An approach to Augmented Reality Classification and an example of its usage for application development with VAK learning styles Markers

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Abstract

Augmented reality (AR) encompasses both technology and the experience it provides, making it applicable in real-world contexts. The field of education is particularly suited for utilizing AR techniques as a novel means of engaging with students. Various classifications of AR techniques exist, each offering remarkable potential for educational purposes. This paper presents an approach to classifying augmented reality based on the characteristics of different techniques. Additionally, we demonstrate the application of a specific type of AR technology in the development of an educational application. Furthermore, we emphasize the importance of designing augmented learning scenarios that align with the VAK learning styles, aiming to deliver personalized and immersive learning experiences. The integration of AR and VAK learning styles shows the potential for creating educational tools that are both engaging and effective.

Keywords: AR Classification, VAK learning styles markers, personalized learning, marker-based application.

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1 Introduction

Augmented reality (AR) goes beyond mere technology; it is an immersive experience with tangible applications in real-world scenarios.

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Among these scenarios, e-learning stands out as a context where AR can be leveraged as a novel means of engaging with students. In the coming years, augmented techniques hold immense potential to revolutionize education on a broader scale. By seamlessly integrating digital elements into the learning process, AR has the ability to transform traditional educational methods and provide students with unique and interactive learning experiences.

To maximize the potential of respective technology, it is beneficial to comprehend the various types of AR and their potential to enhance learning experiences. Thus, in the first part of this paper, we analyze the emergence of augmented technologies and propose a classification based on tech characteristics. In addition, we presented some ways of using the specific type in education.

The integration of augmented reality in education has the power to reshape how knowledge is imparted and absorbed, paving the way for a significant shift in the educational landscape. Additionally, the possibilities for incorporating and presenting information in innovative and interactive ways are virtually limitless. Through these technologies, various forms of multimedia content can be introduced, ranging from videos, sounds, and graphics to the inclusion of three-dimensional (3D) models. Developing learning environments with unforgettable experiences will, definitely, enhance students' perception of the real world. Thus, it will increase their engagement in the learning process, because when the physical and digital worlds collide, it changes everything. Literally, augmented reality is changing the way we see the physical world.

In the second part of this paper, we stressed the importance of integrating learning styles in augmented content. When designing augmented reality in education based on learning styles, the goal is to provide personalized and immersive learning experiences. For visual learners, AR can offer visually rich content, such as interactive 3D models or visual simulations, to enhance their comprehension and retention of information. Auditory learners can benefit from AR applications that include audio instructions, narration, or discussions to support their preferred mode of learning. Kinesthetic learners can engage with AR experiences that involve interactive elements, allowing them to physically manipulate virtual objects or participate in virtual simulations. By tailoring augmented reality experiences to different learning styles, educators can create inclusive and engaging learning environments. This approach recognizes the diversity of learners' preferences and optimizes the potential for knowledge acquisition and retention.

2 The emergence of Augmented reality

Over the past five decades, the landscape of human interaction with the physical world has been profoundly transformed by the emergence of AR technology. Augmented reality revolutionizes our perception of reality by overlaying digital information onto our surroundings. It is important to note that augmented reality is often confused with virtual reality (VR), despite some shared developmental origins. However, AR and VR are distinct from one another. Unlike VR, which constructs entirely artificial environments to replace the real world with a virtual one, augmented reality seamlessly integrates technology into our actual surroundings. By directly integrating with our existing environment, augmented techniques enriches our sensory experience by introducing multimedia elements such as videos, sounds, graphics, and more. Augmented reality is a field that leaves some aspects to scientific advancements while sparking the imagination to envision its limitless potential.

As stated in [1], augmented reality is not confined to a singular device or program, but rather represents a form of interaction between humans and computers. This interaction is facilitated by a blend of technologies that superimpose computer-generated content over the real-world environment. The roots of augmented reality can be traced back to 1968 when Ivan Sutherland pioneered the first head-mounted display system. However, it was not until 1990 that the term ”augmented reality” was coined by researchers Thomas Caudell and David Mizell [2].

During the early 1990s, augmented reality made a significant transition from laboratory settings to practical applications. In 1992, Louis Rosenberg pioneered the development of the groundbreaking augmented reality system known as ”Virtual Fixtures” at the USAF Armstrong Labs. This system enabled military personnel to remotely control and provide guidance to machinery, serving various purposes such as training US Air Force pilots in safer flying practices. Figure 1 showcases an illustration of this technology in action.

Figure 1. Louis Rosenberg testing Virtual Fixtures [15]

A significant milestone in the popularization of augmented reality occurred in 2000 with the development of an open-source software library called ARToolKit by Hirokazu Kato. This software package proved instrumental in enabling other developers to create AR software programs. As our reliance on mobile devices continues to grow, the demand for AR software has also increased, leading to a proliferation of applications in the field. The convergence of AR technology and mobile devices has opened up new possibilities and opportunities for incorporating augmented reality into various aspects of our lives.

In a surprising move, Esquire Magazine introduced the concept of integrating augmented reality into print media back in 2009. This innovative approach aimed to bring static pages to life by leveraging AR technology. By scanning the magazine cover, readers were able to experience an interactive augmented reality experience. Notably, the AR-enhanced magazine featured Robert Downey Jr. engaging in a virtual conversation with the readers. This bold initiative by Esquire Magazine showcased the early potential of augmented reality to transform traditional print media and create dynamic and engaging experiences for readers.

Another impressive application is Volkswagen's MARTA, short for Mobile Augmented Reality Technical Assistance. It is a remarkable adaptation of AR technology. It offers valuable support to technicians by guiding them visually through the repair process. The MARTA app utilizes real-time images of the vehicle, superimposing outlines and labels on the parts, and provides contextually relevant information. For each step of the repair, it even indicates the specific tools required, ensuring technicians have the necessary guidance and assistance.

Furthermore, in 2013, Google introduced its Glass devices, a pair of augmented reality glasses that offer users relevant information through visual, audio, and location-based inputs. For example, when entering an airport, a user could automatically receive flight status updates.

Over the past decade, augmented reality has gained significant recognition as one of the most promising areas within computer graphics. During this time, numerous innovative applications have been developed, highlighting the growing importance of augmented reality in our daily lives. Augmented reality has been built from the ground up, and now is the opportune moment for it to truly flourish and reach new heights.

3 Types of augmented reality

Augmented reality initially made its way into public spaces several decades ago, but its true explosion has occurred in recent years, primarily due to the increased processing power available in today's smart devices. One of the greatest advantages of AR is its accessibility to ordinary users. In this section, we will explore different types of AR and discuss some of its implementations in the field of education.

As per the findings from Wilson's team [3], augmented reality can be categorized into five distinct experience types: "video launch," "3D object," "360-degree surround," "interactive game," and "information overlay". Within each of these types, there are numerous possibilities and opportunities for exploration and innovation.

According to Onirix [4], another classification of augmented reality (AR) is based on triggers that initiate the AR experience. These triggers play a role in determining the placement of augmented content. Onirix identifies three types of trigger-based AR experiences:

1. *Targets* – the anchors that connect the digital and physical

worlds; these are images or surfaces.

2. *Space* – it uses SLAM technologies to create a detailed 3D model of a real-life location. For this case, the triggers are scene recognition.

3. *Places* – this type of experience ties AR content to a specific location; for these types, the main triggers identify the user's geolocation. The used tech can help to guide users through a certain area, etc.

Analyzing many other sources, we found out there are various types of classification, for instance, in [5], the author believes there are four types of augmented reality (marker-based, markerless, projection-based, and superimposition-based AR). As stated in [6], Triggered AR technologies include four types: Markerbased, Location-based, Dynamic Augmentation, and Complex Augmentation. However, we consider that augmented reality can be grouped into two major categories: **marker-based AR** and **markerless AR**. The remaining types may consist of variations or modifications of these two. Below we will present a classification from our point of view, with a description and an example of its application in the education field.

3.1 Marker-Based approach

Marker-based augmented reality is one of the most common types; it uses markers to trigger an augmented experience. Due to its use of image recognition, this type of AR is sometimes also called recognition-based augmented reality. This type works when a camera or app is scanned over a visual marker. Markers are referenced to merge virtual extensions with real media. A QR code or a 2D code serves as a notable example of a visual marker. Before describing the variations of this type of AR, we need to know the answer to a few key questions, like: What content do we need to display in the digital world? What factor will trigger it in the physical world? Where exactly should we put the content within the user's view?

To provide an example, consider a scenario where we aim to display an educational animation directly onto a page of a book. In this case, it becomes crucial to determine the exact location on the page where the user should point their camera. The device needs to recognize the specific page and identify the marker present on that page to initiate the animation. One advantage of this recognition-based technology is that as we turn the page of the book, the animation will remain fixed to the page and move accordingly. Consequently, a marker can take various forms, as long as it possesses distinct visual features. This leads us to identify two variations of marker-based augmented reality:

1. *image-based recognition* – involves the placement of a "tracker" in the form of an encoded image that provides visual cues to the AR application, indicating where to position virtual content. The image marker can take various forms, such as pictures, logos, posters, QR codes, or any type of 2D objects. The crucial factor in image-based recognition is the quality of the image used as a marker. Quality does not solely refer to resolution but also encompasses factors like contrast, color accuracy, distortion, and texture, which aid camera recognition; more about markers requirements is presented in our research [7]. This type of AR can be employed in math worksheets, where QR code images are placed near each task. By triggering the image markers, the AR app can initiate video demonstrations on how to solve the tasks. Consequently, students can check their solutions or understand their mistakes by utilizing this interactive approach after completing exercises.

2. *object-based recognition* – refers to a type of marker in augmented reality (AR) that can take the form of various 3D shapes or objects. Similar to image-based recognition, it involves recognizing objects and displaying corresponding digital content on a screen. The recognition process relies on markers, which are replaced by 3D representations of the corresponding objects. This enables users to view the objects in greater detail and from different angles. As the user rotates the marker, the 3D image also rotates accordingly. One practical application of object-based recognition in the education field is the learning of geometry shapes. Students can use smartphones or tablets to scan 3D objects and

access relevant information about them. Another notable example is the implementation by CISCO, where they utilize this type of augmented reality. CISCO scans their devices, and through an AR app, they provide users with guidance on how to use those devices (see Fig. 2).

Figure 2. AR Solution for CISCO Technical Content [16]

Marker-based augmented reality (AR) predominantly relies on mobile applications, requiring users to download AR software before they can interact with augmented content. This may lead to a perceived loss of spontaneity in marker-based experiences. However, with the advancements in camera systems and precise sensors found in popular devices such as those from Apple and Google, the landscape of AR has shifted from primarily marker-based activations to markerless AR.

Notably, Apple's ARKit and Google's ARCore are software development kits that have been released in recent years, expanding the possibilities of markerless AR. These development kits enable the creation of AR experiences without the need for physical markers. The integration of advanced technologies within these platforms has facilitated the transition towards markerless AR, providing users with more seamless and immersive AR experiences.

3.2 Markerless Augmented Reality

Markerless AR refers to an augmented reality app that can overlay digital content onto the user's environment without requiring prior knowledge or the use of physical markers. According to [8], markerless AR systems integrate 3D virtual objects seamlessly into a real-time 3D environment, enhancing the user's perception and interaction with the world. This type of AR is more versatile compared to marker-based AR since it doesn't rely on markers as visual cues to position digital content in the real world.

Instead, markerless AR utilizes various hardware components of the device, such as GPS, gyroscope, velocity meter, digital compass, and accelerometer, to gather the necessary information for determining the user's location and other details. This approach is often referred to as Position-based AR. By leveraging the collected data, users have the freedom to decide where to place virtual objects within their environment. Additionally, markerless AR allows for experimentation with different styles of 3D virtual objects, enabling users to position them anywhere, regardless of the surroundings. It even allows for objects to appear as if they are floating in the air.

Markerless AR is at the forefront of augmented reality technology, primarily leveraging a powerful tracking system known as SLAM (Simultaneous Localization and Mapping). SLAM enables real-time tracking and mapping capabilities, allowing for the placement of 3D objects in both indoor and outdoor environments without the need for physical markers. This technology has opened up new possibilities for various applications in different settings, including indoor spaces, outdoor areas, aerial environments, and underwater scenarios.

Markerless AR encompasses several types of AR technologies that do not rely on specific markers to trigger digital content. These include location-based AR, superimposition-based AR, projection-based AR, and outlining AR. Each of these techniques utilizes different methods and approaches to integrate virtual content seamlessly into the user's environment.

Location-based or position-based AR is one of the most widely implemented applications of augmented reality, because of the easy availability of smartphones that provide the needed data regarding the user's location by using GPS, compass, gyroscope, accelerometer, etc. In most cases, this type of AR is used for navigation support; it helps travelers in their journey.

Wikitude Navigation, as cited in reference [9], has been acknowledged as the pioneering augmented reality (AR) GPS navigation system globally. It has received numerous prestigious awards and has been hailed as a **"revolutionary step forward"**, recognizing its significant contribution as a groundbreaking advancement in the domain of navigation and guidance.

Location-based augmented reality (AR) holds significant potential in the field of education, offering a multitude of applications. With the aid of AR technology, teachers are liberated from the confines of the traditional classroom setting. Augmented reality breathes life into abstract concepts, enabling educators to guide students through immersive experiences with three-dimensional objects and highlighting intriguing landmarks and artefacts along the way. A noteworthy example of such technology is the AR application known as "Magical Parks," presently utilized in various public parks across New Zealand and Australia and equally suitable for classroom implementation. By seamlessly integrating a virtual fantasy realm into the actual park landscape, "Magical Parks" captivates children's attention, presenting them with life-sized dinosaurs and interactive bears as they navigate through the park.

Projected-based AR, is the most exciting type of AR because of its futuristic experience; it consists of a physical three-dimensional model onto which a computer image is projected to create a realistic-looking object. Projected-based AR may be one of those technologies that might eliminate the use of special gear such as Google Glass or head-mounted displays (HMDS) for experiencing augmented reality. As is obvious by its name, projected-based AR works by using projection onto objects. One of the simplest is a projection of light on surfaces. The only difference between this type of AR and normal projection is that projected-based AR can detect touch and movement and to interact with programs. Although projected-based AR is being used by industry-learning manufacturers (see Fig. 3), it also can be used as training students by developing real-life problem-solving puzzles. The strong point of this kind of training will help students to think and react quickly to make correct decisions.

Figure 3. Light Guide Systems [17]

Superimposition-based AR recognizes an object in the physical world and enhances it in some way to provide an alternative view. Many companies have used this type of AR to help their customers feel more connected to their brand. Superimposition-based technology can recreate or replace a portion of the image or object, or even a whole thing. An exemplary illustration of this type of augmented reality implementation can be seen in the case of IKEA. In 2017, IKEA introduced an augmented reality app that revolutionized the retail industry. The IKEA Place app empowers customers to bring any product from the IKEA catalogue into their own environment, allowing them to make informed purchase decisions. This innovative approach to product interaction enables customers to visualize how a particular item would fit within their space without the need to make a physical purchase. Furthermore, customers can modify colors and even multiply objects to enhance their own interior design. The application of superimposing virtual objects onto the real world can also prove advantageous in educational settings, such as learning about bone structures or providing immersive experiences in history and natural science classes.

Outlining augmented reality (AR) involves the utilization of specialized cameras designed to mimic human vision by delineating specific objects, boundaries, and lines. Although the human eye is widely regarded as the most exceptional camera, it has inherent limitations. Prolonged focus on objects, poor visibility in low-light conditions, and the inability to perceive infrared light are a few of these limitations. To overcome these challenges, specialized cameras have been developed, which are employed in augmented reality (AR) applications that utilize outlining techniques. Object recognition serves as the foundation for the capabilities of outlining AR, which shares some resemblance to projection-based AR. This technique proves beneficial in various scenarios, leveraging object recognition to enhance the understanding of the surrounding environment. Notably, outlining AR finds application in car navigation systems, particularly for ensuring safer driving conditions during nighttime. By employing object recognition, the boundaries of the road can be accurately identified and outlined, aiding drivers in parking their vehicles. This technology shares some similarities with projection-based AR but focuses specifically on object recognition and outlining. Beyond automotive contexts, outlining AR holds potential in fields such as architecture and engineering, where it can assist in outlining buildings and identifying their supporting pillars. This type of augmented reality, combining object recognition and project-based techniques, represents an unparalleled technological solution with vast potential for connecting historical content through augmented reality experiences.

4 Learning styles

Each of us is different, having our own preferences for learning, leading to behavioral manifestations according to these preferences. Preferences may vary depending on the person, task, context, previous experience, education, etc. The frequency, stability, and constancy of the manifestation over time of a particular combination used in the execution of most tasks make it possible to differentiate so-called distinct learning styles. In the educational context, the most known and explored definition of learning styles is the one proposed by Kolb.

Definition 1 [10]. *The learning style designates the concrete ways* *by which individual changes in behavior are achieved through lived experience, reflection, experimentation, and conceptualization.*

The most frequently operated in educational practice are typologies based on sensory encoding methods. Depending on the predominant sensory organ in receiving information and transmitting it to the brain, Barbe, Swassing, and Milone [13] differentiate the following learning styles:

1. *Visual Learner* – prefers to learn based on illustrations, images, maps, and diagrams; for the efficiency of understanding and storing new information, it is important to see the written text, because visual memory prevails; prefers written instructions; learns better in solitude;

2. *Auditory Learner* – learns better by listening to a speech or the explanations of others; associates concepts with various sounds and prefers to learn on a musical background; has a better auditory memory; prefers group discussions, debates; prefers verbal instructions for academic tasks; memorizes very well through repetitions out loud;

3. *Kinesthetic Learner* – prefers learning activities in which he/she can experiment, apply, and carry out practical actions; he/she needs to touch, to get involved through movements and manipulations in the learning activity; he/she remembers best what he does; shows a tendency to play with small objects while listening to classes or studying; he/she prefers physical/sports activities.

Stable individual differences in the way of learning affect the rhythms and quality of learning and especially determine the option for one or another learning strategy as one's own and personal way of approaching a learning situation.

In order to facilitate learning, increase study efficiency and successfully adapt to the multitude of learning situations, it is necessary to determine the specific preferences [11] of the personal learning style so that they can be applied in a targeted manner.

4.1 Distinct characteristics of learning styles

1. **Visual learner**

    - observes especially the details of the environment
    - remembers what he saw faster than what he heard
    - the noise does not distract him
    - forgets the verbal instructions
    - is a good and fast reader
    - prefers to read, not to be read
    - speaks fast
    - is a good organizer.

2. **Auditory learner**

    - learns by listening to conversations or presentations
    - speaks rhythmically
    - talks to himself (in his mind)
    - is easily distracted by noise
    - moves his lips and says the words when he reads
    - likes to learn out loud
    - is a better storyteller than a writer
    - is talkative and likes discussions.

3. **Kinesthetic learner**

    - learns by handling objects
    - wants to try objects and mechanisms
    - speaks rarely
    - has bad handwriting
    - stays close to the person he is talking to
    - uses body actions to demonstrate what he has learned
    - is attentive to gestures

- likes to get involved in games – memorizes while walking
- does not retain geographical locations unless he was there
- uses action verbs

Knowing the person's learning style enables using his strengths during training. Many people show strength in more than one learning style but have a dominant learning style depending on the situation. In order to increase the efficiency of learning, it is recommended to use strategies adapted to learning styles. Suitable learning strategies for different styles are:

1. **For visual learners**
   - highlighting the main ideas, words, and mathematical formulas with different colors
   - providing sufficient time for viewing graphs, tables, and images
   - using studio tools: maps, tables, graphs
   - transcription of the information
   - viewing the written information
2. **For auditory learners**
   - explanation of new information, verbal expression of ideas
   - reading aloud
   - learning with tutors or in a group, where they can ask questions, provide answers, and express how they understand oral information
3. **For kinesthetic learners**
   - handling of the objects to be learned
   - arranging tables and diagrams in a correct order
   - using movements, dramatization, dance, pantomime, or role-playing games for the development of long-term memory
   - talking and walking during knowledge repetition
   - learning by applying the learned knowledge in practice.

5 Augmented Reality in Mathematics Education

In the realm of mathematics education, traditional methods have relied on basic tools such as paper, pencils, and chalkboards or whiteboards. Despite advancements in educational technology, the integration of more advanced technological tools into mathematics instruction has been slow to progress. This lack of progress hinders the potential for improvement in mathematics education, even though educational technology has made significant strides.

While it is true that new technologies may not necessarily solve students' difficulties with arithmetic problem-solving techniques, it is crucial to take action rather than remain inactive. By embracing innovative teaching [21] and learning methodologies [22], educators can enhance conceptual understanding, scaffold learning, and foster opportunities for meaningful dialogue surrounding the application of mathematical problem-solving techniques in real-life contexts [14].

According to [18] study, the researchers focused on investigating the existing literature on augmented reality (AR) in mathematics education. The goal was to explore how AR can enhance interactive learning environments for mathematics in various educational settings, including classrooms.

To conduct their research, the researchers selected papers from 10 different databases, namely Scopus, Web of Science Core Collection, ERIC, IEEE Xplore Digital Library, Teacher Reference Center, SpringerLink, zbMATH Open, Taylor & Francis Online Journals, JSTOR, and MathSciNet. By employing the preferred reporting items for systematic reviews and meta−analysis (PRISMA) method, specifically PRISMA2020, they were able to identify 42 relevant studies from these databases. Upon analyzing the selected papers, the researchers found that the implementation of AR in mathematics education consistently yielded positive outcomes. The positive effects of AR on mathematics learning were demonstrated through the various studies reviewed.

AR technology in mathematics can be applied through various approaches, each catering to different learning objectives. For instance, researchers such as Cheng -Chih Wu's Lab [19] focus on utilizing AR to enhance spatial abilities, while others like Cai [20] explore its potential for teaching probability. In our study, we took a unique approach by developing augmented content based on individual learning styles.

6 Implementation of scenarios in the AR Tool specific to a certain learning style

We develop an AR tool that enhances the learning effect by tracking 2D artefacts that trigger the visualization of the 3D geometry objects using a marker-based Augmented Reality approach, taking learning styles into account.

For this, there were designed 30 types of AR artefacts; when scanned by mobile devices camera, they trigger one of the augmented experiences, such as 3D objects, video content, audio content, text, formulae, and even virtual tutor. Using marker-based augmented developed system, learners can interact with the 3D information, objects, and events in a natural way.

Additionally, pupils can interact with artefacts to change the position, size, and color of 3D objects. Moreover, by interacting with virtual tutor, pupils can see the superimposed digital content that explains and demonstrates the basic theorems. The tool is created by using the Unity platform with the Vuforia database.

MB-AR tool will deliver a positive impact by keeping pupils' high engagement and by enhancing their learning abilities like problem-solving, collaboration, imaginative thinking, and spatial imagination.

The developed friendly interface allows even 2-3th grade kids to be used easily. The tools can be extendable to any age category, even for students. This is created by using the Unity platform with the Vuforia database. For more about workflow, see Fig. 4.

6.1 Scenarios for visual learners

For visual learners, there were developed several scenarious. For example, Figure 5 shows two of them. The first scenario allows viewing the definition of the object to be studied; in this case, it is the definition of the square. The second scenario allows viewing a video sequence in

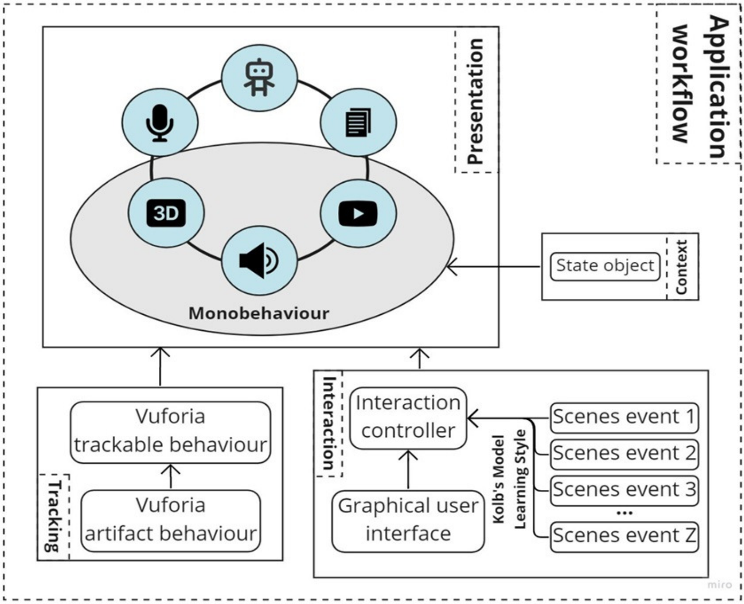

Figure 4. Workflow representation of AR tool

which the notion of the area of the square is explained, and its formula and examples of use are presented.

6.2 Scenarios for auditory learners

For auditory learners, a scenario has been developed that allows the playback of Musical visualisations of Pi (see Fig. 6), composed by Lars Erickson in the early 1990s.

The scenarios for this type of experience are as follows: 1) when the card is scanned, the pi symphony is played; 2) in the example in the middle, the user is asked to calculate the cube of the number 5; if the option 25 is selected, then in the sound form it is pronounced ”you’re wrong”; for option 255 it is pronounced ”try again”; and for option 125 it is pronounced ”is correct”; 3) the last example in this section generates the howl of the wolf.

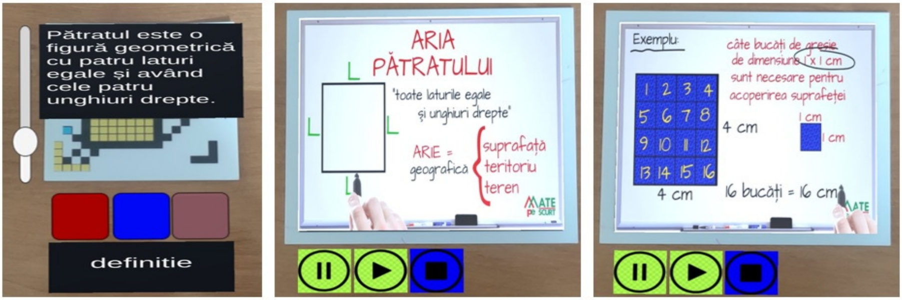

Figure 5. Scenarios for visual learners

Figure 6. Musical visualisations of Pi [12], Scenarios for auditory learners

6.3 Scenarios for kinesthetic learners

For kinesthetic learners, the first scenario has been developed that allows to change 3D object size, to rotate, and change RGB color, or even change color randomly by pressing a bigger green button (see Fig. 7) – handling the object to be learned, in this case, a cube. The second scenario allows viewing angle types.

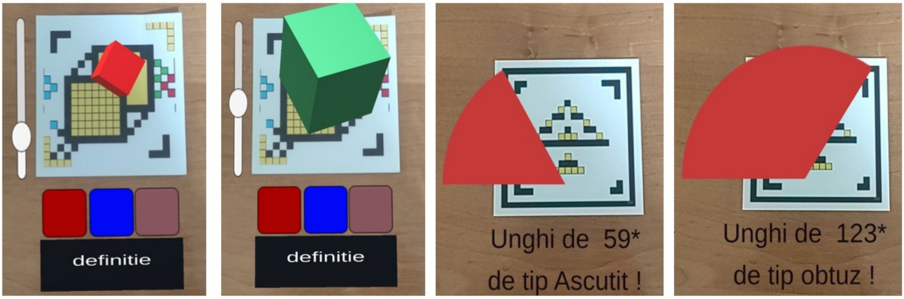

Figure 7. Scenarios for kinesthetic learners

6.4 Evaluation

To carry out the evaluation process, a test consisting of 5 questions is proposed; after selecting the answer to each of the questions, the accumulated score and the answer for each question are visualized (see Fig. 8).

This allows obtaining an immediate feed-back and strengthening the accumulated knowledge.

7 Conclusion

In this paper, an approach to classifying augmented reality based on the characteristics of different techniques was done. Additionally, the application of a specific type of AR technology in the development of an educational application was demonstrated. Furthermore, the importance of designing augmented learning scenarios that align with the VAK learning styles, aiming to deliver personalized and immersive

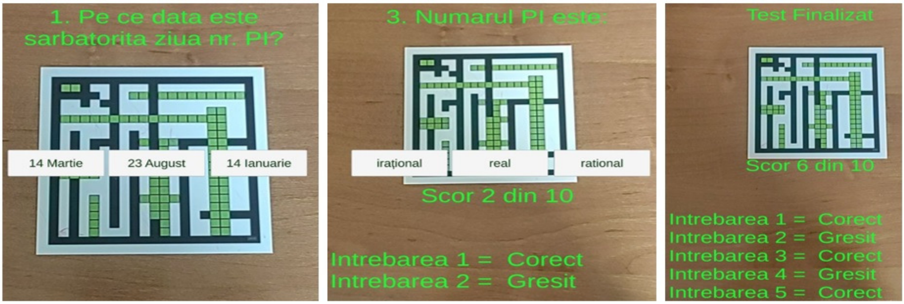

Figure 8. Some stages of scenario for evaluation

learning experiences, was emphasized. The potential for creating engaging and effective educational tools by integration of AR and VAK learning styles was shown.

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