# Methodology for creating applications with augmented reality for education 4.0

# Metodología de creación de aplicaciones con realidad aumentada para la educación 4.0

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**Abstract**

The rise of industry 4.0 (I4.0) technologies increases with the passing of days, as well as their permeability in areas of other kinds, such as education. Currently the term coined for this is Education 4.0 (E4.0) which can be seen as a paradigm and can be conceived as an educational approach that uses the technological axes of I4.0 to optimize the teaching-learning process. One of the technologies that have been implemented the most in E4.0 is augmented reality (AR). However, this technology generally requires a high degree of expertise, which is why this paper proposes a methodology for the creation of applications (app) with AR that can be used as teaching resources in different subjects and educational programs of an affordable and intuitive way. Which is ad hoc to the objective pursued, allowing the creation of apps with AR where the use goes hand in hand and the creativity of the user who will insert it in the pedagogical process corresponds to him and allows students to enter the E4.0.

**Education 4.0, App, Augmented reality**

**Resumen**

El auge de las tecnologías de la industria 4.0 (I4.0) aumenta con el paso de los días, así como su permeabilidad en áreas de otras indoles, como lo es la educación. Actualmente el término acuñado a esto es Educación 4.0 (E4.0), la cual puede ser vista como un paradigma y puede concebirse como un enfoque educativo que utiliza los ejes tecnológicos de la I4.0 para optimizar el proceso de enseñanza-aprendizaje. Una de las tecnologías que más se ha implementado en la E4.0 es la realidad aumentada (AR, por sus siglas en inglés). Sin embargo, esta tecnología por lo general requiere un grado de expertís alto, es por eso que en este trabajo se plantea una metodología para la creación de aplicaciones (app) con AR que puedan usarse como recursos didácticos en distintas asignaturas y programas educativos de una manera asequible e intuitiva, la cual es ad hoc al objetivo que persigue permitiendo la creación de apps con AR donde el uso va de la mano y creatividad del usuario que lo insertará en el proceso pedagógico que le competa y permite adentrar a los estudiantes en la E4.0.

**Educación 4.0, App, Realidad aumentada**

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## Introduction

Industry 4.0 (I4.0) is growing rapidly, leading to new educational models in universities, since, if the educational process does not adapt to the pace of evolution in industry, it can lead to a rupture in the industry-academia relationship [1]. The permeability of I4.0 in education allowed the emergence of E4.0, which can be conceived as an eclectic educational approach that encourages the use of disruptive technologies to optimize learning and thus provide innovative solutions to real and complex problems aiming to train a comprehensive and multifunctional being to achieve their self-realization permanently [2].

The skills and knowledge that students develop through technology-enhanced learning environments can be developed more effectively through AR technology. The immersion and interaction offered by AR motivates students to engage in learning activities [3].

Technological advances in E4.0 require adapting methodologies within the teaching-learning process to the new trends. For this reason, it is important to have the tools, training and updating of teachers in RA convergence.

## 1. Theoretical framework

### 1.1 Augmented reality in education 4.0

Augmented reality (AR) is a direct or indirect view of a real-world physical environment whose elements are "augmented" by a computer or sensory information extracted from the real world, such as sound, video, graphics, haptics, or GPS data [4]. It is the interaction between virtual environments and the physical world, making it possible for both to intermingle through a technological device such as webcams, cell phones, tablets, etc.

The opportunities posed by the use of AR in teaching have been widely reported [5-7], describing the advantages and challenges of its use in teaching and its application in different scientific disciplines [8], as well as the comparison of the impact that the use of AR versus conventional learning has on students.

In the teaching-learning process the use of AR is an advantage that facilitates the work of the teacher. When AR applications are used in a laboratory, for example, it is not necessary to explain the components used by the student, this information is available in real time on the students' smart devices leading them to greater autonomy in training.

### 1.2 Unity 3D

Unity 3D is a multiplatform developed by Unity Technologies to create video games and simulations for computers, consoles and mobile devices. Games with Unity 3D can be operated through a web browser without any installation process thanks to the Unity Web Player plug-in. In addition, Unity offers game creators the possibility to compile games with different platforms (PC, Mac, Web, IOS, Android and Windows Phone) without any infrastructure changes. The Unity 3D platform has support for the Vuforia SDK add-on to develop AR applications and games [9].

### 1.3 Vuforia

Vuforia is a software development platform for mobile devices from Qualcomm for creating AR applications. Developers can easily add advanced computer vision features to any application that allows them to recognize images and objects or reconfigure real-world environments. Vuforia SDK supports 2D and 3D object types, including multiple target configurations, images with some symbols, and frame labels [10].

### 1.4 Tinkercad

It is an "open source" simulation platform, created by the Autodesk company. In which 3D models can be created, in addition to simulating the operation of electronic circuits and allowing programming by code blocks. Within the electronic circuits section you can simulate analog and digital electronic circuits, as well as circuits with microcontrollers such as Arduino UNO. In addition, it allows debugging the code, executing the programs step by step, something that can only be done in this simulator and not in a real Arduino UNO board [11].

## 2. Statement of the problem

The challenge for teachers will always be to innovate, using technologies to meet the demands of students, applying new pedagogical strategies for access to knowledge and information [12]. Regarding the use of AR in classroom applications, teachers have doubts due to technological limitations and their expertise in the subject [13-14]. There is complexity in choosing the elements and approach to programming AR environments (gamification) due to the lack of information on these issues. The attitude of teachers of educational institutions towards gamification is an area little studied so far, likewise the actual use of this learning methodology in classrooms is minimal as a cause of a gap in terms of teacher training [15]. In other words, there is a significant lack of methodological and technical support in the application of gamification [16].

## 3. Methodology

The exposed methodology is designed so that any teacher can create an app with AR as an educational resource for their classes without the need for extensive knowledge of advanced programming. It is divided into three stages: software installation, configuration of AR elements and app creation.

1) Software installation. It should be noted that the software required for the creation of the app is free and should be installed in the following order:

a) Unity Administrator. The Unity platform has an administrator from which you can download the desired and/or necessary elements for the creation of games and apps, called Unity Hub (available at https://unity3d.com/es/get-unity/download).

b) Unity. From Unity Hub the desired Unity editor is downloaded, it is important to have the compatible versions in all the development environments, for this case the recommended version is 2019.4.35f1.

c) Unity modules. The Unity Hub after installing the editor offers a list of modules that can be installed according to the user's needs, for this case see Figure 1.
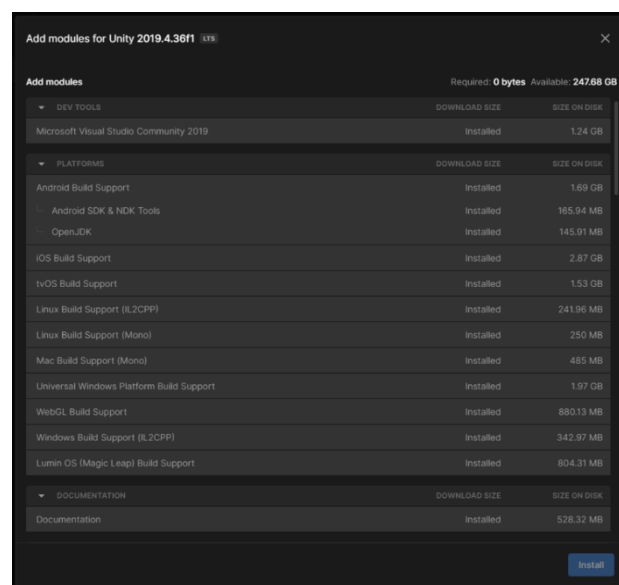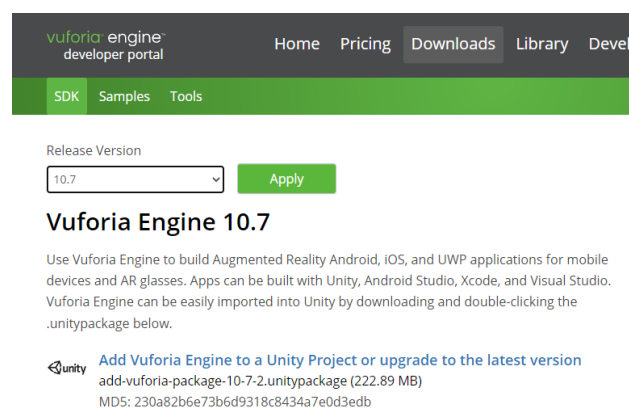


**Figure 1**. Required Unity modules
*Source: Own Elaboration.*

Up to this point, the necessary software is already in place and the next step is the next one.

2) Configuration of AR elements. Create an account and log in to the Vuforia website (https://developer.vuforia.com/), then download the Vuforia add-on for Unity in the Downloads tab (Figure 2).



**Figure 2.** Vuforia add-on for Unity
*Source: Own Elaboration*

In this page everything necessary to load the AR in the app is created in the following order:

a) In the Develop tab in the License Manager submenu click on Basic, to generate a license (Figure 3). On the next page assign a name to the license, check the Terms and Conditions box and click on confirm (Figure 4). The license is added to the License Manager, selecting it you can see the license code that will be used in the app.
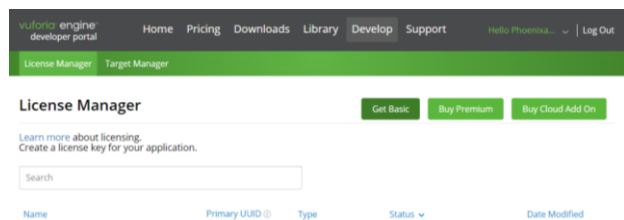
**Figure 3** License Manager.
*Source: Own Elaboration*
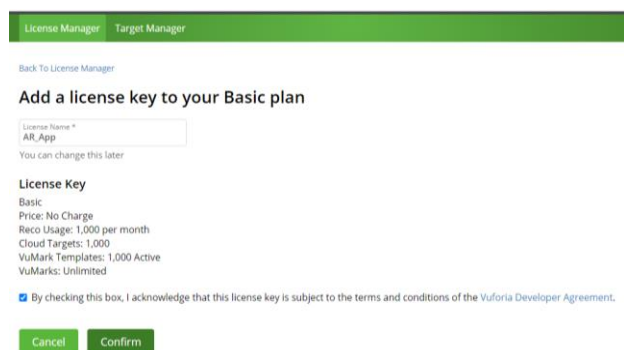


**Figure 4** License creation
*Source: own elaboration*

b)      In the Target manager submenu click on Add Database, assign a name, select Device and click on Create (Figure 5).



**Figure 5** Database creation
*Source: Own Elaboration*

c)     The Database is added in the Target Manager, it is selected with a click to add Targets by clicking on Add Target. This element is an image that is in charge of calling the 3D object of the app, thus creating an AR that is displayed above the Target. The images must have .jpg or .png extension of maximum 2MB, to guarantee a good recognition of the Target it must have well defined contours and objects.

The Width refers to the size it will have in the app. Once the Target image is loaded and defined, click on Add. Vuforia assigns a rating depending on how good the Target is (Figure 6), then download the database by selecting Download Database and the Unity editor option.
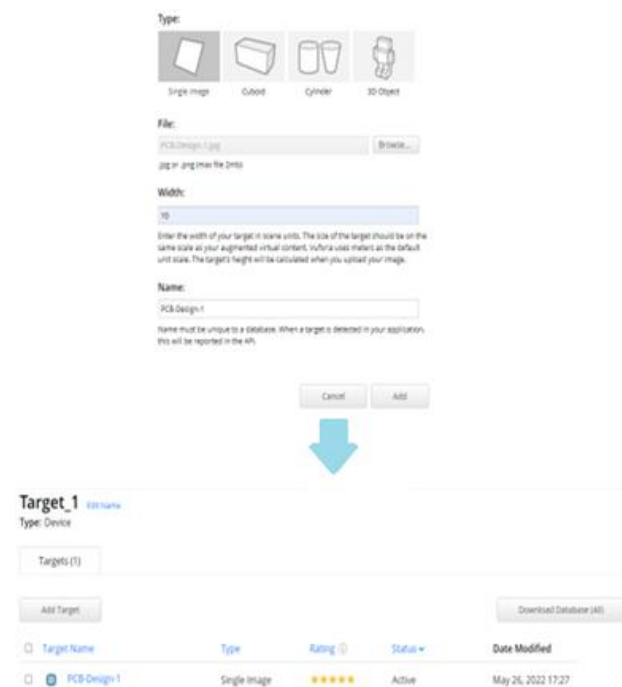


**Figure 6**. Creation of Targets
*Source: Own Elaboration*

d)     The 3D object to be displayed is created. It should be noted that there are libraries with several free AR objects. In this case, Tinkercad (https://www.tinkercad.com/) is used, due to the versatility it offers for object creation. Create an account and log in. Select 3D Design and on the right side in the library menu choose the type of object you want to create or insert (Figure 7). Once the object is created, it is exported with an .obj extension. Unity supports two types of extensions, .fbx and .obj (Figure 8).
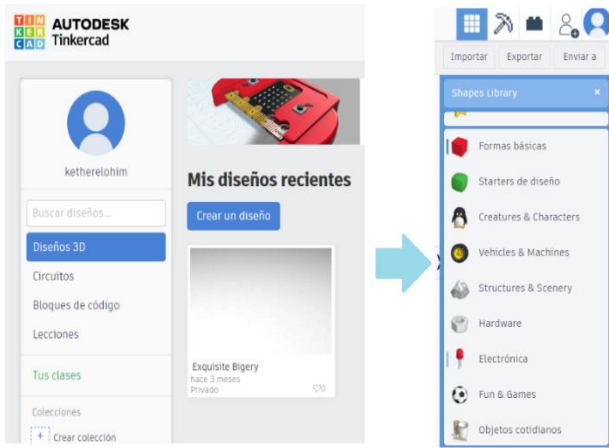
**Figure 7** Object creation
*Source: Own Elaboration*
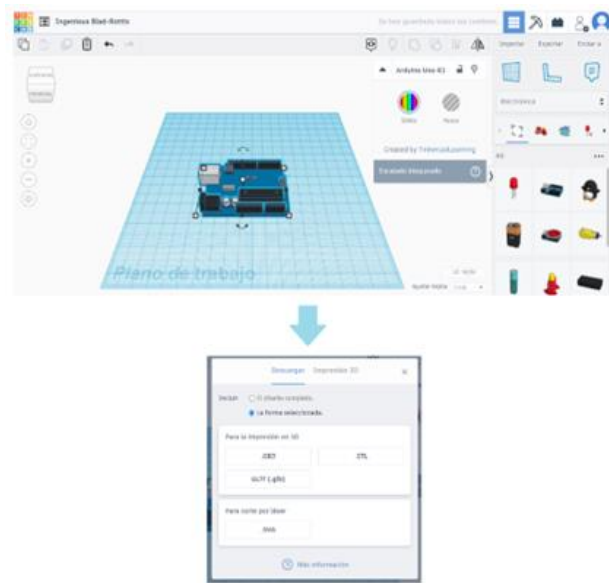


**Figure 8** Tinkercad object export
*Source: Own Elaboration*

With this we now have the necessary elements for the AR of the app and proceed to the next step.

3)    App creation. The steps for the creation of the app are:

a)    Open a new 3D project from Unity Hub.

b)    In File>Build Settings select Android and click on switch platform, when finished exit (see Figure 9).
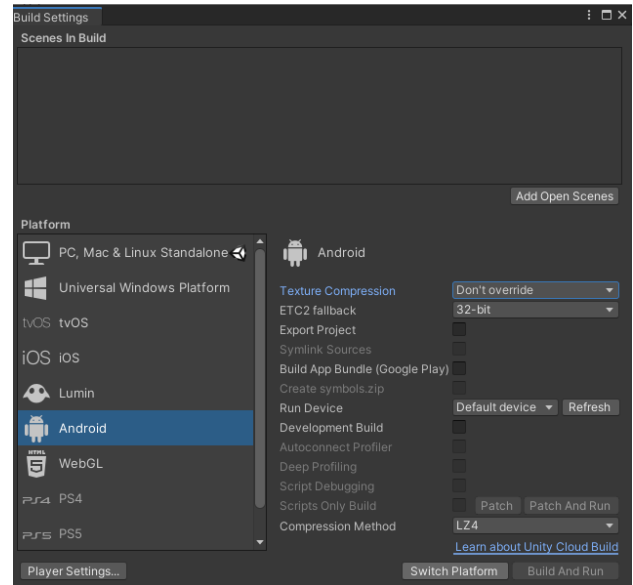


**Figure 9** Build Settings options
*Source: Own Elaboration*

c)    Select the Vuforia plugin for Unity to add it to the project (follow the video https://www.youtube.com/watch?v=2BJ mOMgZCE0). In Windows>Package Manager look for Vuforia engine and install version 8.1.12 (see Figure 10) and close when finished.
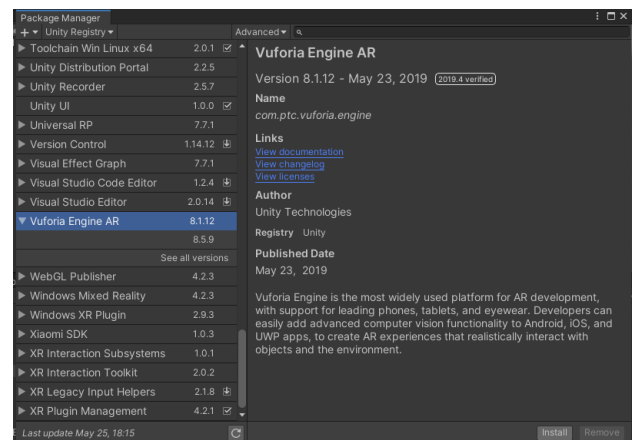


**Figure 10** Vuforia engine in Package manager
*Source: Own Elaboration*

d)    From the page of https://assetstore.unity.com/?orderBy=1 look for the Lean touch add-in, click on Open in Unity, Package Manager opens (see Figure 11). Select import, this will show all the elements of the plug-in, select import again and close when finished. Lean touch allows to perform functions such as moving, rotating objects, among others in a tactile way in the apps with AR.
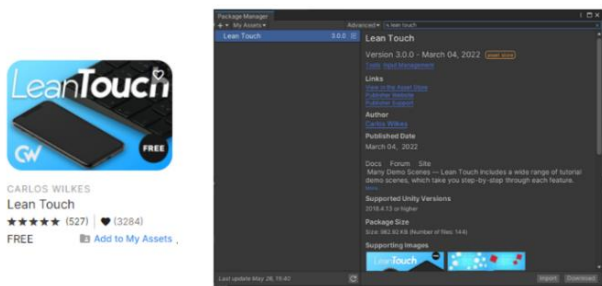
**Figure 11** Lean touch complement
*Source: Own Elaboration*

e)　　The Targets Database is added by clicking on the file previously downloaded from the Vuforia page, the Package manager is opened and the import button is clicked (see Figure 12).
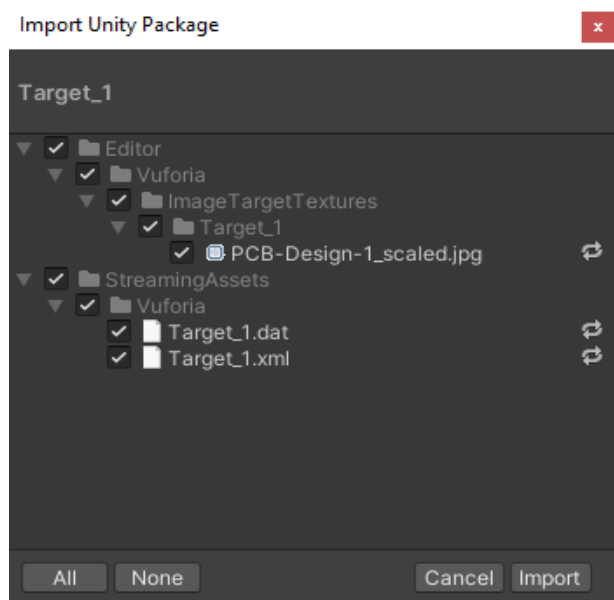


Figure 12 Targets Database import.
*Source: Own Elaboration*

f)　　With the previous steps the app environment is ready to configure the AR elements. The Main camera is removed from the scene hierarchy by selecting it and with a right click an options menu is opened and Delete is selected. Then add an AR camera from the Vuforia engine in the same menu (see Figure 13).
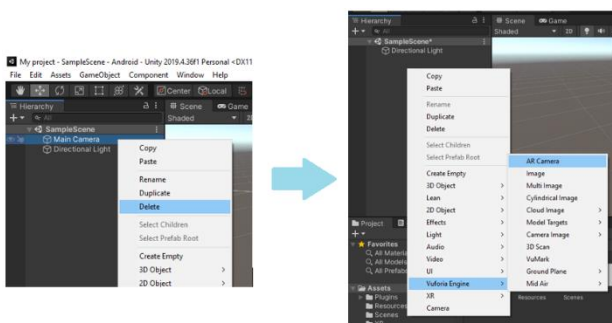


Figure 13 Creation of AR camera
*Source: Own Elaboration*

g)　　Select the AR camera and in the property inspector select Open Vuforia Engine configuration, in the Global option the Vuforia license is attached (see Figure 14).
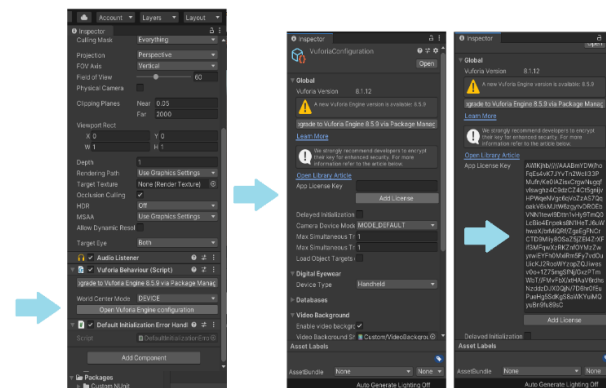


**Figure 14** Vuforia license configuration
*Source: Own Elaboration*

h)　　In the AR camera an Image is added, when doing so the Target created is automatically loaded in the scene (see Figure 15).
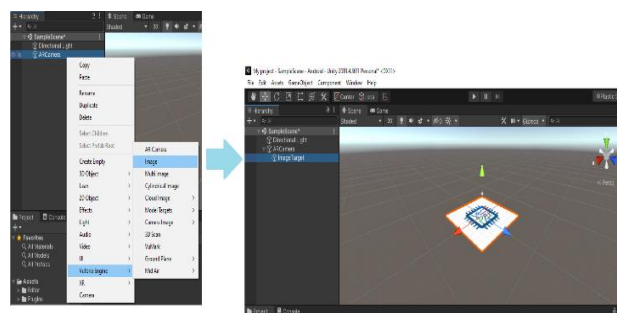


**Figure 15** Image of AR camera with Target in scene
*Source: Own Elaboration*

i)　　The object is added by dragging it to the Resources folder (see Figure 16).
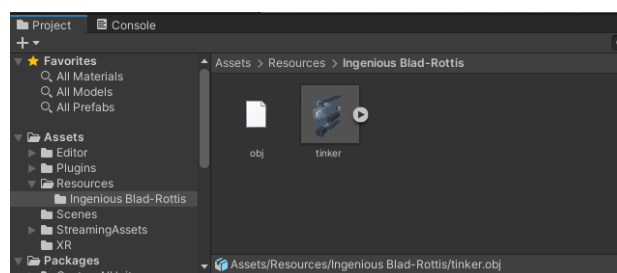


**Figure 16** Object insertion in Unity
*Source: Own Elaboration*

j)    Then place the object on the Target by dragging it into the scene, modifying the size, rotation and scale with which you want it to be displayed in the app (see Figure 17). This can be done from the property inspector or from the tools menu at the top left. The object must be left inside the Image Target menu in the hierarchy.
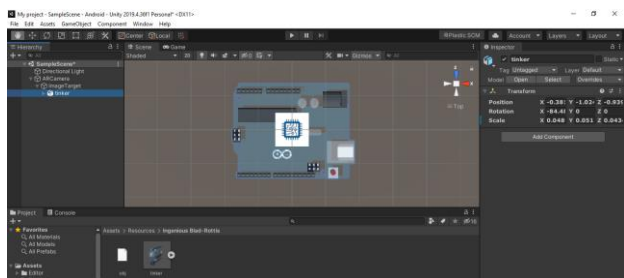


**Figure 17** Insertion of object on Target
*Source: Own Elaboration*

k)    A Lean complement is added in the scene hierarchy (see Figure 18).
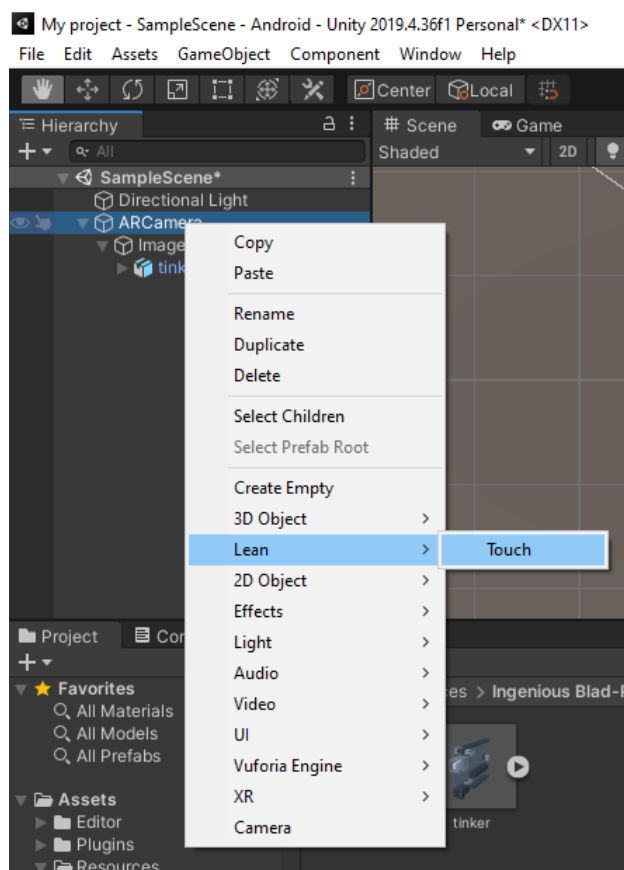


Figure 18 Insertion of Lean Touch add-on
*Source: Own Elaboration*

l)    Selecting the object (tinker), in the inspector add components in Add Component, in the menu that opens select Lean>Touch and look for the components Lean Drag Translate, Lean Pinch Scale and Lean Twist Rotate (see Figure 19).
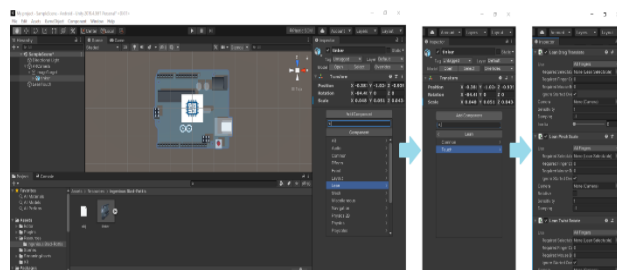


**Figure 19** Insertion of complements
*Source: Own Elaboration*

m)    This completes the programming of the AR app. Before packaging it for installation, its behavior can be simulated by pressing Play at the top of the scene (see Figure 20), in case it is necessary to make any changes.
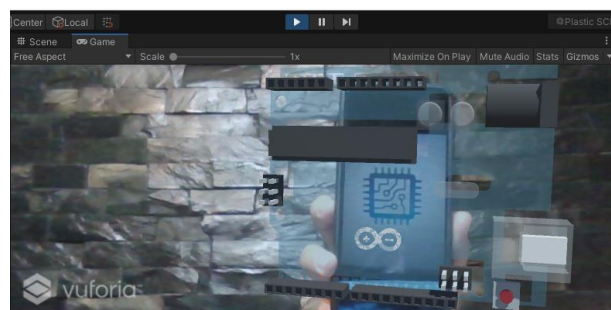


**Figure 20** App simulation
*Source: Own Elaboration*

n)    To package the app in File>Build Settings, select Build, name and address where the .apk file will be saved (see Figure 21).
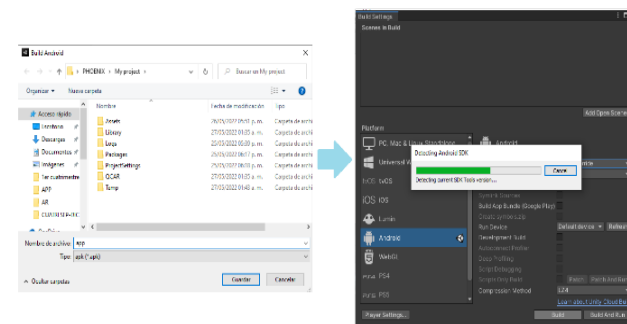


**Figure 21** App packaging
*Source: Own Elaboration*

This concludes the stages of the methodology.

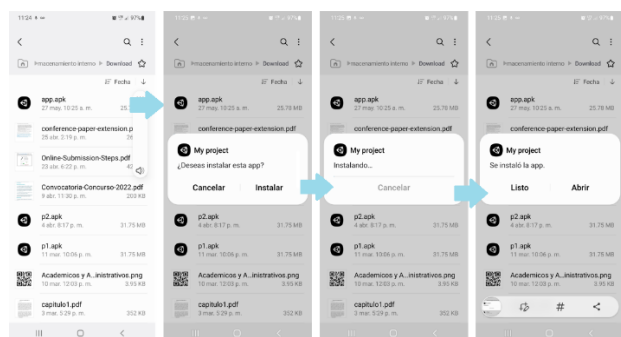## 4. Results and discussion

The .apk file resulting from following the methodology described above is installed on a device to verify the functionality of the app created (see Figure 22).



**Figure 22** App installation on cell phone
*Source: Own Elaboration*

When passing the cell phone camera over the Target, the AR object unfolds and the user can manipulate it with his fingers through the cell phone screen (see Figure 23). This demonstrates that it is functional and meets the proposed objective.
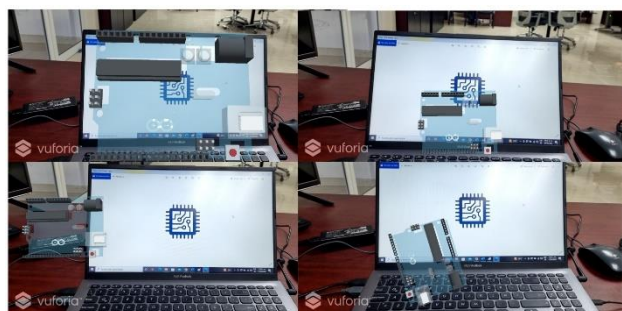


**Figure 23** App operation
*Source: Own Elaboration*

E4.0 is a set of technological innovations and pedagogical transformations in education that promote a combination of man and technology to improve and adapt the teaching-learning process where learners are the architects of their learning, in a flexible, dynamic and adaptive way [17]. With this type of methodologies, relevant tools are provided to teachers to create educational environments with AR and to introduce students to E4.0. In addition, the teacher has creative freedom according to the need of his pedagogical resource.

## Conclusions

The implementation of AR technologies in E4.0 stimulates students to be self-taught, capturing their interest, motivating them to discover new possibilities, in addition to having the advantage of being able to replace expensive laboratory equipment with multimedia models. The real objects can be complemented by adding context information and visualization of the learning material, which increases the level of perception and interest of the students and in turn the quality of professional training through the use of didactic resources with AR.

The teaching-learning process becomes more interactive and more productive. The application of this technology in E4.0 opens new horizons in the training of students in educational institutions of different levels through appropriate methodologies that allow the insertion of teachers in this technological axis. Therefore, the methodology proposed in this work is pertinent and contributes to this end.

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