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AUGMENTED REALITY MOBILE APPLICATION FOR LEARNING NURSING SURGICAL INSTRUMENTS

AUGMENTED REALITY MOBILE APPLICATION FOR LEARNING SURGICAL INSTRUMENTS FOR NURSES

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Abstract -- The mobile application [1] of augmented reality for learning [2] of nursing surgical instruments [3] is specifically designed to teach adolescents (mainly students) about nursing surgical tools with the aim of assisting in the acquisition and reinforcement of their professional technical competencies.

The application [4] is designed to facilitate end-user interaction through a user-friendly and accessible user interface. The technologies used for the development of the augmented reality mobile application are Vuforia [5], Unity 3D [6,7], Blender [8] and JSON [9] technologies, which seek to combine innovative technology with interactive educational methods to enhance learning in a digital environment.

Keywords: Augmented Reality, Application, Learning, Unity, Vuforia, Surgical Tools.

Abstract -- The augmented reality mobile application for learning about nursing surgical instruments is specifically designed to teach adolescents (mainly students) about nursing surgical tools in order to assist in the acquisition and reinforcement of their professional technical skills.

The application is designed to facilitate the interaction of end users through an easy-to-use and accessible user interface. The technologies used for the development of the augmented reality mobile application are the Vuforia and Unity 3D software, which seek to combine innovative technology with interactive educational methods to improve learning in a digital environment.

Key words - Augmented Reality, App, Learning, Unity, Vuforia, Surgical Tools.

INTRODUCTION

During the Covid-19 pandemic, the teaching and learning process underwent considerable changes, migrating to virtual education; in addition, the technical education institutions, mainly in the health area, suffered losses of material and equipment in the clinical practice laboratories, which meant that when students returned to the new normal, they faced the unknown in their hospital practices and suffered from stress, fear and uncertainty and did not meet the performance required by the health institutions in hospital practices [10].

Technology [11] has revolutionized various fields, and education is no exception. In recent years, augmented reality (AR) [12,13] has emerged as a powerful tool to enhance traditional teaching methods, offering interactive and visually engaging experiences that facilitate learning and information retention. In nursing and medicine, AR has the potential to transform the way students and professionals acquire and apply complex knowledge [14].

This initiative arises from the need to find innovative educational methods that capture the interest of young people and motivate them to explore and understand essential topics in the field of health.

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The application, called "Augmented Reality Mobile Application for Learning Nursing Surgical Instruments", is designed to provide an interactive and immersive learning experience. It consists of three main modules:

1. AR Viewer: This module allows users to view three-dimensional models of surgical tools in an augmented reality environment, using their device's camera. Physical markers trigger the visualization of these models, offering a practical and visual experience.

2. Learning Quiz: To evaluate and reinforce acquired knowledge, this module includes a quiz with multiple-choice questions. Users receive immediate feedback, which facilitates effective and continuous learning.

3. General Surgical Information: This module provides explanatory texts and links to videos related to surgical tools and procedures, offering a solid theoretical background and additional resources to further explore the topic.

Since it is a customized mobile application [15], we started with the planning and went through the development of the application until its implementation, thus allowing it to be scalable, giving the opportunity to integrate new functionalities.

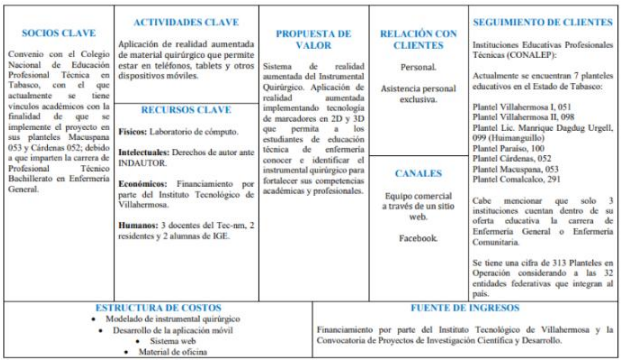
DEVELOPMENT

For the development of the application, the Unified Development Process (UDP) methodology [16] was implemented, which together with the Unified Modeling Language (UML) [17], is the most widely used standard methodology for the analysis, design, implementation and documentation of object-oriented systems. It should be noted that in each of the four phases of the RUP methodology, various software engineering disciplines are used.

Phase 1 - Initiation.

This phase focused on the development of the business model of the augmented reality mobile application, this model used the Canvas model canvas [18], interviews, surveys and observation were also conducted to obtain requirements, books and nursing manuals containing information on surgical instruments were used [19,20], as well as requirements were obtained in meetings with teachers, students and nursing staff of the Colegio Nacional de Educación Profesional Técnica Tabasco.

Figure 1. Canvas Model



Source. Own creation.

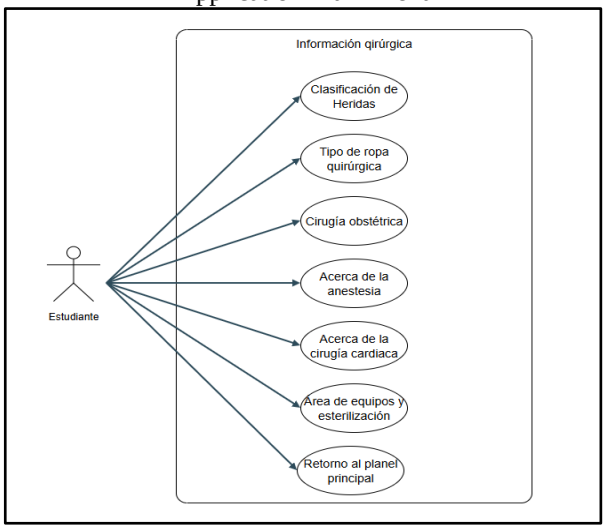
Phase 2 - Elaboration.

In this phase, the analysis and design of the mobile application was developed. Subsequently, the Unified Modeling Language (UML) diagrams were developed.

The interface design of the augmented reality application was carried out according to the Material Design design standards for devices with the Android operating system [21] and Apple's guidelines for designing Apps for the IOS operating system.

Similarly, Vuforia [5] was used because it allows Unity [6,7] developers to create engaging augmented reality experiences, deploy the augmented reality mobile app on a wide range of portable devices and operating systems such as iOS, Android, as well as overlay digital content on top of physical 3d objects.

Figure 2. Use Case: Augmented Reality Mobile Application Main Menu



Source. Own creation.

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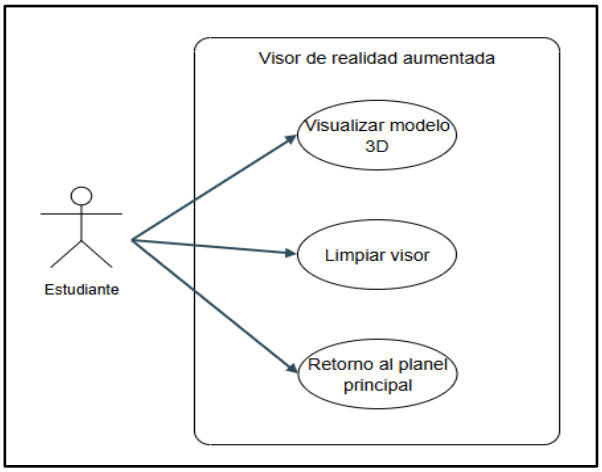
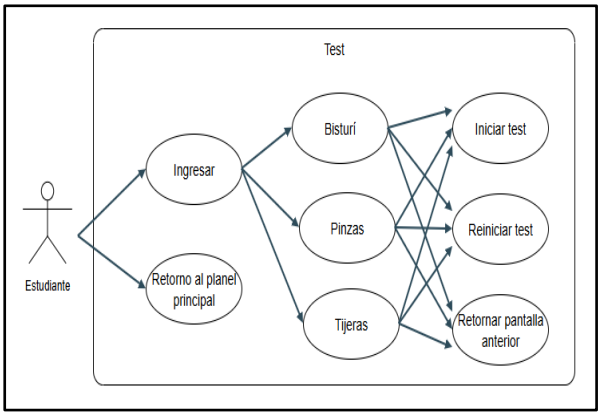
Figure 3. Use case: surgical information from the Augmented Reality mobile application.



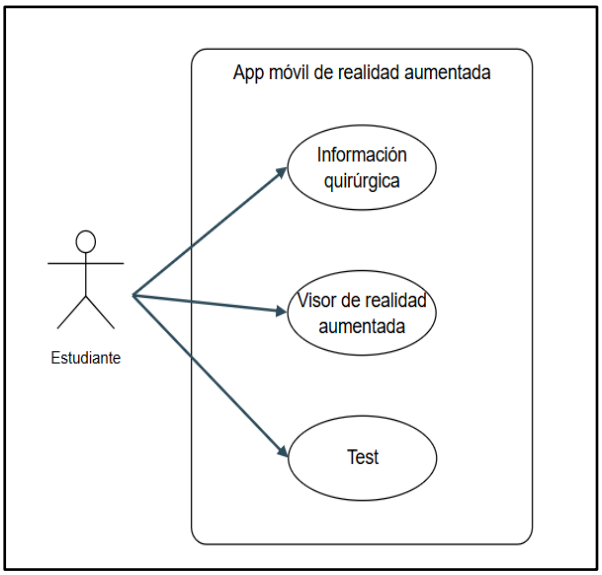
Source. Own creation.

Figure 4. Use case: augmented reality viewer



Source. Own creation.

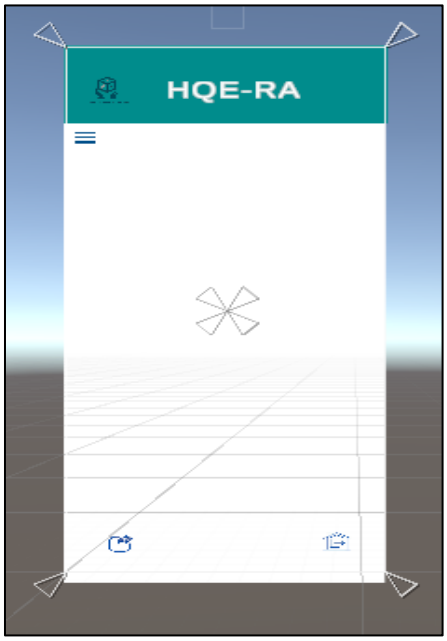
Figure 5. Use case: test



Source. Own creation.

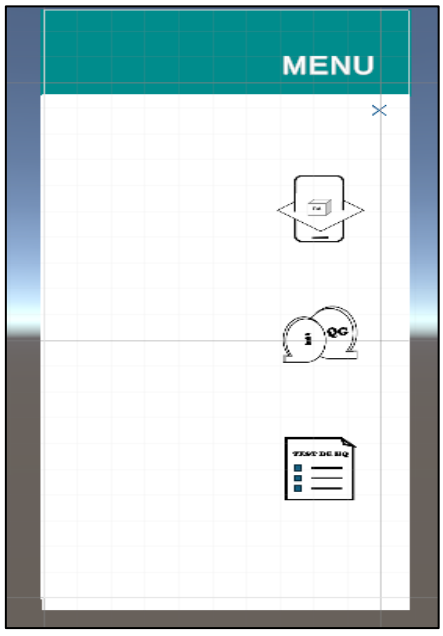
The application incorporates the creation and arrangement of the following elements within the sliding panel: a button to access the Augmented Reality (AR) viewer, a header text, a button to close the sliding panel, a button leading to the general surgical information panel, and another button leading to the questions panel. This main menu includes buttons that allow access to the different panels of the application, facilitating navigation between the different sections.

Figure 6. Main screen



Source. Own creation.

Figure 7. AR mobile app menu



Source. Own creation.

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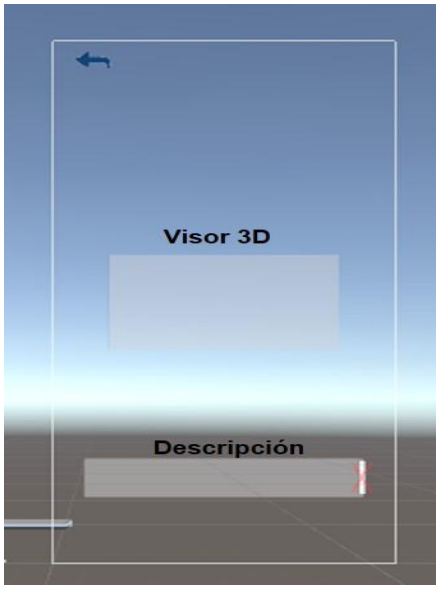
This is the main panel of General Surgical Information, it contains buttons that allow access to the different panels of the application. It contains the following elements: the header text, panel buttons, wound classification, type of surgical clothing, obstetric surgery, anesthesia, about cardiac surgery, equipment and sterilization and a return button to the main panel.

Figure 8. General surgical information screen

Source. Own creation.

The AR panel contains back button elements, a scroll view for the tool description text, and buttons to reset when the 3D model has been displayed.

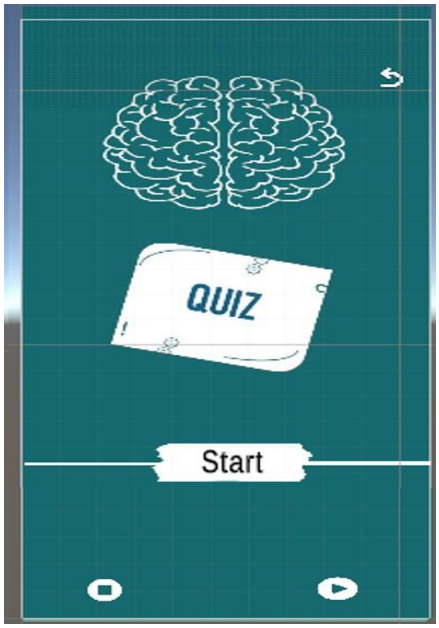
Figure 9. AR viewer screen



Source. Own creation.

This is the interface of the quiz panel, it contains elements such as: a picture of a Brain, a Start button that shows you the quiz panel, a timer, a button that restarts the quiz and the return button.

Figure 10. Test screen



Source. Own creation.

Phase 3 - Construction.

In this phase of the methodology, the 3D content was created using Blender [8], the development of the augmented reality mobile application code was performed using Unity [6,7] and Vuforia [5], and various third-party technological services were incorporated, such as YouTube, Camera and HTTPS Security.

Through the 3D models, real-world shapes and appearances of nursing surgical instruments [19,20] were simulated and captured and represented in digital format.

Figure 11. Dean scissor modeling

Source. Own creation.

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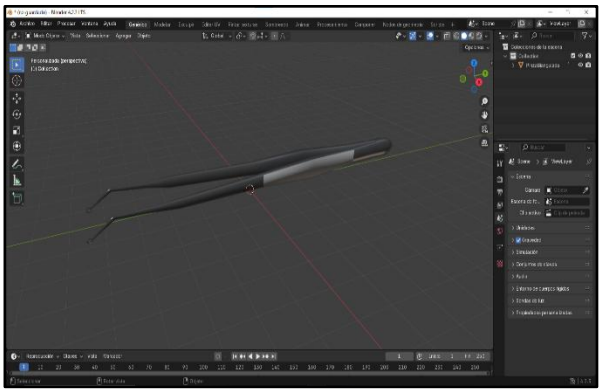
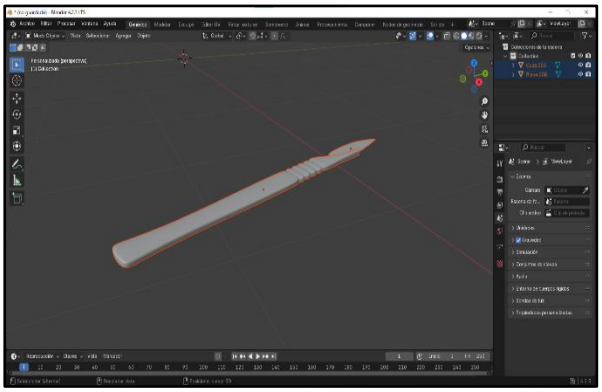
Figure 12. Modeling of cotton clamps



Source. Own creation.

Figure 13. Scalpel modeling



Source. Own creation.

The C# programming language [22] was used to implement the business logic of the application. C# is the native language of Unity [23] and offers a robust syntax and functionalities suitable for the development of interactive applications; these are installed from Unity [6,7].

The ButtonsManager controls navigation between screens including the Slider Panel, exiting the application and application sharing.

Figure 14. ButtonsManager code

```
using System.Collections;
using UnityEngine;

public class ButtonsManager : MonoBehaviour
{
    private string shareMessage = "¡Mira esta aplicación! Descárgala en el siguiente enlace: https://www.enlace-a-mi-aplicacion.com";
    public GameObject slidingPanel;
    public GameObject mainMenuPanel;
    public GameObject arViewerPanel;
    public GameObject infoPanel;
    public GameObject quizPanel;
    public float slideDuration = 0.5f;
    private bool isPanelVisible = false;
    private bool isSliding = false;

    public ARPanelController arPanelController;

    private void Start()
    {
        slidingPanel.SetActive(false);
        // Ajusta la posición inicial del panel deslizante para que se oculte completamente a la izquierda
        RectTransform slidingPanelRect = slidingPanel.GetComponent<RectTransform>();
        slidingPanelRect.anchoredPosition = new Vector2(-slidingPanelRect.rect.width, slidingPanelRect.anchoredPosition.y);
    }
```

Source. Own creation.

Figure 15. CameraManager code

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
using Vuforia;

public class CamaraManager : MonoBehaviour
{
    public VuforiaBehaviour vuforiaBehaviour;  // Referencia al componente VuforiaBehaviour
    public Button onButton;  // Botón de UI para encender la cámara
    public Button offButton;  // Botón de UI para apagar la cámara
    private bool isCameraActive = true;  // Estado inicial de la cámara AR

    void Start()
    {
        OffCamera();
        // Vincular los botones a los métodos correspondientes
        if (onButton != null)
        {
            onButton.onClick.AddListener(OnCamera);
        }
        if (offButton != null)
        {
            offButton.onClick.AddListener(OffCamera);
        }
    }
```

Source. Own creation.

The InfoPanel manages the navigation between the general surgical information panels: infoPanel, obstetrical surgery, etc. Return to the main "Menu" panel and return to the general surgical information panel.

Figure 16. InfoPanel Code

```
using UnityEngine;

public class InfoPanelManager : MonoBehaviour
{
    public GameObject mainMenuPanel;
    public GameObject infoPanel;
    public GameObject clasificacionHeridasPanel;
    public GameObject ropaQuirurgicaPanel;
    public GameObject cirugiaObstetricaPanel;
    public GameObject anestesiaPanel;
    public GameObject cirugiaCardiacaPanel;
    public GameObject equiposEsterilizacionPanel;

    // Funciones para mostrar los paneles
    public void ShowClasificacionHeridasPanel()
    {
        HideAllPanels();
        clasificacionHeridasPanel.SetActive(true);
    }

    public void ShowRopaQuirurgicaPanel()
    {
        HideAllPanels();
        ropaQuirurgicaPanel.SetActive(true);
    }
```

Source. Own creation.

The following script allows to display data in the application interface, the data was obtained from a tools.Json (Json type file) [9].

Figure 17. Json script code

```
using UnityEngine;
using TMPro;
using System.IO;
using System.Collections;

public class JSONMenu : MonoBehaviour
{
    public TextMeshProUGUI textDisplay; // Asigna el objeto TextMeshProUGUI desde el Inspector

    void Start()
    {
        StartCoroutine(LoadJSON());
    }

    private IEnumerator LoadJSON()
    {
        string jsonFilePath = Path.Combine(Application.streamingAssetsPath, "tools.json");

        #if UNITY_ANDROID
        // Uso de UnityWebRequest para obtener el archivo JSON en Android
        UnityEngine.Networking.UnityWebRequest request = UnityEngine.Networking.UnityWebRequest.Get(jsonFilePath);
        yield return request.SendWebRequest();
```

Source. Own creation.

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Figure 18. Equipment and sterilization panel code

```
sing UnityEngine;
using TMPro;
using System.IO;
using System.Collections;

public class EquiposyEsterilizacion : MonoBehaviour
{
    public TextMeshProUGUI descripcionText; // Para mostrar la descripción

    void Start()
    {
        StartCoroutine(LoadSurgicalClothingInfo()); // Llama al método para cargar la información
    }

    // Método para cargar la información de vestimenta quirúrgica
    private IEnumerator LoadSurgicalClothingInfo()
    {
        string jsonFilePath = Path.Combine(Application.streamingAssetsPath, "tools.json"); // Cambia el nombre del archivo si es necesario

        #if UNITY_ANDROID
        // Uso de UnityWebRequest para obtener el archivo JSON en Android
        UnityEngine.Networking.UnityWebRequest request = UnityEngine.Networking.UnityWebRequest.Get(jsonFilePath);
        yield return request.SendWebRequest();
```

Source. Own creation.

Figure 19. Cardiac surgery panel code

```
using UnityEngine;
using TMPro;
using System.IO;
using System.Collections;

public class CirugiaCardiaca : MonoBehaviour
{
    public TextMeshProUGUI descripcionText; // Para mostrar la descripción

    void Start()
    {
        StartCoroutine(LoadSurgicalClothingInfo()); // Llama al método para cargar la información
    }

    // Método para cargar la información de vestimenta quirúrgica
    private IEnumerator LoadSurgicalClothingInfo()
    {
        string jsonFilePath = Path.Combine(Application.streamingAssetsPath, "tools.json");
```

Source. Own creation.

Phase 4 - Transition.
In this phase of the methodology, the augmented reality mobile application was installed on the mobile device for evaluation.

Figure 20. Scanning markers from the augmented reality mobile application.

Source. Own creation.

Figure 21. Evaluation of the performance of the augmented reality mobile application.

Source. Own creation.

DISCUSSION AND ANALYSIS OF RESULTS

The use and development of educational mobile applications has had an exponential growth since the Covid-19 pandemic, and according to the National Survey on Access and Permanence in Education 2021 of the National Institute of Statistics and Geography (INEGI) 95.6% of the total student population aged 3 to 29 years has a smartphone, 77.5% with digital television, 50.9% with a computer and 22.7% with an electronic tablet. It is important to mention that 46.1% of high school students stated that they have some technological means in their homes (computer, electronic tablet, smart cell phone). It is relevant to mention that the media used by teachers as of 2019 to teach classes were varied, of the total 30.7% used virtual platforms, in addition, at the upper secondary level 76.2% of the student population used audiovisual media for the development of didactic material [24,25].

Derived from the above, many technological entrepreneurs started the exponential growth of mobile application development, as stated in the publication of Radamés Camargo on July 12, 2021, in which he mentions that 86.1 million users older than five years make use of mobile applications [26]. Several authors agree that educational applications promote meaningful learning [27] either by observation, discovery or association, they allow to increase the level of understanding of different topics regardless of the student's educational level.

Therefore, in the health area, mainly in nursing, several applications focused on the study and identification of surgical tools were identified [28], one of them and that is in the Google Play Store is Instrumental en quirófano by José Juan Quesada Guzmán [29] which has more of 10k downloads and a rating of 4.6, this application shows a photo of the surgical instrument and a description of it, likewise a quiz and organizes the instruments according

to medical specialties, this application is free but to use it you must see some ads.

A second app is Surgical Instruments by RER MedApps [30] which has a 4.4 rating and has been downloaded by more than 100k, this app classifies surgical instruments by specialty, but only gives a brief description of each tool and contains a photo or image. The aforementioned applications can be used on devices with Android operating system.

The Instrumental en quirófano app by Juan Manuel Quesada is also in the App Store and costs $39 pesos, but it is for iOS operating systems.
According to Aidée Cruz Barragán and Arisaí Darío Baarragán López in their article Aplicaciones Móviles para el Proceso de Enseñanza Aprendizaje en Enfermería, significant learning is achieved through the use of mobile applications because they allow the student to identify, understand and classify information, and they are also a didactic tool that can be consulted at any time.

Therefore, after analyzing the previous results it can be determined that the augmented reality mobile application for learning surgical instruments for nursing is a didactic tool that allows visualizing or superimposing 3D objects in a real environment, which shows the characteristics of each of the objects, the student can perform an evaluation or test of the instruments he has studied, also allows knowing information related to the nursing area and is applying a gamification strategy that makes different from the application of the existing ones, therefore allows the student to have a significant knowledge through observation, discovery or observation.

1. In the initiation phase: information was gathered to establish the requirements for the development of the augmented reality mobile application. Based on these requirements, decisions were made about the functionalities to be developed, the users or people involved, the technologies to be used and the type of design of the mobile application.

In the elaboration phase: the requirements obtained in the initiation phase facilitated the analysis and design of the augmented reality mobile application.

In the construction phase: the augmented reality mobile application was developed based on the design made in the elaboration phase.
Below are screenshots of the augmented reality mobile application:

When starting the augmented reality mobile application, the main view is the following screen, which shows a welcome message, the menu, the start button and exit the application.

Figure 22. Initial screen of the augmented reality mobile application.

Source. Own creation.

When the user enters the menu option, the following options are displayed: general surgical information, augmented reality viewer and test or questionnaire.

Figure 23. Augmented reality mobile application menu screen.

Source. Own creation.

In the general surgical information view, the following options are displayed: wound classification, types of surgical gowns, obstetric surgery, about anesthesia, about cardiac surgery, and about the equipment and sterilization areas.

Figure 24. General surgical information screen

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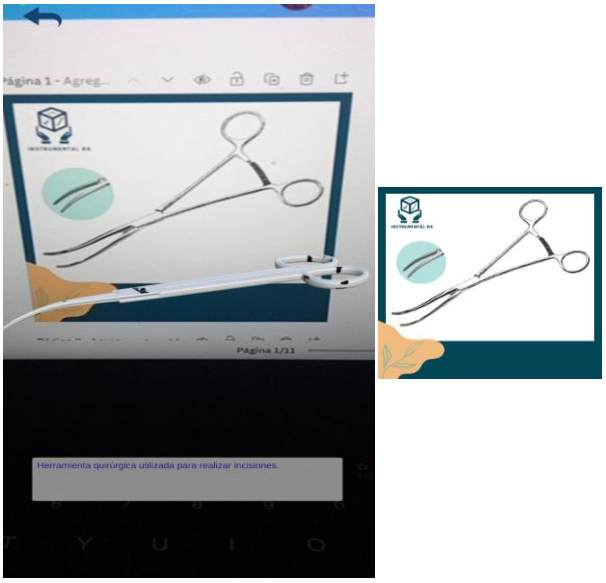
Source. Own creation.

The augmented reality viewer view is in charge of scanning the marker to show the surgical instruments in 3D, their written description for reading and audio with information about the instruments being viewed.

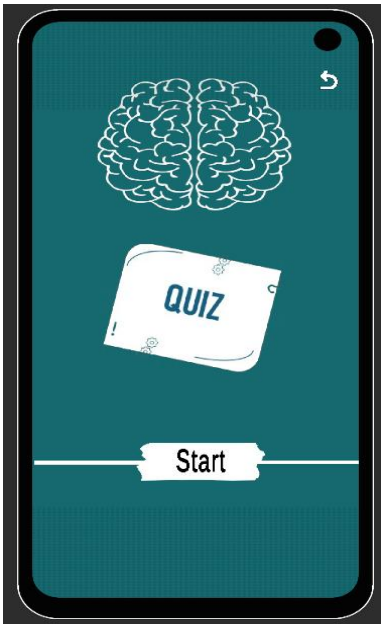
Figure 25. Augmented reality viewer screen, scanning a marker.



Source. Own creation.

The test or quiz view displays the options to start or return to the previous screen where the menu options are located.

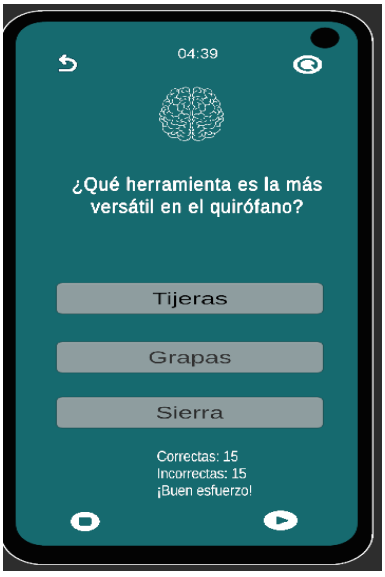
Figure 26. Initial test or questionnaire screen



Source. Own creation.

When starting the test or questionnaire, the questions are displayed with answer options so that the user can choose the one he/she considers correct and evaluate the knowledge acquired. The time taken to complete the test and the number of correct and incorrect answers are also displayed.

Figure 27. Test or questionnaire screen



Source. Own creation.

4.In the transition phase: for the production deployment of the augmented reality mobile application, the head of information technology of CONALEP Tabasco was contacted to authorize the installation on the institution's devices. The augmented reality mobile application was

successfully deployed. This process involved the preparation of the production environment, the compilation and packaging of the application, the transfer and decompression of the application on the devices, the configuration of the application, security and its monitoring.

CONCLUSIONS

The augmented reality mobile application was implemented for learning the surgical instruments of nursing as part of the transition stage, during this period it was installed on different mobile devices with Android operating system including tablets and cell phones, the cards were printed on opaline paper with markers, it was used by teachers of the National College of Technical Professional Education Tabasco Plantel 052 Cardenas and Plantel 053 Macuspana, reaching the conclusion that the application is easy to use, adapts to any mobile device, has modules that allow to know and identify the nursing surgical instruments through 3D markers allowing to see a digital image that simulates a real image, allows the evaluation and identification of surgical instruments, provides relevant information on topics of interest to the nursing area such as types of sutures, autoclave management. They mention that it allows to visualize the small differences between surgical instruments that have similar physical characteristics, which guarantees an optimal identification in real life.

In addition, access to online videos or tutorials provides a broad overview of the diversity of nursing topics, although it would be feasible to add activities that allow the learner to choose the instruments needed for a specific procedure.

Regarding the appreciation of the students when using the application, they mentioned that they find interesting the way in which the nursing surgical instruments are visualized, because they look like real objects which allows to observe in detail the physical characteristics of each one, the description coincides with the topics studied in class, but the audio should have a friendly voice, the tests allow to really evaluate what the application shows, they consider that the complementary topics provide relevant information on topics related to nursing but that others can be implemented or modified from time to time; they consider that gamification activities should be implemented. After the observations and comments, the pertinent modifications were made to the application.

In general, the augmented reality mobile application for learning surgical instruments for nurses meets the characteristics of being a functional, responsive application, with a user-friendly design, which allows a correct interaction with the user; in addition, it has the characteristics of being an educational tool.

According to the results obtained, it is convenient that in the future the mobile application integrates tools from the area of dental surgery, equipment and techniques used for cleaning, disinfection, sterilization and storage in the Central Sterilization Area (CEyE) of hospitals, in this way the tool can be used as an educational tool not only in technical secondary education institutions but also at the undergraduate level, to evaluate its functionality.

For future research we intend to create a responsive web system implementing Python, Bootstrap, CSS and MySQL for its development; which will allow teachers to create questionnaires or digital or printed tests to evaluate the knowledge acquired by the student through the mobile application, assign gamification activities to reinforce knowledge and record progress in knowledge, identification and use of nursing surgical instruments. Through the web system they will be able to create reports by groups, by students and by dates.

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ROLES

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Project management	Victor Manuel Arias Peregrino
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