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# Technological strategies for teaching peripheral venipuncture procedure skills

# Estratégias tecnológicas para o ensino de habilidades em procedimento de punção venosa periférica

# Estrategias tecnológicas para la enseñanza de habilidades en procedimiento de punción venosa periférica

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## Resumo

Objetivo: Este estudo tem como objetivo propor uma estratégia de ensino remoto para desenvolver habilidades de Punção Venosa Periférica (PVP) com base em metodologias de gamificação e agentes inteligentes conversacionais (Chatbots). Metodologia: A metodologia adotada consistiu em um estudo transversal com abordagem descritiva, empregando métodos qualitativos e quantitativos. Resultados: Foram desenvolvidos quatro módulos de um curso online baseado em metodologias de gamificação com a plataforma Moodle. Esses módulos foram avaliados quanto à satisfação, usabilidade e aprendizado utilizando protocolos padronizados. De acordo com a análise dos resultados do questionário System Usabilidade Scale (SUS), o curso obteve nota 79 em 100 indicando boa usabilidade e bom índice de aceitação, mas também revela que usabilidade precisa ser revista devido a problemas no desenvolvimento de alguns objetos de aprendizagem. Conclusão: A utilização de recursos instrucionais interativos mostrou ser uma abordagem promissora para

promover engajamento, comunicação e habilidades de resolução de problemas dentro do curso.

**Descritores:** Cateterismo Periférico; Educação a Distância; Gamificação

**Abstract**

Objective: This study aims to propose a remote teaching strategy to develop Peripheral Venipuncture skills based on gamification methodologies and intelligent conversational agents (Chatbots). Methodology: The methodology adopted consisted of a cross-sectional study with a descriptive approach, employing qualitative and quantitative methods. Results: Four modules of an online course were developed based on gamification methodologies with the Moodle platform. These modules were evaluated for satisfaction, usability and learning using standardized protocols. According to the analysis of the results of the System Usability Scale (SUS) questionnaire, the course obtained a score of 79 out of 100, indicating good usability and a good acceptance rate, but it also reveals that usability needs to be reviewed due to problems in the development of some learning objects. Conclusion: The use of interactive instructional resources proved to be a promising approach to promoting engagement, communication and problem-solving skills within the course.

**Keywords:** Catheterization, Peripheral; Education, Distance; Gamification

**Resumen**

Objetivo: Este estudio tiene como objetivo proponer una estrategia de enseñanza remota para desarrollar habilidades de Venipunción Periférica basada en metodologías de gamificación y agentes conversacionales inteligentes (Chatbots). Metodología: La metodología adoptada consistió en un estudio transversal con enfoque descriptivo, empleando métodos cualitativos y cuantitativos. Resultados: Se desarrollaron cuatro módulos de un curso online basado en metodologías de gamificación con la plataforma Moodle. Estos módulos fueron evaluados en cuanto a satisfacción, usabilidad y aprendizaje utilizando protocolos estandarizados. Según el análisis de los resultados del

cuestionario System Usability Scale (SUS), el curso obtuvo una puntuación de 79 sobre 100, lo que indica una buena usabilidad y una buena tasa de aceptación, pero también revela que la usabilidad necesita ser revisada debido a problemas. en el desarrollo de algunos objetos de aprendizaje. Conclusión: El uso de recursos educativos interactivos demostró ser un enfoque prometedor para promover la participación, la comunicación y las habilidades de resolución de problemas dentro del curso.
**Descriptores:** Cateterismo Periférico; Educación a Distancia; Gamificación

## Introdução

The emergence of COVID-19 in late 2019, first identified in China, triggered a rapid transformation in education worldwide. To navigate the new reality of social distancing, educational institutions swiftly adapted their teaching methodologies, embracing online learning and remote instruction [1].

The sudden need for remote learning during the pandemic thrust educational technologies into the spotlight. Defined as the integration of tech resources like devices, software, and virtual environments, these tools enhance teaching and learning practices. Their inherent flexibility made them equally at home in traditional classrooms and the virtual spaces necessitated by social distancing. From image editing software to interactive simulations, the possibilities seemed endless [2].

Technology, when used effectively, can be a game-changer in education. It goes beyond just textbooks and lectures, offering a dynamic and personalized learning experience. For example, a student struggling with a math concept. Instead of rote memorization, they can use an interactive app with personalized learning paths and engaging games to grasp the concept at their own pace. This personalized approach caters to individual learning styles and needs, leading to better understanding and retention [3].

In this sense, currently virtual learning environments packed with digital resources and engaging games are taking center stage. These tools, especially gamification techniques, spark students' curiosity and drive participation in the learning process.

More than just absorbing knowledge, these methods foster communication, problem-solving, and skill development, ultimately leading to deeper understanding and better outcomes[4].

Manzano[5] suggests that students exposed to gamified teaching exhibit enhanced motivation, engagement, and academic performance compared to those in traditional teaching settings. This underscores the effectiveness of integrating technology in education, fostering the development of proactive and competent professionals. Utilizing digital resources can infuse dynamism into teaching methods and challenge conventional approaches, as highlighted by Silveira and Cogo[6].

Gone are the days of dry textbooks and rote memorization. As Holanda and Pinheiro[7] point out, embracing technological innovation in healthcare education is key. By infusing pedagogical strategies with interactive tools and resources, we unlock a world of possibilities for deeper understanding, improved skills, and ultimately, better prepared healthcare professionals.

By embracing gamification and the utilization of virtual learning environments, we're not just educating, we're empowering. Students develop essential skills like problem-solving, critical thinking, and adaptability, preparing them for success in a world that demands lifelong learning and proactive engagement. Gamified education doesn't just make learning fun; it cultivates a generation of capable, confident professionals ready to tackle the challenges of the future.

In healthcare, venipuncture is an invasive, complex, and recurrent procedure in the clinical setting, which consists of the insertion of a short intravenous catheter into a peripheral vein, preferably a large caliber, by the puncture method, in order to provide an access route for the administration of fluids, electrolytes, contrasts, medications, among other features [8].

In healthcare, venipuncture stands as a recurring, invasive, and intricate procedure within clinical environments. It involves inserting a short intravenous catheter into a peripheral vein, ideally one with a larger diameter, using a puncture technique. The primary goal is to establish a pathway for the administration of fluids, electrolytes,

medications, contrasts, and other necessary substances[8]. Though seemingly small, venipuncture plays a critical role in patient care. From essential blood tests to timely medication delivery, this delicate procedure enables accurate diagnosis, effective treatment, and ultimately, improved patient outcomes. By prioritizing proper training and meticulous technique, healthcare professionals ensure this routine intervention remains safe, reliable, and a cornerstone of quality healthcare.

The present work aims to analyze the usability of the use of educational technologies based on interactive video and gamification strategies, associated with intelligent conversational agents (Chatbots) in a self-instructional course for teaching Peripheral Venipuncture (PVP) skills.

## Methodology

Prospective cross-sectional descriptive study with a quantitative and qualitative approach.

### Scenario

The scenario used in the study consists of a self-instructional course embedded in a virtual learning environment to be taken by undergraduate nursing and medical students. In the course, students go through a learning trail composed of content through interactive videos and assessment activities in a playful and gamified way to promote student engagement and participation. In addition to the self-instructional course, the virtual learning environment has made available an intelligent conversation virtual assistant (chatbot) that is intended to answer questions that students may have about the course subject.

### Planning Steps

The planning of the course was based on the 5 stages of the Addie instructional design model: Analysis, Design, Development, Implementation, and Evaluation[9]. The analysis step is intended to analyze the target audience and define the objectives of the instruction and the resources that will be needed to develop the course. First, a literature

review was conducted to find the skills gaps caused by the lack of knowledge and skills in teaching peripheral venipuncture and to define the most appropriate peripheral venipuncture protocol to be used as the basis for constructing the content. Then, a quantitative analysis of the socio-demographic and technological profile of the course's target audience was performed using a questionnaire structured by a G suit form.

Based on findings from our literature review, we opted to focus on the peripheral venipuncture procedure as a whole, focusing on its steps from hand cleaning to identification of venous access. As well as by the use of a multimedia approach through animated and interactive videos with gamification strategies embedded throughout the course and the use of evaluative methods of the content were defined based on pre and post-tests, as resources to be used. After the content was developed, it was validated by experts of the area.

The design phase is intended to establish the learning objectives, instructional strategies, and assessment strategies. In this step, we sought to create an environment that could demonstrate the effectiveness of the use of technologies in teaching PVP, through gamification strategies and multimedia tools, such as interactive videos and the use of chatbots, to facilitate the student's study, removing doubts and getting quick answers about the subject. As an evaluative resource, we chose to use multiple-choice tests.

The development step aims to develop the learning resources that will be used in the course. Initially, the course was prototyped within a Virtual Learning Environment based on the Moodle platform, as this is the official environment used in the institution Universidade Federal de Pernambuco (UFPE). The interactive animated videos were developed on the Powtoon platform, a web platform launched in 2012 with the goal of creating presentations and animations accessible to everyone. According to Amaral and Sobota[10], Powtoon contributes to knowledge development, not only during content creation within the platform but also when viewing the content in animated form. The interactivity embedded in the animated videos was implemented using the H5P platform, which is a free and open-source JavaScript-based content collaboration framework. The

acronym H5P is an abbreviation for HTML5 Package and is intended to facilitate the creation, sharing, and reuse of interactive HTML5 content. Throughout the five modules of the self-instructional course, there are tests of prior knowledge, to be taken before viewing the lesson corresponding to the module, and tests of acquired knowledge, to be taken after the lesson. In total, ten tests allowed us to evaluate the student's learning throughout the course.

For the incorporation of gamification aspects, it was decided to use reward tools (badge or trophy), interactivity, and challenges to attract and engage students. The reward element was incorporated through nine badges, five earned at the end of each module and four earned by performing the final challenges.

In the implementation step, the course was advertised and offered to nurse and medical students from different teaching institutions, and they were monitored during the course. Finally, the course evaluation step was carried out. In this step, students' performance regarding learning, satisfaction, self-assessment, and usability was evaluated. The learning evaluation was done through pre and post-tests at each module of the course, totaling 10 multiple-choice tests. In addition, other evaluations were conducted through a separate questionnaire at the end of the course. This included a course satisfaction evaluation, consisting of 8 Likert scale questions, as well as an open-ended question to gather additional feedback. There was also a self-assessment evaluation, which comprised 4 Likert scale questions. Furthermore, a usability evaluation was conducted based on 10 questions using the System Usability Scale (SUS)[11]. Finally, students were invited to provide an overall course evaluation on a numeric scale from 1 to 10.

**Instruments**

In the overall course evaluation, the student had answered the questionnaire and to rate the course from 0 to 10, where 0 was the lowest and 10 was the highest. The satisfaction evaluation was elaborated on a Likert scale, with 5-frequency answers ranging from "almost never" to "almost always". There were 4 affirmative questions

about learning, 4 questions about the relation of the content to professional life, and one discursive question, thus portraying the apprehension and understanding of the content and its applicability in the students' future daily lives. All questions are structured in the form of affirmative sentences.

The usability evaluation was based on the System Usability Scale (SUS) protocol[11] composed of 10 questions where each user would answer on a scale of 1 to 5, the lowest number being equivalent to "strongly disagree" and the highest being equivalent to "strongly agree".

#### Data Analysis

Regarding the analysis of the data collected from the SUS protocol, it produces a single number, which proposes to offer aspects about the effectiveness in achieving the course objective, efficiency of the chosen platform, and user satisfaction with the experience offered. The values are classified into 20.5 (worst imaginable); 21 to 38.5 (bad); 39 to 52.5 (average); 53 to 73.5 (good); 74 to 85.5 (excellent); and 86 to 100 (best imaginable)[12].

#### Ethical aspects

The article in question was submitted to the Ethics Committee of the Center for Medical Sciences of the Federal University of Pernambuco and received approval. With the approval of the Ethics Committee under number CAAE number 23347119.8.0000.5208, the article can proceed to the next stage of the publication process.

## Results

#### Course structure

The online course on venipuncture was elaborated into five distinct modules and guided by the venipuncture protocol of the teaching institution itself (Federal University of Pernambuco - UFPE). This protocol is divided into 4 scenes describing how the

procedure should be performed at each scene. From this, we opted for the elaboration of a course in 5 modules, which would facilitate understanding among the students.

Module 1 of the course addressed the importance and correct form of hand washing. The preparation of the materials used in the puncture is shown in module 2. Modules 3 and 4 due to the number of steps of the venipuncture process covered where we discuss the procedure itself, from choosing the catheter to the disinfection process and its insertion. Finally, Module 5 addresses the process of identifying the inserted peripheral venous access and subsequently recording it in the patient's medical record. This module focuses on identifying the key information that should be documented accurately.

It used interactive audiovisual strategy to broaden the participants' knowledge, promote greater engagement, and try to narrow the cognitive learning path[13]. Therefore, the act of watching the video together with the course module leads the participant to continue the process of memorizing concepts and their interconnection, and therefore, meaningful learning is achieved[14]. The gamification strategy was based on the concept of Game Based Learning (GBL), which aims to use game mechanics to promote student engagement, learning, and problem-solving through a more engaging process[15].

In each module, the student took the following cognitive path: before watching the video lesson, the student took a questionnaire of previous knowledge (pre-test). After the video lesson, the acquired knowledge questionnaire (post-test) was made available to assess the student's level of learning. The questions in the post- and pre-test allowed a more concrete analysis of the data obtained. If the student did not achieve the required score to move on to the next module, he or she was instructed to return to the beginning and watch the videos again. In addition, a challenge was made available which was an extra activity in each module so that the students could discuss a problem situation about the module's theme. This extra activity was not mandatory, but if the student could successfully complete it, they received an extra trophy for participation and socialization.

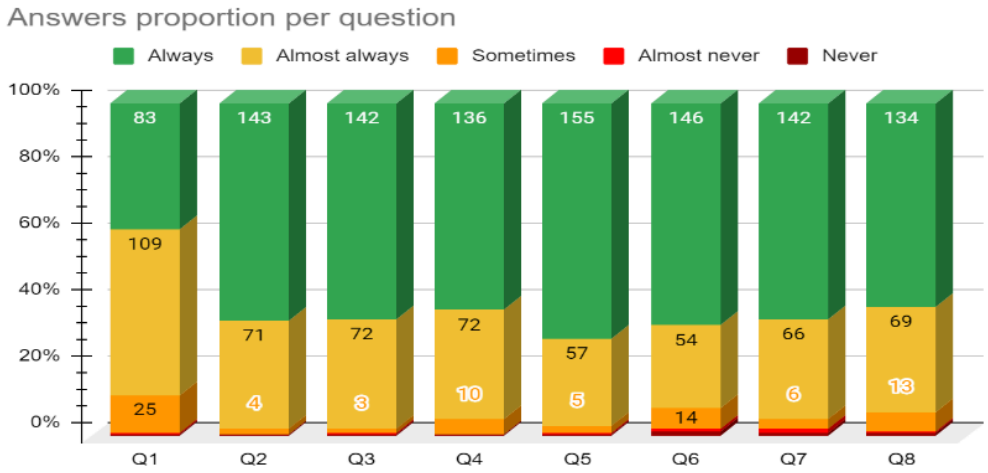
**Overall course evaluation, satisfaction, and self-assessment.**

At the end of the course, a quality evaluation questionnaire was applied, consisting of general evaluation, satisfaction evaluation, and self-assessment. There were 219 responses for the alternative questions and 127 for the discursive question, representing 81.7% and 47.3% respectively of the 268 students who started the course. In the overall evaluation, the student evaluated the course on a grade between 0 and 1.

According to results, the overall evaluation concentrated 93.2% of the answers in grades 8, 9, and 10, with 62.6% (137 answers) consisting only of grade 10, reflecting a good grade for the course. The grades 8 and 9 had close numbers, with 37 (16.9%) and 30 (13.7%) responses respectively. Grades 1 and 4 got no response, while 0, 2, 3, 5, and 6 got 1 (0.4%) response in each, as seen in Figure 4.

In the satisfaction evaluation, the students answered 8 questions on a Likert scale and 1 discursive question about aspects to be improved regarding the course content. The distribution of answers to the Likert scale questions are shown in Figure 1.

**Figure 1 -** Course satisfaction evaluation: Answers proportion per question




According to Figure 1, the evaluation of course satisfaction, in general, is concentrated on "always", with this answer representing more than 50% in all statements except the first one, which deals with the student's interest, in which the option "almost always" appears more frequently, with 109 (49.8%) answers against 83

(37.9%) in "always". As for the proportion between answers, the fifth statement, which deals with the relevance of the course contents, deserves to be highlighted because it presents a higher frequency of "always" among all the statements, with 155 (70.8%) against 57 (26%) of the "always" answer. The answers "never", "almost never", and "sometimes" had responses ranging from 1 to 3, 0 to 3, and 3 to 25, respectively.

The discursive question presented in the course satisfaction survey collected 127 responses, of which 48 were classified as positive, 27 as negative, and 53 as neutral. In addition, 83 students who answered the questionnaire left this question blank.

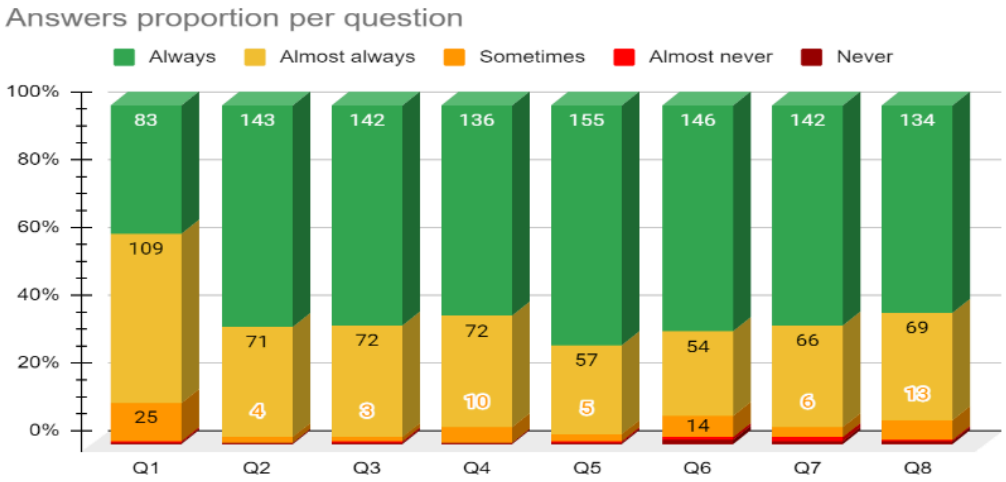
The positive comments brought mostly compliments regarding the didactics, dynamics, and learning provided by the course. The repetition of questions in the pre and post-test activities was addressed as a facilitating point to the fixation of the presented content. Furthermore, the fact that the course was self-instructional and online were also mentioned as positive points.

The suggestions given, in general, concerned video activities and the availability of materials. Longer videos and videos of real situations in the work environment were presented as possibilities for greater use and retention of the content. Many students suggested producing theoretical material in the form of a workbook for study during and after the course.

The criticisms generally dealt with the lack of feedback on answers and the number of attempts at the activities. The lack of feedback was raised as a complicating point in the study and absorption of the content that, together with the limited number of attempts to only one, generated doubts that would not be solved exclusively with the course material. Problems on the platform were also cited concerning server instability and bugs in the video player. Finally, the dubbing of the videos was raised as a hindrance to maintaining attention during the class, as well as being unpleasant, mechanized, and fast.

Finally, the students answered a self-assessment consisting of 4 questions on a Likert scale and the results can be seen in Figure 2.

**Figure 2 -** Self-assessment: answers proportion per question




According to Figure 2, the self-assessment answers, in general, are also concentrated in "always", representing more than 50% of all statements. In the first statement, 120 (54.8%) students answered "always", 85 (38.8%) answered "almost always", 12 (5.5%) "sometimes", and 1 (0.5%) each "almost never" and "never". The second statement had 120 (54.8%) "always", 78 (35.6%) "almost always", 18 (8.2%) "sometimes", 2 (0.9%) "almost never", and 1 (0.5%) "never" answers. In the third statement, 119 (54.3%) students answered "always", 73 (33.3%) answered "almost always", 22 (10%) "sometimes", 4 (1.8%) "almost never", and 1 (0.5%) "never". Finally, the fourth statement got 135 (61.6%) responses in "always", 69 (31.5%) in "almost always", 13 (5.9%) in "sometimes", and 1 (0.5%) in "almost never" and "never".

#### Usability Evaluation

The course, according to the analysis of the results of the System Usability Scale (SUS)[11] questionnaire, scored 79 out of 100, which on the scale corresponds to a B grade, indicating good usability and a good acceptance rate, but also reveals that usability needs to be reviewed due to problems in the development of some learning

objects, the lack of user knowledge in the use of virtual learning environments, and the lack of a good equipment and internet infrastructure.

These needs for usability improvements were also observed by the users, such as the need for "a more efficient video player when loading", or even annoyances with the audio in the classes: "the robotic voice was not pleasant to listen to". Other aspect to be improved upon consisted of the interaction with the platform, where some "errors and bugs during the playback of the interactive videos" were pointed out.

## Discussion

Because it is an environment that requires technique, training, and practice from its operator in order to avoid complications associated with erroneous introduction, the learning of PVP must be constant and recurrent. For Holanda and Pinheiro[7], it is essential to use technologies that aim to facilitate teaching didactics in health practices. Thus, technological innovation applied in pedagogical strategies becomes crucial when it comes to the students' learning process.

Through gamification strategies, we seek to propose a remote teaching methodology with interactive tools that allow the student to learn in a remote and self-instructional way through a virtual environment, and that allows the resumption of the main subjects and the training of all the stages of the procedure.

The course's free and self-instructional nature resulted in a notably low dropout rate, indicating that gamification methodologies were both appealing and effective in capturing students' interest, as evidenced by the significant number of generated badges. Furthermore, the students' grade progression throughout the course demonstrated the instructional resource's ability to facilitate learning. Evaluation of usability and satisfaction revealed that while there were some criticisms regarding the learning environment, the available technological tools generally yielded a high level of user satisfaction.

## Conclusion

In conclusion, the objective of the study was achieved according to the analysis of the results of the System Usability Scale (SUS) questionnaire, which obtained a score of 79 out of 100 indicating good usability and a good acceptance rate, but also reveals that usability needs to be revised due to problems in the development of some learning objects.

The use of interactive instructional resources based on gamification methodology and intelligent conversational agents (chatbots) has proven to be a promising approach to promoting engagement, communication and problem-solving skills within the course. These findings reinforce the intended objectives, demonstrating that educational technologies can effectively complement traditional Peripheral Venipuncture (PVP) teaching methods.

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