sciences in Finland* Retrieved November 29, 2025. [https://tenk.fi/sites/default/files/2021-01/Ethical\\_review\\_in\\_human\\_sciences\\_2020.pdf](https://tenk.fi/sites/default/files/2021-01/Ethical_review_in_human_sciences_2020.pdf).
- Goldsworthy, S., Muir, N., Baron, S., Button, D., Goodhand, K., Hunter, S., McNeill, L., Perez, G., McParland, T., Fasken, L., & Peachey, L. (2022). The impact of virtual simulation on the recognition and response to the rapidly deteriorating patient among undergraduate nursing students. *Nurse Education Today*, 110, Article 105264. <https://doi.org/10.1016/j.nedt.2021.105264>.
- Jacob, E., Duffield, C., & Jacob, A. M. (2019). Validation of data using RASCH analysis in a tool measuring changes in critical thinking in nursing students. *Nurse Education Today*, 76, 196–199. <https://doi.org/10.1016/j.nedt.2019.02.012>.

- Kajander-Unkuri, S., Koskinen, S., Brugnolli, A., et al., (2021). The level of competence of graduating nursing students in 10 European countries: Comparison between countries. *Nursing Open*, 8(3), 1048–1062. <https://doi.org/10.1002/nop2.712>.
- Kiekkas, P., Michalopoulos, E., Igoumenidis, M., Michalopoulos, A., & Stefanopoulos, N. (2019). Factors associated with self-reported competence of graduating nursing students. *Collegian (Royal College of Nursing, Australia)*, 26(2), 267–272. <https://doi.org/10.1016/j.colegn.2018.08.004>.
- Koivisto, J.-M., Buure, T., Engblom, J., Rosqvist, K., & Haavisto, E. (2024). Association between game metrics in a simulation game and nursing students' surgical nursing knowledge: A quasi-experimental study. *BMC Nursing*, 23, 16. <https://doi.org/10.1186/s12912-023-01668-0>.
- Koivisto, J.-M., Haavisto, E., Niemi, H., Haho, P., Nylund, S., & Multisilta, J. (2018). Design principles for simulation games for learning clinical reasoning: A design-based research approach. *Nurse Education Today*, 60, 114–120.
- Lakanmaa, R.-L., Suominen, T., Perttilä, J., Ritmala-Castrén, M., Vahlberg, T., & Leino-Kilpi, H. (2014). Graduating nursing students' basic competence in intensive and critical care nursing. *Journal of Clinical Nursing*, 23, 645–653. <https://doi.org/10.1111/jocn.12244>.
- Lee, J., Kim, E., Kim, S., & Oh, E. G. (2020). A systematic review of early warning systems' effect on nurses' clinical performance and adverse events among deteriorating ward patients. *Journal of Patient Safety*, 16(3), e104–e113. <https://doi.org/10.1097/PTS.0000000000000492>.
- Liou, S.-R., Liu, H.-C., Tsai, S.-L., Chu, T.-P., & Cheng, C.-Y. (2020). Performance competence of pregraduate nursing students and hospital nurses: A comparison study. *Journal of Clinical Nursing*, 29, 2652–2662. <https://doi.org/10.1111/jocn.15287>.
- Mok, W., Wang, W., Cooper, S., Ang, E. N. K., & Liaw, S. Y. (2015). Attitudes towards vital signs monitoring in the detection of clinical deterioration: Scale development and survey of ward nurses. *International Journal for Quality in Health Care*, 27(3), 207–213.
- Norton, C. (2017). Acute coronary syndrome: Assessment and management. *Nursing Standard*, 31(29), 61–71. <https://doi.org/10.7748/ns.2017.e10754>.
- Presti, C. R., & Sanko, J. S. (2019). Adaptive quizzing improves end-of-program exit examination scores. *Nurse Educator*, 44(3), 151–153. <https://doi.org/10.1097/NNE.0000000000000566>.
- Repo, H., Vahlberg, T., Salminen, L., Papadopoulos, I., & Leino-Kilpi, H. (2017). The cultural competence of graduating nursing students. *Journal of Transcultural Nursing*, 28(1). <https://doi.org/10.1177/104365961663204>.
- Resuscitation Council UK. *The ABCDE approach* Retrieved November 29, 2025. <https://www.resus.org.uk/library/abcde-approach>.
- Salminen, L., Tuukkanen, M., Clever, K., Pilar, F., Kelly, M., Kiele, V., Koskinen, S., Sveinsdottir, H., Löyttyniemi, E., & Leino-Kilpi, H. (2021). The competence of nurse educators and graduating nurse students. *Nurse Education Today*. <https://doi.org/10.1016/j.nedt.2021.104769>.
- Sarvan, S., & Efe, E. (2022). The effect of neonatal resuscitation training based on a serious game simulation method on nursing students' knowledge, skills, satisfaction and self-confidence levels: A randomized controlled trial. *Nurse Education Today*, 111, Article 105298. <https://doi.org/10.1016/j.nedt.2022.105298>.
- Sharoff, L. (2022). RN-BSN students' perception of vSim for nursing R using the simulation effectiveness tool: Modified (SET-M). *Journal of Nursing Education and Practice*, 13(2). <https://doi.org/10.5430/jnep.v13n2p21>.
- Siddaram, S., & Sharma, A. (2018). A comparative analysis between objective structured clinical examination (OSCE) and conventional examination (CE) as a formative evaluation tool. *International Journal of Nursing Education*, 10(3), 102–105. <https://doi.org/10.5958/0974-9357.2018.00076.4>.
- Strickland, H., Cheshire, M., & March, A. (2017). Clinical judgment during simulation: A comparison of student and faculty scores. *Nursing Education Perspectives*, 38(2), 85–86. <https://doi.org/10.1097/01.NEP.0000000000000109>.
- Sulosaari, V., Huupponen, R., Hupli, M., Puukka, P., Tornainen, K., & Leino-Kilpi, H. (2015). Factors associated with nursing students' medication competence at the beginning and end of their education. *BMC Medical Education*, 15, 223. <https://doi.org/10.1186/s12909-015-0513-0>.
- Suomalainen Lääkärisaira Duodecim ja Suomen Kardiologinen Seura. (2022). Sepelvaltimotautikohtaus. Käypä hoito -suositus. <https://www.kaypahoito.fi>.
- Toale, C., Morris, M., & Kavanagh, D. (2023). Perspectives on simulation-based assessment of operative skill in surgical training. *Medical Teacher*, 45(3), 313–320. <https://doi.org/10.1080/0142159X.2022.2134001>.
- Turjamaa, R., Simon-Bellamy, J., Salminen, L., Löyttyniemi, E., & Kajander-Unkuri, S. (2022). Graduating nursing students' competence in nursing patients with acute coronary syndrome. *Central European Journal of Nursing and Midwifery*, 13(4), 741–753. <https://doi.org/10.15452/CEJNM.2022.13.0007>.
- Vageriya, V. (2018). Assessment and evaluation – in perspective of medical education. *Nursing Health Care International Journal*, 2(4), Article 000154.
- World Health Organization. *Cardiovascular diseases* Retrieved November 30, 2025. <https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-cvds>.