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Nursing Students' Perceptions of a Bilingual Simulated Electronic Health Record in Low-Resource Cambodian Nursing Education: A Post-Intervention Evaluation with a Cross-Site Baseline Comparison

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ABSTRACT

Background

Digital health competence, particularly proficiency in electronic health records (EHRs), is crucial for nursing practice globally but faces challenges in low-resource settings. Cambodian nursing students encounter linguistic barriers due to limited English proficiency and lack of bilingual digital training tools. This study evaluated a bilingual simulated EHR platform designed to improve digital health competencies among Cambodian nursing students.

Methods

First-year associate degree nursing students at three Cambodian institutions were offered a six-module bilingual (Khmer–English) simulated EHR course in 2024. In this single-group evaluation, anonymous, content-validated surveys were administered in Khmer and English before and after the course. Post-course responses were summarised descriptively; baseline responses were compared between sites using the Mann–Whitney U test and Hodges–Lehmann estimator.

Results

After the course, 203 of 291 students (69.8%) rated their understanding of EHRs as good or very good, 287 (98.6%) said the platform had helped prepare them for EHR use, and 281 (96.6%) would recommend the platform. Most students worked in Khmer or both languages (286, 98.3%) and used a smartphone (210, 72.2%). Technical problems (53.3%), limited computer literacy (36.1%), and difficulty with English (34.7%) were the most common challenges. In total, 584 students completed the pre-survey; post-course responses came from the two urban sites, where the full course was delivered, because computer laboratory access was lost at the regional site. Baseline exposure to EHRs differed sharply between sites: 213 of 240 students (88.8%) at the regional training center had never heard of an EHR, whereas most at the urban sites selected options indicating clinical exposure (median 1 vs. 4; $p < .001$; effect size $r = 0.82$). No pre–post comparison was made because the items used different response descriptors.

Conclusions

Students rated the bilingual simulated EHR platform highly and reported that it had helped prepare them for workplace EHR use, although the design cannot establish that the platform improved competence. Students' language and device choices were consistent with the platform's bilingual, mobile-accessible design. Baseline exposure to EHRs differed markedly between urban and regional institutions, and loss of laboratory access prevented full delivery at the regional site, underlining the dependence of such training on digital infrastructure.

Keywords

Bilingual, simulated electronic health record, Cambodia, nursing students, Southeast Asia

Background

The digital transformation of healthcare has made proficiency in the use of electronic health records (EHRs) an essential competency for nurses globally. EHRs are vital tools in the collection, management, and analysis of patient data [1, 2]. A nursing workforce skilled in the use of EHRs facilitates care coordination, enhances patient safety, and creates effective data management, resulting in a higher standard of healthcare safety [2-4]. Furthermore, studies consistently underscore that early and practical experience with simulated EHRs prepare nursing students for modern digital health and build essential informatics competencies and digital literacy [5-9]. A 2025 scoping review of electronic medical record use in simulation-based nursing education confirmed these benefits across studies, finding consistent improvements in self-confidence, documentation, and informatics competency [10]. Yet the training gap persists even in high-resource settings: a 2026 cross-sectional study of nursing students at a Canadian university found that students rated their EHR training coverage as low across all years of their program [11].

In Southeast Asia, whose countries make up the 11 member states of the Association of Southeast Asian Nations (ASEAN) (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam), the integration of EHR training into nursing education faces unique challenges. Examples of challenges include disparities in digital literacy and workforce capacity, fragmented digital infrastructure limiting interoperability, and investment in data protection, cybersecurity, and sustainable digital health training programs [12].

Among these nations, Cambodia faces particularly significant barriers to digital integration [13, 14]. Cambodia ranks 151st out of 193 countries in the United Nations Human Development Index (HDI), placing it in the ‘medium human development’ category and at the lower end of the

ASEAN region [15]. This ranking reflects disparities in infrastructure, educational resources, and digital literacy, emphasizing the need for sustainable, context-sensitive solutions that address linguistic and cultural diversity to ensure equitable access to digital health education across the region [12, 16]. While Khmer is the national and dominant language in the Kingdom of Cambodia, English is widely used in private hospitals, non-governmental organizations, and among medical professionals, and Cambodian nursing programs train in English in preparation for this workforce requirement [17, 18].

In 2023, the University of Puthisastra (UP) nurse faculty recognized the need to prepare Cambodian nursing students for a rapidly digitizing healthcare environment and piloted EHR Go (an educational, English-only EHR platform developed in the U.S.) in their nursing informatics curriculum [18, 19]. Their subsequent descriptive study evaluating this pilot program, which, to the authors' knowledge, was the first such research initiative in Cambodia, found 32% of students reported difficulties with English proficiency, and 43% experienced challenges with English medical terminology [18]. This substantial language barrier revealed the necessity for a bilingual simulated EHR tailored to the needs of Cambodian English language learner (ELL) nursing students. Despite these challenges, the overall success of EHR Go from the students' perspective was evident, with 93% recommending the continuation of EHR training, recognizing its value in improving healthcare delivery and clinical readiness [18].

Responding to this language gap, the Up Skill Cambodia project was developed as a bilingual simulated EHR platform, tailored to the Cambodian cultural context through a collaborative partnership. Up Skill Cambodia was co-designed by the same UP nurse faculty who participated in the previous EHR Go study, a new researcher from Kampot Regional Training Center (RTC), and Khalibre Co., Ltd. [20], an IT company located in Cambodia. This project was designed to

enable nursing students to interact with EHR simulations in both Khmer and English, supporting a gradual approach to building confidence in digital EHR education. The design is informed by both the Technology Acceptance Model (TAM) and Krashen's language acquisition theory to maximize perceived usefulness, ease of use, and language accessibility.

This study evaluates a bilingual simulated EHR platform, Up Skill Cambodia, which is available to students in both Khmer and English, addressing the recognized need for a bilingual, culturally diverse educational tool in Cambodian nursing education. This project aims to enhance digital health capacity on a national scale. Academic simulated EHR platforms for nursing education are well established [5, 6, 10], but to our knowledge no published study has described the development or evaluation of a bilingual academic simulated EHR platform, in Cambodia or elsewhere.

Methods

Design

This study was a single-group evaluation of a simulated electronic health record (EHR) training program among Cambodian nursing students, with anonymous surveys administered before and after the course and a cross-site comparison of baseline responses. A single-group design was used because randomization was not feasible and no control group was available within the existing nursing cohorts [21, 22], and because such designs are useful for studying the implementation of educational technology in real educational settings [23]. Because the pre- and post-survey EHR items were not equivalent (see Survey Content and Administration), post-course findings are reported descriptively rather than as a pre–post comparison. Because all enrolled students were offered the intervention, participants, course facilitators, and those

collecting data were not blinded; surveys were anonymous and self-administered to reduce social desirability bias.

The study was an exploratory pilot evaluation, aimed at describing students' self-perceived EHR knowledge and experiences before and after participation in Up Skill Cambodia, a bilingual simulated EHR platform. Up Skill Cambodia, created by Khalibre, is a capacity-building, cloud-based portal integrated with an EHR simulator in both the English and Khmer languages.

The study was designed to collect both pre- and post-intervention data from three participating institutions: the University of Puthisastra (UP), Technical School for Medical Care (TSMC), and the Regional Training Center in Kampot (Kampot RTC). However, post-intervention data collection at Kampot RTC was not possible due to infrastructure constraints that were beyond the control of both the researcher and the participants. This contextual limitation, common in research conducted in resource-constrained environments, meant that no post-intervention data were collected from Kampot RTC's 240 students; together with 53 fewer post-survey than pre-survey responses at the other two sites, the number of responses fell from 584 at baseline to 291 at follow-up. Students at Kampot RTC completed Module 1, which contained the pre-intervention survey, but access to the computer laboratory, which was both the timetabled venue for the course and the students' source of internet access through its Wi-Fi, became unavailable thereafter, and Modules 2–6 could not be delivered; no post-intervention data were collected at that site. Course instructors reported that most students could not afford personal mobile data plans and connected their own devices through institutional Wi-Fi, so personal devices could not substitute for laboratory access. This represents a deviation from the planned protocol, in which all three sites were to receive the full six-module intervention. Post-course findings were therefore available only from the two sites that completed the intervention. A comparison

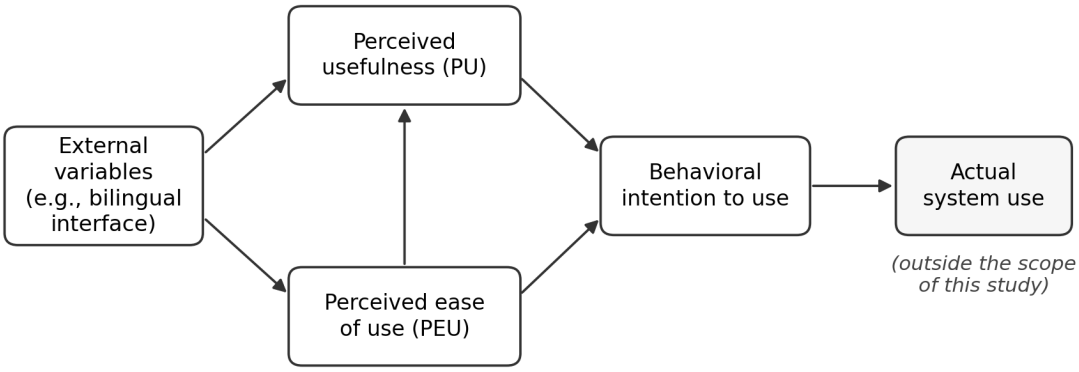
including Kampot RTC baseline data is reported separately in the Results, not as an estimate of the intervention effect, but to document baseline differences between sites and the potential for attrition bias.

The two theoretical frameworks used to guide this study design are the Technology Acceptance Model and Krashen's Second Language Acquisition Theory. The TAM theoretical framework, illustrated in Figure 1 [24] below, was used to assess the acceptance of Up Skill Cambodia and to explore students' perceptions of its usefulness and ease of use as a bilingual, simulated EHR platform. This also includes the students' intention to use the platform in the future and their self-perceived understanding of EHRs. TAM theorizes that technology adoption is driven by perceived usefulness (PU) and perceived ease of use (PEU) [24]. Prior evidence applying TAM to healthcare education in other countries found that PU is the strongest predictor of adoption and PEU reduces perceived barriers to using technology [5, 16]. Up Skill Cambodia was introduced as a single six-module simulation course within an existing nursing informatics course, representing most students' first structured exposure to an EHR. Accordingly, this study examined perceived ease of use, perceived usefulness, and intention to use. After the course, students' accounts remained active, and they could return to the platform to review or repeat the modules at any time; access was limited to students enrolled in the nursing informatics course. Actual system use was nevertheless outside the scope of this study, which surveyed students only at the end of the course and did not examine their use of the platform after it. Intention to use was therefore the most proximal TAM construct relevant to this pilot, and was approximated by students' willingness to recommend the platform. The post-survey was designed to capture students' perceived ease of use and perceived usefulness of the platform, although it was not a validated TAM instrument. Items were grouped by the TAM construct they most closely

reflected, as shown in the survey item table under Survey Content and Administration. Perceived ease of use was indicated by the ease of course completion and of registration (items 2 and 3), with the adequacy of lab time (item 6) and reported challenges (item 5) reported alongside as related implementation factors. Perceived usefulness was indicated directly by whether the platform had helped prepare students for EHR use (item 16), and indirectly by the importance students attached to EHRs and to EHR training (items 7 and 8). Language-related items (items 9–11) and AI translation items (items 12 and 13) were treated as external variables.

Figure 1

Technology Acceptance Model



Note. Adapted from Davis [24] and Davis, Bagozzi and Warshaw [25].

Krashen's Second Language Acquisition Theory was selected because it emphasizes the importance of providing the Cambodian ELL students with comprehensible input that supports gradual acquisition and confidence in bilingual educational settings [26, 27]. Comprehensible input in this study refers to English language that is understandable to the Cambodian nursing

students but includes some elements that are just slightly beyond their current proficiency level [26]. Up Skill Cambodia was developed in both the Khmer and English languages to support Cambodian nursing students who are ELLs [26]. By allowing the nursing students to toggle between Khmer and English in each course, it ensures that they can engage with the Up Skill Cambodia platform in the Khmer language while being exposed to English. This experience gradually increases exposure to English medical terminology. According to Krashen's theory, this progression helps reduce anxiety and increases confidence, ultimately fostering better retention and application of English [26, 27].

Furthermore, as mentioned in the Background section, Mao and Hester's pilot study [18] further supports the use of a bilingual approach within simulated EHR training. This study found that Cambodian ELL nursing students themselves reported limited English proficiency as one of the main reasons they struggled to use the English-only simulated EHR tool [18].

Instrument Development and Validity

The survey questionnaire included sections on perceived benefits, perceived challenges, and artificial intelligence applications for use as a translation tool in EHR. To protect student anonymity and encourage participation, no identifying demographic data, such as age or gender, was collected. This context-specific ethical decision was made in close alignment with recommendations from Cambodian nurse faculty, who advised that collecting such information could compromise confidentiality, given the predominantly female composition of cohorts and the small size of some class groups. The surveys were administered anonymously during course sessions but were separate from course assessment, to encourage honest feedback without fear of academic consequences.

The pre- and post-survey instruments were researcher-developed questionnaires. The questions were developed by the three nurse faculty members who designed the courses. All three reviewed studies and evaluated existing tools for nursing informatics competencies, including their previously published pilot study [18, 28, 29], and the two Cambodian faculty members (ME and CU) made the final decisions on item content and wording so that the survey would fit the Cambodian context. No validated tool specifically evaluating simulated EHRs for ELL was found [18]. As Cambodia has no graduate-level (master's or doctoral) nursing programs, although a master's program is being established, and no formal nursing informatics specialty or national nursing informatics society [30], it was challenging to secure in-country expertise and support for developing a Khmer/English bilingual tool.

Because the pre-survey comprised two single items measuring distinct constructs, and the post-survey combined heterogeneous item formats spanning several domains, internal-consistency coefficients such as Cronbach's alpha are not meaningful for these instruments and are not reported. Evidence for instrument quality instead rests on content validity — all items were rated relevant by an external expert panel of three MSN-prepared Cambodian nursing professionals who were not involved in developing the survey (I-CVI = 1.00 for every item; S-CVI/UA = 1.00) [31, 32] — and on forward–backward translation and review by two bilingual Cambodian nurse educators. The main outcome, self-perceived understanding of EHRs, was measured by a single self-report item; the absence of multi-item or test–retest reliability evidence for this item is acknowledged as a limitation.

A three-member expert panel is at the minimum end of accepted practice for content validity assessment, which is noted as a constraint of conducting instrument development in a setting without graduate-level nursing programs.

Survey Content and Administration

The pre-course survey comprised two items, shown in Table 1 below: self-rated comfort with computer technology and software applications, and self-perceived understanding of electronic health records (EHR). Both were rated on a 5-point scale ranging from Not good at all (1), Not very good (2), Neutral (3), Good (4), and Very Good (5). For the EHR item, each label carried a descriptor of prior exposure, ranging from "I have never heard of electronic health records (EHR) before now" (1) through having heard of EHRs (2) or seen one used as a patient or family member (3) or as a healthcare worker (4), to "I am proficient in EHR and have used them in a job before" (5). The full pre- and post-survey instruments, including all response options, are provided in Additional file 1.

Table 1

Pre-Up Skill Cambodia Survey Questions

Question Number	Item Type	Survey Question
1	Likert-scale	How well do you feel about using computer technology and software applications?
2	Likert-scale	How well do you understand electronic health records (EHR)? EHRs are used for collecting and saving patient health information on the computer.

Note. Students were given the choice to complete the survey in English or Khmer.

The post-course survey assessed students' understanding of EHR concepts after the course, the ease of course completion, and the challenges encountered, as shown in Table 2 below. Likert-scale items included self-perceived understanding of and readiness to use EHRs after training. Additional categorical selections through multiple-response questions were employed to gather

information on device access during training (e.g., laptop, tablet, mobile phone) and challenges faced (e.g., medical terminology, computer literacy, language difficulties, internet connectivity). Both surveys were conducted anonymously via the Up Skill Cambodia platform, ensuring standardized responses and secure digital cloud storage of participant data by Khalibre. The post-survey EHR item used the same five labels as the pre-survey item, but its descriptors referred to understanding and readiness after the course, ranging from "I do not feel prepared to use EHR" (1) through "I have a very basic understanding of EHR" (3) to "I feel prepared with the skills necessary to start using an EHR" (5). The two items therefore do not measure the same construct on a common scale (Table 3).

Table 2

Post-Up Skill Cambodia Survey Questions

Question Number	Item Type	Survey Question	TAM construct
1	Likert-scale	How well do you understand electronic health records (EHR) after completing the Up Skill Cambodia EHR courses?	Main outcome (self-perceived understanding)
2	Likert-scale	How easy or difficult were the Up Skill Cambodia EHR courses?	Perceived ease of use
3	Likert-scale	How easy was it for you to get registered using your email and password with Up Skill Cambodia?	Perceived ease of use
4	Multiple response	What type of technology device did you use to complete the EHR activities? (select all that apply)	Implementation factor
5	Multiple response	What challenges did you have when using Up Skill Cambodia? (Select all that apply)	Implementation factor
6	Likert-scale	Did you feel like you had enough time to complete your EHR activities during your computer lab practicum (when you worked in the computer lab during class)?	Implementation factor

7	Likert-scale	How important do you think it is to have EHR digital training like Up Skill Cambodia in the nursing curriculum at your school?	Perceived usefulness (indirect)
8	Likert-scale	How important do you think electronic healthcare records (EHR) are in hospitals and clinics?	Perceived usefulness (indirect)
9	Single choice	Did you complete Up Skill Cambodia EHR activities in English or Khmer or both?	External variable
10	Single choice	How would you describe your English level?	External variable
11	Likert-scale	How important is it to you to have a learning system, courses, and information in the Khmer language instead of another language, such as Chinese, English, or French?	External variable
12	Dichotomous	Do you know how to use artificial intelligence (AI) translation tools for translating English to Khmer or Khmer to English?	External variable
13	Multiple response	If you answered “yes” to using AI, then what tools have you used in school for translation? (select all that apply)	External variable
14	Single choice	What type of nursing program are you enrolled in right now?	Sample description
15	Dichotomous	Does your school have a Learning Management System (LMS)?	External variable
16	Dichotomous	Has Up Skill Cambodia helped you prepare for the workplace and given you basic skills and confidence to use an EHR system?	Perceived usefulness (direct)
17	Dichotomous	Would you recommend the Up Skill Cambodia platform to other nursing students?	Intention to use (proxy)

Note. Students were given the option to complete the survey in English or Khmer. Items 7, 8 and 11 used five-point importance scales from 1 (not important) to 5 (extremely important), on which 3 = important and 4 = very important; on item 11, point 2 was labelled “neutral” rather than “a little important” (Additional file 1). Item 6 was scored from 1 (had to finish outside the lab every

time) to 5 (plenty of time, with time to spare). The TAM construct column shows how items were grouped for reporting (see Design).

Table 3

Response Descriptors for the Pre-Survey and Post-Survey EHR Items

Score and label	Pre-survey item 2: "How well do you understand electronic health records (EHR)?"	Post-survey item 1: "How well do you understand electronic health records (EHR) after completing the Up Skill Cambodia EHR courses?"
5 – Very good	I am proficient in EHR and have used them in a job before.	I feel prepared with the skills necessary to start using an EHR.
4 – Good	I have personally witnessed the use of an EHR in a clinic or hospital setting as a healthcare worker.	I have a good understanding of EHR.
3 – Neutral	I have personally witnessed the use of an EHR in a clinic or hospital setting as a patient, or as a family member or friend accompanying a patient.	I have a very basic understanding of EHR.
2 – Not very good	I have only heard about EHRs but have never seen them used.	I have gained some knowledge but need more instruction about EHR.
1 – Not good at all	I have never heard of EHRs before now.	I do not feel prepared to use EHR.

Note. Both items used the same five labels, but the descriptors displayed with each label differed. The pre-survey descriptors describe prior exposure to EHRs; the post-survey descriptors describe understanding and readiness after the course. The two items were therefore not treated as repeated measures. Full instruments are provided in Additional file 1.

An item on English language proficiency (ELP; Question 10) was included in the post-survey [18]. To ensure linguistic accuracy, the instruments underwent forward–backward translation [33]. The instruments were translated from English into Khmer and back-translated into English

to check equivalence by two bilingual Cambodian nurse educators on the study team (ME and CU), who also taught the course. Translation was deliberately led by Cambodian educators, not by the non-Cambodian members of the team, so that the wording would be culturally and linguistically appropriate for Cambodian students. The two translators, both academic nursing lecturers and registered nurses, then reviewed the Khmer and back-translated versions together and resolved any differences; no independent bilingual reviewers were involved. Google Translate was used as an initial aid, and all translations were reviewed and finalised by the bilingual educators.

Sampling and Recruitment

This study targeted first-year associate nursing program students from three institutions in Cambodia: the Technical School for Medical Care (TSMC) of the University of Health Sciences, the University of Puthisastra (UP), and the Kampot Regional Training Center (RTC). These institutions were purposively selected to represent a diverse range of educational environments, including a private university (UP), a public university (TSMC), and a governmental regional training center (Kampot RTC). Two of the nursing schools are in the urban capital of Phnom Penh. Kampot is a more rural area. The research nursing team made the selection to provide a broader perspective on the integration of a simulated electronic health record (EHR) training across different institutional settings.

Institutions were selected purposively, and all students enrolled in the nursing informatics course at each institution were invited to participate (a census of eligible students), in alignment with the Cambodia National Curriculum for Associate Degree in Nursing (ADN), as governed by the Human Resources Development Department, Ministry of Health (MoH) of Cambodia [34]. The

ADN programs were selected because the MoH formally released the Nursing Informatics ADN curriculum guidelines, explicitly including the EHR learning objectives. The MoH had not yet released the BSN Nursing Informatics guidelines at the time of this study.

Sample Size

The total sample comprised 584 nursing students for the pre-Up Skill Cambodia surveys and 291 nursing students for the post-Up Skill Cambodia surveys. Kampot RTC students were unable to complete the post-training surveys due to limited computer lab access; together with non-response at the other two sites, this resulted in 291 students for post-intervention assessment. Thirty additional pre-survey responses from two institutions outside the study were excluded from all analyses; these institutions were not study sites and had no Memorandum of Understanding with Khalibre for this evaluation.

Consent and Data Management

Participation in the surveys was voluntary and anonymous. Students were told that the surveys were optional and that clicking the survey link and completing the survey would be taken as consent to the use of their responses for research and publication; consent was therefore implied by participation. Although students logged in to the Up Skill Cambodia platform with an email address to access the course modules, survey responses were recorded by Khalibre with the student's institution but without the student's identity or IP address. Course instructors and the participating institutions had no access to information on which students had or had not completed the surveys. The survey data provided to the research team contained no names, email addresses, account identifiers or IP addresses; each response carried only the institution, survey

language and, for the pre-survey, class group. The data was securely stored on Khalibre's cloud server in compliance with ethical and industry standards.

Population and Sample

The population comprised first-year ADN students, all aged 18 years or older, enrolled in a nursing informatics course at TSMC, UP, and Kampot RTC.

Inclusion and/or Exclusion Criteria

Inclusion criteria required participants to be actively enrolled in a nursing informatics course within the ADN program in one of the three institutions. The student must attend the course in person as a synchronous course in the designated on-campus computer lab skills laboratory and be present for the faculty-led synchronous instruction. Students enrolled in other nursing programs or not attending the synchronous laboratory sessions were not eligible.

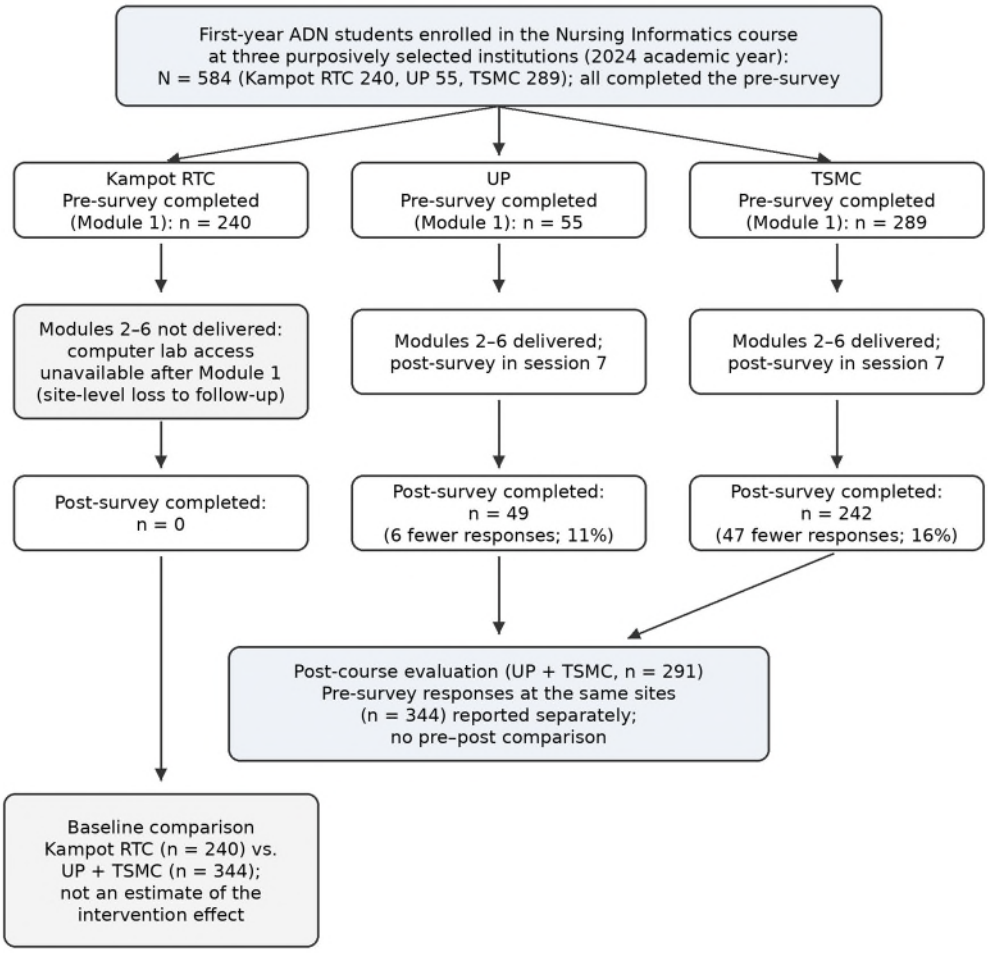
Data Sources/Collection

The data collection was conducted in two phases during the 2024 academic year. The pre-intervention survey was administered before participants began the Up Skill Cambodia EHR courses, implemented by the Cambodian nurse faculty with support from Khalibre. The pre-intervention survey was administered at the start of Module 1, before the orientation content. After completing six weekly EHR training modules, participants were asked to complete the post-intervention survey during the seventh scheduled session. Before survey access, participants were informed that participation was voluntary and anonymous, that the findings could be published, and that clicking the survey link and completing the survey would be taken as consent; the course instructors also explained verbally, in Khmer and English, that the surveys

were optional and would not affect grades. Surveys were completed during designated computer lab sessions. Course instructors and Khalibre's technical support staff at TSMC also made informal observations during implementation, for example of internet access and device sharing; these were not collected systematically and are reported in the Discussion as context only. Participant flow by institution is shown in Figure 2.

Figure 2

Participant Flow by Institution, from Pre-Survey through Post-Intervention Survey and Analysis



Pre-survey responses from two institutions outside the study sample (n = 30) were excluded from all analyses.

The intervention consisted of six Up Skill Cambodia EHR courses, preceded by a pre-course survey and followed by a post-course survey, with the pre-survey embedded in the EHR Orientation Guide. Three master's-level nurses, two Cambodian (Khmer-speaking) and one American (English-speaking), developed the course content and surveys, with the two Cambodian nurses making the final decisions on survey content. Khalibre's IT team transferred the content to the Up Skill Cambodia platform. All materials were available in both English and Khmer, allowing students to toggle between languages.

The courses were delivered over six weeks between April and September 2024 as part of the required synchronous computer lab skills training within the Nursing Informatics course at each institution. Each 90- to 120-minute session was scheduled collaboratively by Khalibre and nursing faculty. Instruction was provided in both English and Khmer by bilingual nursing faculty, with in-class technical support from Khalibre at TSMC. Each learning course contained evidence-based, scholarly healthcare educational content, simulated case studies within the Cambodian cultural context, and a simulated EHR activity reflecting real-life clinical nurse charting. All nursing informatics faculty were given direct training before the launch of the courses with the students. The course content was developed in both English and Khmer. In addition to aligning with the Ministry of Health Nursing Informatics ADN Course Outline, the curriculum covered six essential modules, bookended by the pre- and post-intervention surveys: (1) EHR Orientation, (2) Patient Registration, (3) Vital Signs Recording, (4) Medication Management, (5) Vaccination and Scheduling, and (6) Evidence-Based Practice in Handwashing. The pre-intervention survey was embedded in the EHR Orientation session and the post-intervention survey was administered in a seventh session. Refer to Table 4 below.

Table 4

EHR Modules, Activities, and Intended Learning Outcomes

Module	Main Activities	Intended Learning Outcome
EHR Orientation	Pre-survey; system navigation demonstration	Understanding EHR basics; navigate digital charting interfaces
Patient registration	Enter simulated patient information	Perform accurate electronic patient registration procedures
Vital signs recording	Record temperature, pulse, respirations, blood pressure	Document vital signs in EHR using standard protocol

Medication management	Chart medication administration	Safely record and manage digital medication documentation
Vaccination and scheduling	Log vaccinations; create digital schedules	Manage immunization and use EHR tracking for appointment tracking
Evidence-based practice (handwashing)	Complete charting for simulated practice	Apply evidence-based action in EHR; document clinical procedures

Note. Students were given the option to complete each module in English or Khmer.

Data Analysis

Data analysis was conducted using IBM SPSS Statistics (version 29.0.2.0 for the original analysis; version 26 for the pre-submission reanalysis). Frequencies for multiple-response items were computed from the compiled survey export.

Descriptive statistics, including frequencies, percentages, medians, and interquartile ranges (IQR), were calculated to summarize the data. Medians and IQRs were reported rather than means and standard deviations because all survey items were ordinal, in accordance with best practice for analyzing Likert-type data [35]. Nonparametric methods were selected on the basis of measurement level: the Likert-scale responses were ordinal rather than continuous, with no assumption of equal intervals between scale values [36]. For multiple-response items, percentages are reported as the proportion of respondents who selected each option; because more than one option could be selected, these percentages sum to more than 100%.

Because surveys were anonymous by design, individual pre- and post-intervention responses could not be linked. In addition, the pre- and post-survey EHR items used different response descriptors (Table 3). For these two independent reasons, no inferential pre–post comparison is reported: pre- and post-survey responses at the retained sites are presented descriptively and separately, with no test statistic connecting them. The Mann–Whitney U test for independent

samples was used to compare baseline (pre-survey) responses between Kampot RTC and the combined UP and TSMC sites [36, 37].

The research proposal submitted to the University of Puthisastra Research Committee specified a t-test comparison of pre- and post-intervention perceptions. This analysis was not carried out, because responses were ordinal, could not be linked between surveys, and, as identified during pre-submission statistical review, the pre- and post-survey EHR items used different response descriptors. The baseline comparison between Kampot RTC and the combined UP and TSMC sites uses the same item at both sites and was added after data collection to document site differences and the potential for bias arising from the loss of Kampot RTC post-intervention data. All tests were two-sided with $\alpha = 0.05$. All 584 pre-survey and 291 post-survey records were complete for the items analysed, so no missing-data procedures were required.

The Hodges-Lehmann estimator was calculated alongside the test to provide a robust, nonparametric estimate of the median shift between groups, reported with a 95% confidence interval. The two-sample Hodges–Lehmann estimate is the median of all pairwise differences between responses in the two groups, and is most readily interpreted when the groups differ mainly in location [38, 39]. Because responses were recorded on a five-point integer scale, all pairwise differences between groups are whole numbers; the Hodges-Lehmann estimate and its confidence limits therefore take integer values, and the confidence interval can have zero width.

Effect sizes are reported as Rosenthal's r, the standardized statistic $r = |Z|/\sqrt{N}$.

The post-course survey was completed only by students from UP and TSMC, as participants from Kampot RTC were unable to access the computer lab after the first course session, when they completed the pre-survey. Post-course results are therefore reported for UP and TSMC only.

Statistical Statement

The original statistical analyses were designed and conducted by Pedro I. B. Souza, an engineer specializing in statistical analysis. Following pre-submission statistical review, and with his agreement, the analyses were re-run and verified by Editage (Cactus Communications) using IBM SPSS Statistics (version 26), and all reported values were independently cross-checked against the raw data. All authors have reviewed the statistical methods reported here and take responsibility for their appropriate application and interpretation.

Reporting Method

The study adhered to the TREND guidelines for reporting non-randomized intervention studies. The completed TREND checklist is provided as Additional file 2.

Use of Artificial Intelligence

Artificial intelligence tools were used during manuscript preparation and revision. ChatGPT (OpenAI) supported drafting and grey literature searching, and SciSpace, Elicit, and Perplexity AI supported literature searching and review, during manuscript preparation; Grammarly, Google Translate, and Student AI supported grammar, language clarity, and translation. Claude (Anthropic) supported formatting, reference management, figure preparation, language editing, and independent re-computation of the reported statistics from the raw data during revision. All AI-assisted content was reviewed, verified against source materials, and approved by the authors, who take full responsibility for the manuscript.

Results

Participant Demographics

All 584 ADN nursing students enrolled in the Nursing Informatics course at the three institutions (Technical School for Medical Care of the University of Health Sciences, University of Puthisastra, and Kampot Regional Training Center) participated in the pre-survey assessment (100% response, based on enrolment figures reported by the course instructors). To respect cultural norms, and upon advice by the Cambodian nurse faculty, no comparisons were made between school or student groups beyond the baseline comparison reported below. Additionally, no demographic identifiers were analyzed or reported. Table 5 below presents the total number of participants in each of the pre- and post-surveys according to the respective institutions.

Table 5

Number of Participants by Institution

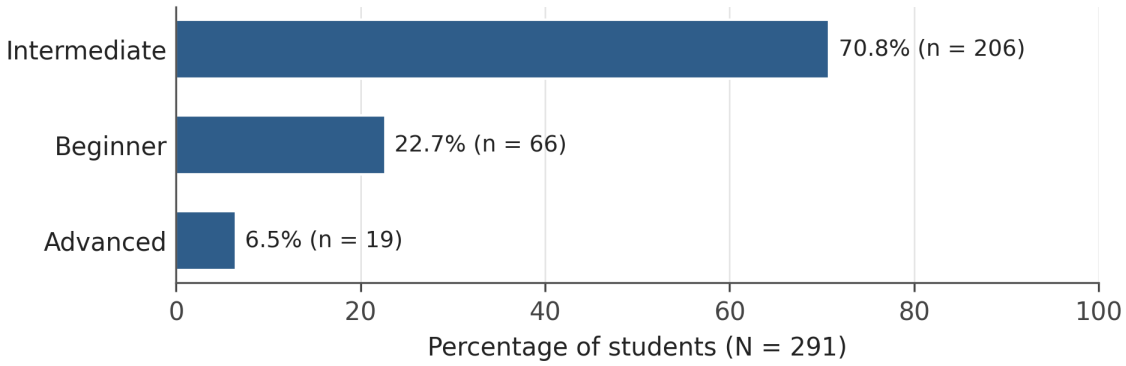
	Kampot	**UP**	**TSMC**	**TOTAL**
Pre-course Survey	240	55	289	584
Post-course Survey	0	49	242	291
Post-course Survey Non-Completion	100%	11%	16%	–

Note. Students at Kampot RTC completed Module 1, which contained the pre-intervention survey. Computer lab access became unavailable thereafter, so Modules 2–6 were not delivered and no post-intervention data were collected; this represents partial intervention exposure and site-level loss to follow-up (site-level attrition) rather than individual students dropping out. Figures for UP and TSMC are the differences between pre- and post-survey response counts; because surveys were anonymous, individual non-response could not be tracked.

All post-survey respondents reported being enrolled in an ADN program. Regarding English language proficiency (ELP), 206 of the 291 post-survey respondents (70.8%) self-reported having intermediate English skills, 66 (22.7%) reported being beginners, and 19 (6.5%) reported being advanced English speakers. Refer to Figure 3 below.

Figure 3

Self-Reported English Language Proficiency

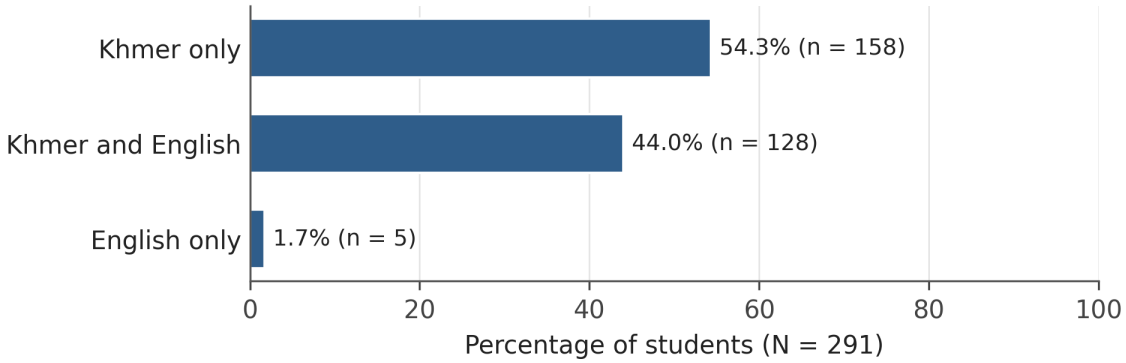


Overview of Up Skill Cambodia Simulated EHR Usage and Baseline Exposure

The findings reported here, unless otherwise stated, should be interpreted with consideration of the aforementioned decrease in post-survey participants, as this may influence the overall representativeness of the results. Students used both language options available on the Up Skill Cambodia platform, with the majority demonstrating a clear preference for the Khmer language interface. The majority (158/291, 54.3%) completed simulated EHR activities exclusively in Khmer, while 128 (44.0%) used a combination of both Khmer and English. Only 5 students (1.7%) used the English language exclusively (see Figure 4 below).

Figure 4

Student-Selected Language Options for Simulated EHR Interaction



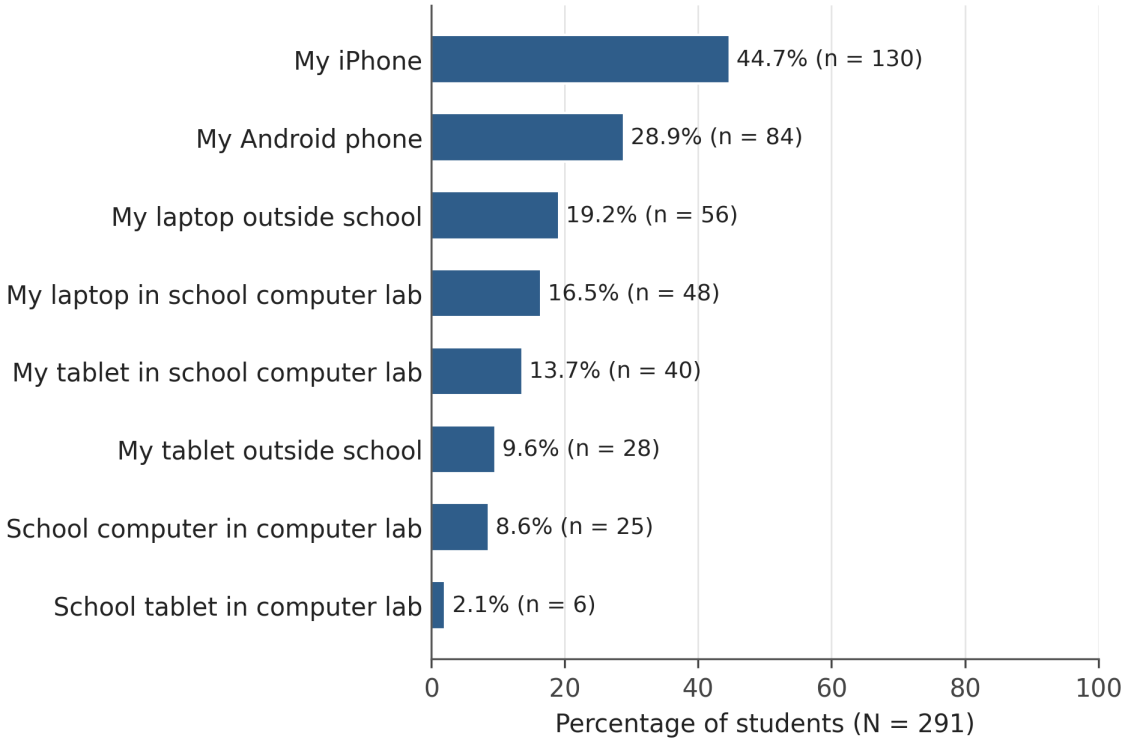
In the pre-survey, students' self-rated comfort with computer technology differed between sites: the median was 4 (IQR 4–4) at UP and TSMC combined (n = 344) and 2 (IQR 2–2) at Kampot RTC (n = 240). Across all three sites, responses to the EHR item had a median of 2 and an IQR of 1 to 4. At the two sites contributing post-intervention data, the corresponding baseline median was 4 (IQR 3–4); the lower pooled figure reflects the substantially lower baseline scores at Kampot RTC. The wide IQRs indicate considerable variability in students' prior exposure. Because each response option described a level of prior exposure, 303 of 584 students (51.9%) had never heard of EHRs or had only heard of them, whereas at UP and TSMC 218 of 344 students (63.4%) selected the options describing having seen an EHR used as a healthcare worker or having used one in a job.

The analysis of technology devices used by nursing students to complete the Up Skill Cambodia simulated EHR activities revealed a predominance of personal devices. Most students (210/291, 72.2%) used a smartphone for at least part of the activities: 130 (44.7%) used an iPhone and 84 (28.9%) an Android phone. Personal laptops were used outside school by 56 students (19.2%) and in the school computer lab by 48 (16.5%), and personal tablets were used in the computer lab by 40 (13.7%) and outside school by 28 (9.6%). Only 28 students (9.6%) reported using a

school-owned computer (25, 8.6%) or tablet (6, 2.1%). A comprehensive breakdown of the types of devices utilized by students to complete the EHR activities is presented in Figure 5 below.

Figure 5

Types of Devices Used by Students for EHR Activities



Note. Percentages are of the 291 post-survey respondents; students could select more than one option, so percentages sum to more than 100%. "My" denotes a student's own device; "school" denotes a device owned by the institution.

Perceived Ease of Use (PEU)

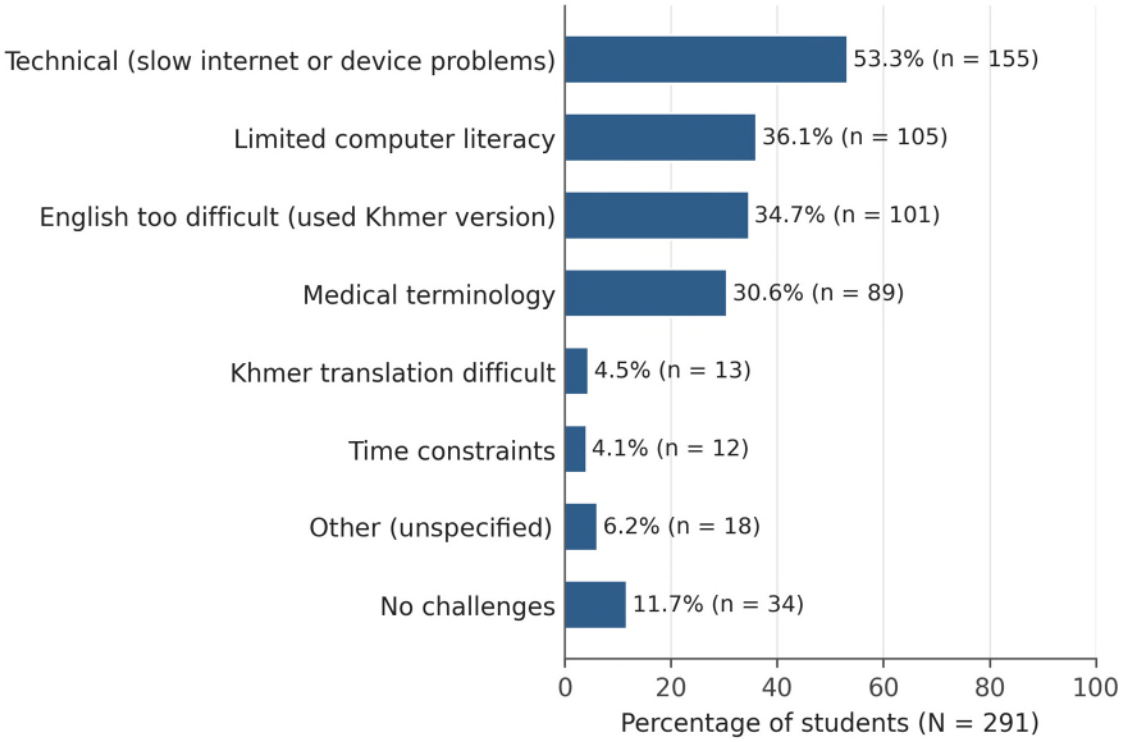
Students rated the Up Skill Cambodia platform registration process as easy to navigate, with a median of 4 and an interquartile range (IQR) of 4 to 5, indicating a user-friendly onboarding

experience. The time allotted for EHR activities during the lab practicums was considered adequate, with a median of 4 and an IQR of 3 to 5. The overall difficulty level of the courses was rated as moderate, reflected by a median of 3 and an IQR of 3 to 4.

Students also reported various implementation challenges when using the Up Skill Cambodia platform, as demonstrated in Figure 6 below. Students were allowed to select multiple responses addressing challenges. Technical difficulties were the most prevalent issue, reported by 155 of 291 students (53.3%) and described in the survey as slow or unreliable internet connections or problems with the student's device; the survey did not distinguish between the two. Additionally, 105 students (36.1%) reported limited computer literacy as a barrier, indicating that many students lacked sufficient experience with computer systems. Computer literacy was defined as "experience using computers." Language-related challenges were also significant, with 101 students (34.7%) finding the English version too difficult and opting for the Khmer version. Comprehension of medical terminology was problematic for 89 students (30.6%). Medical terminology was explained in the survey as "I struggle to understand medical words." Smaller numbers reported difficulty understanding the Khmer translation (13, 4.5%), time constraints (12, 4.1%), or other unspecified issues (18, 6.2%), and 34 students (11.7%) reported no challenges when utilizing the Up Skill Cambodia platform.

Figure 6

Challenges Faced by Students when Utilizing Simulated EHR



Note. Percentages are of the 291 post-survey respondents; students could select more than one option, so percentages sum to more than 100%. Six students who selected “no challenges” also selected at least one challenge; responses are reported as recorded.

Perceived Usefulness (PU)

As indirect indicators of perceived usefulness, students strongly recognized the importance of EHRs in clinical settings, with a median of 4 and an interquartile range (IQR) of 4 to 5, reflecting their understanding of the relevance of digital health records in modern healthcare delivery. Similarly, they acknowledge the value of including EHR training in the nursing curriculum, with a median of 4 and an IQR of 3 to 5. Students also rated as high the importance of having learning systems, courses and information in Khmer (median 4, IQR 3 to 4); this item was treated as an external variable rather than as an indicator of perceived usefulness (Table 2). The Up Skill

Cambodia platform was overwhelmingly perceived as beneficial for workplace preparation, with 98.6% (287/291) of students reporting that the platform had helped prepare them for the workplace and given them basic skills and confidence to use an EHR.

Students' high regard for the platform was also reflected in a very high recommendation rate, with 96.6% (281/291) of students indicating they would recommend the Up Skill Cambodia platform to other nursing students. These ratings were reported by students under conditions of a highly supported environment during the Up Skill Cambodia training in the computer lab, where bilingual Cambodian nursing faculty taught the practicum in Khmer and English, with technical support from Khalibre at TSMC.

Intention to Use

As mentioned in the methodology section previously, this study was guided by the Technology Acceptance Model (TAM) [24]. The relationships between TAM constructs are illustrated in a path diagram in Figure 1 previously listed, showing how perceived ease of use and perceived usefulness influence intention to use, ultimately leading to actual system use [24, 25]. Intention to use was not measured with a dedicated scale; the closest indicator available in this study is students' willingness to recommend the platform (281/291, 96.6%).

Self-Perceived EHR Understanding Before and After the Course (Descriptive)

Because the pre- and post-survey EHR items used different response descriptors (Table 3), responses from the two administrations are reported separately and are not compared statistically. After the course, 203 of 291 students (69.8%) at UP and TSMC rated their

understanding of EHRs as good (134, 46.0%) or very good (69, 23.7%), that is, as having a good understanding of EHRs or feeling prepared to start using one; 70 (24.1%) reported a very basic understanding, and 18 (6.2%) reported needing more instruction or not feeling prepared (median 4, IQR 3–4). At the pre-survey, 218 of 344 students (63.4%) at the same two sites selected the options describing having seen an EHR used as a healthcare worker (171, 49.7%) or having used one in a job (47, 13.7%), whereas 74 (21.5%) had only heard of EHRs or had never heard of them (median 4, IQR 3–4). The two distributions are shown in Table 6.

Table 6

EHR Item Responses at UP and TSMC: Pre- and Post-Survey, Reported Separately

Score and label	Pre-survey (N = 344): prior exposure, n (%)	Post-survey (N = 291): understanding and readiness, n (%)
5 – Very good	47 (13.7)	69 (23.7)
4 – Good	171 (49.7)	134 (46.0)
3 – Neutral	52 (15.1)	70 (24.1)
2 – Not very good	65 (18.9)	17 (5.8)
1 – Not good at all	9 (2.6)	1 (0.3)
Median (IQR)	4 (3–4)	4 (3–4)

Note. The pre- and post-survey items shared the same labels but used different descriptors (Table 3), so the two columns describe different constructs and are not compared statistically. Percentages may not sum to 100 because of rounding.

Baseline Site Differences and Potential Attrition Bias

Kampot RTC contributed 240 pre-intervention responses and no post-intervention responses. Because post-course data came only from UP and TSMC, differences between Kampot RTC and the two retained sites at baseline indicate how the loss of Kampot RTC data may limit the representativeness of the post-course findings.

Baseline responses differed between the regional training center and the two Phnom Penh institutions: Kampot RTC students reported a median of 1 (IQR 1–1; n = 240), and 213 of the 240 (88.8%) selected the lowest response option ("I have never heard of electronic health records"), compared with a median of 4 (IQR 3–4; n = 344) at UP and TSMC combined (U = 3,275, Z = −19.80, p < .001, r = 0.82; Hodges–Lehmann estimate 3 points, 95% CI 3 to 3; Table 7). This difference is interpreted in relation to digital infrastructure in the Discussion.

Table 7

Baseline Prior Exposure to EHRs: Kampot RTC vs. UP and TSMC (Pre-Survey Only)

	N	Median	IQR	Mean Rank	Mann-Whitney U	Z score	p-value	Effect size (r)
Kampot RTC	240	1	1–1	134.15	3,275	−19.80	< .001	0.82
UP + TSMC	344	4	3–4	402.98	–	–	–	–

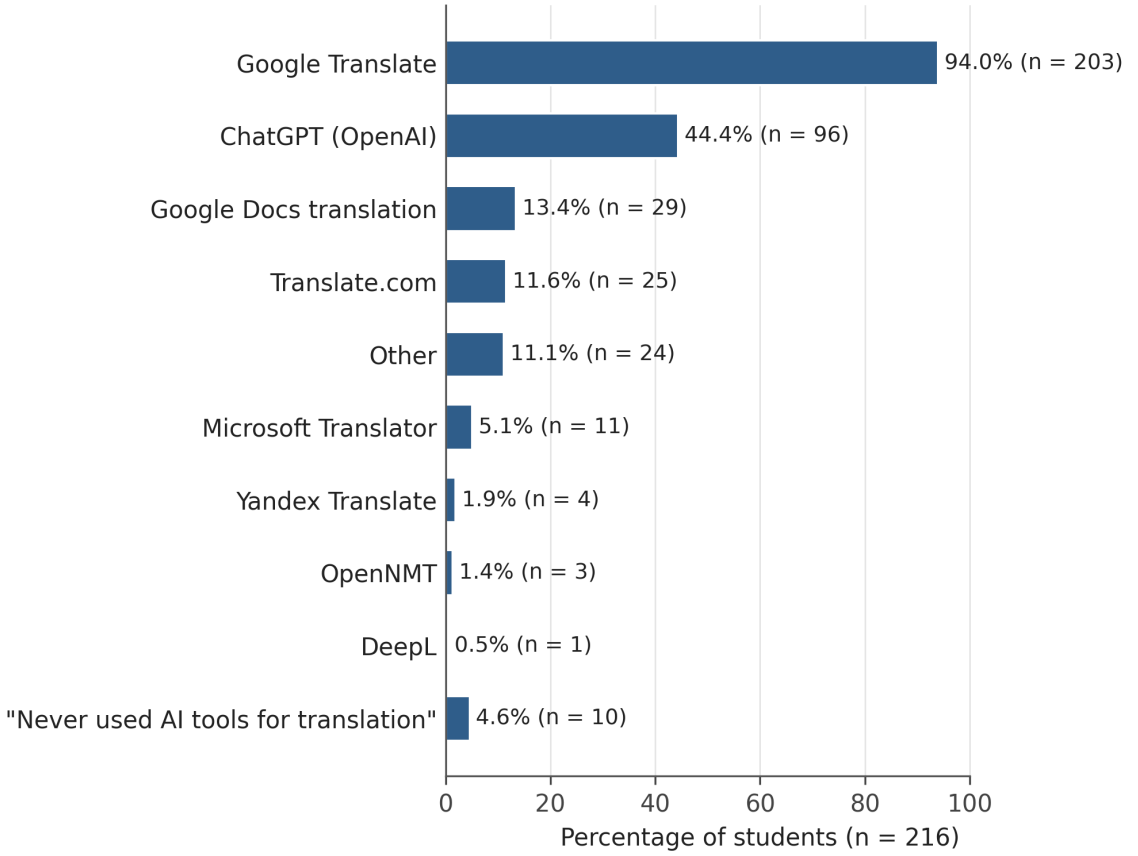
Note. Pre-survey (baseline) responses only. This comparison documents differences between sites before the intervention and is not an estimate of the intervention effect. Hodges–Lehmann estimate of the shift (UP + TSMC minus Kampot RTC) = 3 (95% CI 3 to 3). Mean rank is the average rank of each group's responses when all responses are ranked together. The effect size is Rosenthal's $r = |Z|/\sqrt{N}$.

External Variables

Most students (234/291, 80.4%) reported that their school had a learning management system. Students' familiarity with artificial intelligence (AI) translation tools was also assessed. A substantial majority of students (216/291, 74.2%) reported knowing how to use AI translation tools for translating between English and Khmer. The remaining 75 (25.8%) did not. Among the 216 students who knew how to use these tools, Google Translate (203, 94.0%) and ChatGPT by OpenAI (96, 44.4%) were the most commonly used translation tools; students were allowed to make multiple selections. Figure 7 below illustrates the AI translation tools that nursing students reported being familiar with and selected for use in translation.

Figure 7

AI Translation Tools Commonly Utilized by Cambodian Nursing Students



Note. This question was shown only to the 216 students who reported knowing how to use AI translation tools, and percentages are of those 216 students; students could select more than one option, so percentages sum to more than 100%. Ten of these students selected "never used AI tools for translation," six of whom also selected at least one tool; responses are reported as recorded.

Summary of Statistical Analysis

The formal inferential result of this study is the baseline comparison: Kampot RTC students reported markedly less prior exposure to EHRs than students at UP and TSMC (median 1 vs. 4; $U = 3{,}275$, $Z = -19.80$, $p < .001$, $r = 0.82$; Hodges–Lehmann estimate 3, 95% CI 3 to 3). Post-course responses at UP and TSMC are reported descriptively: 203 of 291 students (69.8%) rated

their understanding of EHRs as good or very good. Because the pre- and post-survey items used different response descriptors and responses could not be linked, no pre–post comparison is reported.

Discussion

This study evaluated a bilingual simulated electronic health record (EHR) platform, Up Skill Cambodia by Khalibre, for nursing students in Cambodia. The educational intervention was guided by the Technology Acceptance Model (TAM) and Krashen's Second Language Acquisition Theory. It was introduced at three institutions and fully delivered at two. The findings add to the limited literature on technology-enhanced nursing education in Southeast Asia and may inform curriculum development for nursing informatics courses.

Key Findings and Interpretations

After the course, most students rated their understanding of EHRs as good or very good (203/291, 69.8%), and almost all reported that the platform had helped prepare them for workplace EHR use (287/291, 98.6%). Because the pre- and post-survey items used different response descriptors, the study cannot establish whether understanding changed during the course. Previous studies have shown that targeted EHR training enhances knowledge and perceived confidence in utilizing EHRs [40]; the present post-course ratings are compatible with this, although this study could not measure change directly. They also align with recent synthesis-level evidence: a 2025 scoping review found that EMR use in simulation-based education consistently improves self-confidence, documentation, and informatics competency [10], domains that overlap with those examined in this study. Notably, recent evidence that nursing students rate their EHR training as inadequate even in high-resource programs [11]

indicates that gaps in EHR training are not confined to low-resource settings. The present findings suggest that a bilingual approach can be delivered in low-resource settings where students have scheduled access to a teaching space with internet access, although technical problems were common even at the two sites where the course was delivered.

Students' pronounced preference for the Khmer and mixed-language options, together with the proportion identifying language as a barrier, is consistent with the bilingual design addressing the language difficulties identified in the team's earlier English-only pilot study [18]. This inference rests on students' language selections and self-reports rather than on a direct comparison between the two platforms, which the present design did not permit.

Technology Usage and Mobile Compatibility

Nearly three-quarters of students (210/291, 72.2%) accessed the training via smartphones, and only 28 (9.6%) reported using a school-owned computer or tablet. This likely reflects both the prevalence of mobile device ownership and the limited availability of institution-provided computers. Using their own phones did not, however, make students independent of the institution: instructors observed that most connected through campus Wi-Fi because personal data plans were unaffordable, so access to a teaching space with a working network remained a precondition for the course, as the loss of laboratory access at Kampot RTC showed. Instructors also informally observed students sharing devices. These findings underscore the importance of developing fully mobile-compatible simulated EHR platforms in low-resource settings, such as Cambodia, where many students rely on their own phones rather than institutional computers. Designing platforms, such as Up Skill Cambodia, for mobile use may support equitable digital health education and aligns with global mobile-first trends in underserved regions [41, 42].

Internet Access

Instructors informally observed that limited Wi-Fi access was a substantial barrier during the implementation of Up Skill Cambodia. While some locations provided free, reliable internet (and one site informally noted external support for expanding Wi-Fi coverage), this was not the case everywhere. At a certain site, a faculty member explained that due to bandwidth limitations, Wi-Fi was reserved for other students taking online exams and was further restricted to academic sites, such as PubMed and Google Scholar. Instructors informally observed that a portion of students relied on personal cellular data, which was frequently slow, limited, or sometimes unavailable. Those without personal data plans had to share devices, which restricted their individual course experience. Although internet access was not formally measured, technical problems (slow or unreliable internet or device problems, which the survey did not distinguish) were the challenge students reported most often (155/291, 53.3%). Unreliable internet and limited digital infrastructure are widely reported barriers to digital health in low- and middle-income settings [43-48]; where students cannot afford personal data plans, institutional internet access is likely to be essential for equitable participation in digital learning. These observations, together with students' reports, underscore the importance of sustainable, campus-wide connectivity to support the integration of education technologies.

Baseline Differences and the Possible Role of Infrastructure

Baseline prior exposure to electronic health records differed between the regional training center and the two Phnom Penh institutions, with students at Kampot RTC reporting lower familiarity before the intervention (88.8% had never heard of EHRs; median 1, IQR 1–1, against median 4, IQR 3–4; r = 0.82; Table 7). One possible explanation is differences in access to digital

infrastructure, including the availability of EHRs in local health facilities: Kampot RTC was also the site where computer laboratory access was lost after the first module. However, infrastructure was not measured at site level, and Kampot RTC also differed from the other sites in institution type, location and cohort, so the baseline difference cannot be attributed to any single factor.

If this interpretation is correct, infrastructure may affect digital health education twice over: through what students bring into the classroom and through whether the teaching can take place at all. Regional and rural institutions, which train many of the nurses needed for a geographically distributed workforce, may be the most exposed to both effects, a possibility that studies measuring infrastructure directly across several regional sites could test. Kampot RTC nonetheless contributed 41% (240 of 584) of the baseline sample, illustrating how large a cohort can be excluded from the full course when infrastructure fails at a single regional institution.

Institutional Support: Computer Labs and Synchronous Learning

The availability of computer labs and structured synchronous learning sessions also appeared to be important factors for student access during the implementation phase. These were informal observations by instructors and were not part of the formal scope of this research. Instructors noted that some students without access to institutional computers shared personal laptops, tablets or smartphones, which limited individual hands-on practice with the simulated EHR, and that students frequently sought their guidance during the courses, particularly in Khmer. Studies of EHR adoption in resource-constrained settings consistently identify infrastructure, training and technical support as critical success factors [47-50]; in education, computer labs and synchronous, in-person sessions may play an equivalent role.

Language Preference and AI Translation Tools

A total of 93.5% of participants (272/291) identified as having beginner or intermediate English proficiency, with 6.5% reporting advanced proficiency and 1.7% choosing the English-only version of Up Skill Cambodia. Most students (286/291, 98.3%) selected Khmer or a combination of Khmer and English. This result is consistent with TAM's emphasis on perceived ease of use and Krashen's theory of comprehensible input [24, 26, 27]. Students are more likely to engage with and benefit from educational resources when the language is accessible and understandable [51-53]. Although 74.2% of students reported knowing how to use AI translation tools, the remaining 25.8% did not. Given how widely students already use these tools, future nursing informatics courses could include guidance on their appropriate use, including their limitations with clinical terminology and the need to protect patient information [52, 54, 55], as English is commonly used in hospitals, clinics, non-governmental organizations, healthcare institutions, and training schools [17, 18].

Perceived Workplace Preparation

Up Skill Cambodia simulated EHR platform was overwhelmingly perceived as beneficial for workplace preparation, with 98.6% (287/291) of nursing students reporting that the platform helped prepare them for the workplace and gave them basic skills and confidence to use an EHR system. These results are consistent with the team's earlier finding that Cambodian nursing students valued simulated EHR training [18], although the present design cannot show that the bilingual format caused these ratings.

Recommendations

1. Guidance on AI Translation Tools. Because most students already use AI translation tools, nursing informatics courses, especially for ELLs, could include guidance on using them

appropriately, such as checking translations of medical terminology and never entering identifiable patient information.

2. AI Literacy in the Curriculum. The Ministry of Health could consider including AI literacy, covering both the uses and the limitations of AI tools, in future revisions of the nursing informatics course outline.

3. Ensure Equitable Access to Technology. Educational institutions should prioritize equitable access to digital infrastructure, including reliable, no-cost internet connectivity and access to digital devices, when implementing technology-dependent coursework.

4. Computer Labs and Synchronous Learning Opportunities. Institutions are encouraged to invest in well-equipped computer labs and to offer synchronous, in-person training sessions for nursing students who lack personal devices and computer literacy skills.

5. Adoption and Expansion of Bilingual Simulated EHR Platforms. Nursing institutions could consider bilingual simulated EHR platforms, ideally alongside evaluations that compare them with existing approaches. This approach may help address challenges related to English proficiency and usability, although medical terminology remained a challenge for nearly one-third of students in this study (89/291, 30.6%).

Strengths and Limitations of the Work

To our knowledge, this is the first published evaluation of a bilingual academic simulated EHR platform for nursing education, addressing a gap in digital health training for English Language Learners (ELLs). The use of instruments subjected to expert content validation and forward–backward translation, the large baseline sample, and the inclusion of urban and regional

institutions of different types enhance the relevance of the findings, including by revealing marked baseline differences between sites. The use of explicit theoretical frameworks further strengthens the study's relevance to digital health education in low-resource, multilingual contexts.

The most important limitation concerns the pre- and post-survey EHR items. Although the pre- and post-survey versions of the EHR item shared the same five response labels, their descriptors differed: the pre-survey descriptors described prior exposure to EHRs (from never having heard of them to having used one in a job), whereas the post-survey descriptors described understanding and readiness after the course. No pre–post comparison is therefore reported; the post-course ratings are interpretable as descriptive findings in their own right. Responses to the baseline item may also reflect how students interpreted its descriptors, which could have differed between sites. For example, 218 of 344 first-year students at UP and TSMC (63.4%) selected options describing having seen an EHR used as a healthcare worker or having used one in a job. Some may have had prior clinical employment, but others may have read the first of these descriptors as having seen an EHR used by a healthcare worker, or responded to the label (Good, Very good) rather than to its descriptor. Responses to this item are therefore best read as approximate indicators of prior exposure. Future evaluations should use identical items and response options at both time points.

Because the surveys were anonymous, pre- and post-intervention responses could not be linked at the individual level, which, together with the non-equivalence of the EHR items, precluded any inferential pre–post analysis. Separately, the post-survey received 11–16% fewer responses than the pre-survey at the two retained sites, and this non-response could shift the post-intervention distribution in either direction.

The main outcome was post-course self-perceived understanding of electronic health records, measured by a single ordinal self-report item. Single-item measures cannot demonstrate internal consistency, and test–retest reliability was not feasible within an anonymous, one-shot design. Self-perceived competence is also distinct from demonstrated competence; no objective assessment of EHR knowledge or performance was administered, and the findings should be read accordingly. Translation, back-translation and review were carried out by two bilingual members of the study team; no independent translators or reviewers were involved, so translation errors or ambiguities may have gone undetected. The workplace-preparation and recommendation items were single yes/no questions, the first combining several ideas, and both were completed in class with instructors present; responses to them may overstate students' positive views. Participation in the pre-survey was complete (100%); in a classroom setting with instructors present, this may partly reflect classroom norms, although surveys were anonymous, students were told that participation would not affect their grades, and instructors could not see who had participated.

Several factors other than the platform could have influenced students' post-course ratings. Students were concurrently enrolled in a nursing informatics course and progressing through their first year, so maturation and other coursework may have contributed. Students' frame of reference for judging their own competence may have changed once they had encountered an EHR, a response-shift effect that can operate in either direction. Selective non-response, reflected in 11–16% fewer post-survey responses at the retained sites, may also have altered the composition of the post-intervention sample. The design cannot separate these influences from the effect of the platform.

The effect size for the baseline comparison is reported as a point estimate, with a 95% confidence interval for the Hodges–Lehmann estimate. Interval estimates for the rank-based effect size were not computed, which we note as a reporting limitation.

A key limitation of this study is the incomplete delivery of the intervention at one site. The decrease in participation between surveys was attributable mainly to infrastructural constraints at Kampot RTC, where students were unable to access the computer lab necessary for completing Modules 2–6 and the post-intervention survey. This represented a systemic access barrier beyond the control of the research team or participants, not a reflection of student disengagement or study design inadequacy. Despite multiple attempts to resolve this issue, computer lab access remained unavailable throughout the critical data collection period at Kampot RTC, and Modules 2–6 could not be delivered. The inability to deliver the full intervention and collect post-intervention data at the Kampot RTC site represents a deviation from the original planned protocol. The use of purposive sampling and lack of randomization may introduce confounding variables.

The sample comprised nursing students from three Cambodian institutions, but post-intervention data was only available from two sites. Of the 291 post-course responses, 242 (83.2%) came from TSMC, so the post-course findings largely reflect students at a single institution. A limitation of this study is the absence of age and gender demographics, which follows the ethical decision described in the Methods and prevents any examination of whether responses varied by student characteristics.

The single-group, post-intervention design has limitations, including the presence of confounding variables. The relationship between the intervention (Up Skill Cambodia) and

outcomes (students' self-reported understanding and ratings) could lead to misleading causal conclusions. Fiscal and structural limitations also constrained the number of participating institutions. This study design provided benefits, including cost-effectiveness within the nursing department's limited resources in a lower-middle-income country, practicality, and the capability to describe outcomes within a single group.

A formal sample size calculation was not performed due to resource constraints. The loss of one site between administrations reduced the post-intervention sample from three sites to two. The principal cost of this loss is to the representativeness of the sample and the potential for bias. Given that all survey items were either multiple choice or Likert scale (ordinal) responses, outlier analysis was not applicable. All responses fell within the expected range of the instrument.

Infrastructure limitations of this kind are routinely encountered in research conducted in developing countries and are well documented [47, 56-58]. Despite these limitations, the study provides valuable insights into nursing students' experiences of the Up Skill Cambodia training program in Cambodia, with potential relevance for similar low-resource settings in Southeast Asia.

Recommendations for Future Research

Future research should investigate the long-term impact of bilingual simulated Electronic Health Record (EHR) platforms on nursing students' digital health skills and clinical practice, ideally through longitudinal and multi-site studies. Qualitative research examining student and faculty experiences, along with studies on integrating generative AI and mobile-first strategies, is also necessary to inform scalable and effective digital health education in resource-limited settings.

Conclusions

In this exploratory evaluation, Cambodian nursing students rated the bilingual Up Skill Cambodia simulated EHR platform highly, and almost all reported that it helped prepare them for workplace EHR use, although the design cannot establish that the platform improved their competence. The integration of Khmer and English language options was accompanied by high student ratings, and almost all students said they would recommend the platform to other nursing students. Students' responses and instructors' informal observations point to language accessibility, mobile compatibility, reliable internet, and institutional support through computer labs and synchronous learning as important to implementation.

Despite limitations such as the partial delivery of the intervention at one site and the absence of a control group, the findings may inform educators and policymakers in low-resource settings. The results support further development and evaluation of bilingual, culturally responsive EHR training platforms, alongside attention to digital infrastructure, to advance nursing informatics and digital health equity in Cambodia and similar contexts.

List of Abbreviations

EHR Electronic Health Records

UP University of Puthisastra

TSMC Technical School for Medical Care

RTC Regional Training Center

MoH Ministry of Health

TAM Technology Acceptance Model

ELL English Language Learner

AI Artificial Intelligence

CVI Content Validity Index

I-CVI Item-level Content Validity Index

S-CVI/UA Scale-level Content Validity Index, Universal Agreement

IQR Interquartile Range

TREND Transparent Reporting of Evaluations with Nonrandomized Designs

ADN Associate Degree in Nursing

ASEAN Association of Southeast Asian Nations

BSN Bachelor of Science in Nursing

CI Confidence Interval

ELP English Language Proficiency

EMR Electronic Medical Record

HDI Human Development Index

LMS Learning Management System

MSN Master of Science in Nursing

PEU Perceived Ease of Use

PU Perceived Usefulness

UHS University of Health Sciences

UPRC University of Puthisastra Research Committee

Declarations

Ethics approval and consent to participate

Ethics approval was not obtained before data collection began. The research proposal was submitted to the University of Puthisastra Research Committee (UPRC), the university's institutional research ethics review body, on 14 October 2024 and approved on 3 January 2025 (No. 001UPRC); approval was therefore retrospective. The anonymous surveys were designed by the study team and administered between April and September 2024 as part of a course evaluation agreed under Memoranda of Understanding between Khalibre Co. Ltd. and each participating institution (UP, TSMC and Kampot RTC), which provided for the use and publication of the anonymous findings. TSMC/UHS and Kampot RTC gave institutional approval for their participation through signed Memoranda of Understanding with Khalibre Co. Ltd. The study was conducted in accordance with the principles of the Declaration of Helsinki, except that ethics approval was obtained retrospectively rather than before data collection.

Participation was voluntary and anonymous, and no identifying information was collected. All participants were aged 18 years or older, as required for enrolment in the ADN programs; no minors took part. Students were shown a consent statement explaining that participation was optional and anonymous and that the findings might be published (Additional file 1), and were told that clicking the survey link and completing the survey would be taken as consent to the use of their responses for research; consent was therefore implied by participation. The consent statement also mentioned a possible voluntary focus group; no focus groups were conducted. In addition, the bilingual course instructors explained to students, in Khmer and English, that the surveys were optional and separate from the course and would not affect their grades. Students who chose not to complete the surveys continued with the course modules.

The study used simulated patient data within the EHR environment; all patient records were fictitious and no real patient data were used. Participants received no academic credit, financial compensation or other incentives for completing the surveys, and neither students nor institutions paid any fees.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form.

Clinical trial number

Not applicable.

Availability of data and materials

The datasets used and analysed during the current study are not publicly available because they are owned by Khalibre Co. Ltd. under the institutional Memoranda of Understanding, but are available from the corresponding author on reasonable request and with the permission of Khalibre Co. Ltd.

Competing interests

PIBS was employed by Khalibre Co. Ltd. as implementation manager and Up Skill Cambodia trainer of trainers at the time the study was conducted and is no longer employed by the company. Khalibre Co. Ltd. developed and owns the Up Skill Cambodia platform. Under its Memorandum of Understanding with the University of Puthisastra, Khalibre may use the survey results and resulting publications to promote the platform. TJH, ME and CU co-designed course content for the platform. Under its Memorandum of Understanding with Khalibre, the University

of Puthisastra, the employer of TJH, ME and ST, receives free, perpetual access to the platform in recognition of its contributions to the research, translation, promotion and development of Up Skill Cambodia. CI and VH declare that they have no competing interests.

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Authors' contributions

TJH: Conceptualization, Methodology, Project administration, Writing – original draft, Writing – review & editing, Resources, Supervision, Investigation, Visualization. TJH designed the English version of the curriculum for Up Skill Cambodia, was the primary author, wrote and negotiated all the Memoranda of Understanding, designed the study concept, and provided overall project administration and supervision.

ME: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Resources, Translation, Supervision. ME co-designed the Khmer version of the

curriculum, implemented the course in Khmer at the University of Puthisastra, translated the curriculum, and contributed to writing, reviewing, and editing the manuscript.

CU: Conceptualization, Methodology, Investigation, Writing – review & editing, Resources, Translation, Supervision. CU, a registered nurse, was the nursing informatics instructor at Kampot Regional Training Center, where he delivered Module 1 in Khmer; he co-designed the Khmer version of the curriculum, translated the curriculum, carried out the forward–backward translation of the survey instruments with ME, and contributed to writing, reviewing, and editing the manuscript.

PIBS: Formal analysis, Software, Resources, Writing – original draft, Investigation, Training. PIBS developed and conducted the initial statistical analysis, trained the nursing informatics instructors at all three institutions who delivered the course to students, assisted with data collection, uploaded English content, and oversaw the uploading of the Khmer version onto the platform.

CI: Investigation, Writing – review & editing. CI implemented the course in Khmer at the Technical School for Medical Care and critically reviewed the manuscript.

VH: Supervision, Project administration, Resources, Writing – review & editing. VH, as TSMC supervisor, provided institutional support and oversight for the project at TSMC and critically reviewed the manuscript.

ST: Supervision, Investigation, Writing – review & editing. ST was the overall project supervisor and contributed to manuscript review.

All authors read and approved the final manuscript.

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Additional files

Additional file 1 (.docx). Survey instruments: consent statement, pre-course survey and post-course survey, with all response options (English; Khmer version available from the corresponding author on request).

Additional file 2 (.docx). TREND checklist: completed Transparent Reporting of Evaluations with Nonrandomized Designs checklist, indicating where each item is reported in the manuscript.