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PAPER

Augmented Reality in Mobile Learning: Enhancing Interactive Learning Experiences

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ABSTRACT

A new platform for learning in a mobile environment was established by improvements in e-learning technologies. However, probably because of the low level of interactive learning content, many of the concepts in mobile-based learning environments have begun struggling to engage students. Therefore, this study paper proposes an augmented reality (AR) technique for the enhanced interactive learning experience for the students. A new platform for learning in a mobile environment was established by innovations in e-learning technologies. Unsurprisingly, owing to a tiny amount of interactive learning content, many of the concepts in mobile-based learning environments are now underperforming to engage students. To erect the mapping process for mobile task learners and empower the software of AR through mobile with the parameter, the deployment of mobile learning parameters is also appreciated. This study analyzes how AR could impact traditional learning methodologies by using mobile devices to combine digital information with actual surroundings. It achieves this by carrying out an in-depth evaluation of the most current research and an analysis of case studies. In regards to considerable accomplishments, AR in mobile learning might improve student engagement, boost experiential learning, and support better knowledge retention. The publication additionally includes implementation-related difficulties for AR, such as technological barriers and the prerequisite for revised instructional schemes. The study finalizes with proposals for future research to advance our comprehension of and enhance the value of AR applications in educational contexts and additionally suggests to educators and developers how to fully utilize the beneficial features of AR in mobile learning.

KEYWORDS

mobile learning, augmented reality (AR), enhancing interactive learning, modern technique to learn easily

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1 INTRODUCTION

Research on the application of augmented reality (AR) in education is significant. Because of AR, virtual objects may be included in actual environments to foster immediate interaction. There is a shortage of studies on the impacts and effects of AR in the realm of education, and study on AR applications in schools is still in its earliest phases. Because of the convenience of consumption on mobile devices and the absence of requirements for specialized equipment, AR has become more accessible. Currently, a large percentage of people believe in mobile devices, and as their actual use has risen, so has access to AR. There is an absence of study on the consequences of using mobile AR in education, but there is nevertheless room to explore the potential of AR to increase student learning motivation and contribute to improved academic achievement. Mobile AR applications are spreading swiftly, and the viability of mobile AR has increased due to advances in mobile technology. AR mobile games are available for various kinds of education, and education-related AR services are now more commonly found on mobile devices. Only a few studies have looked into how AR could be leveraged to foster student motivation, and the potential of AR in education has remained unreached [1].

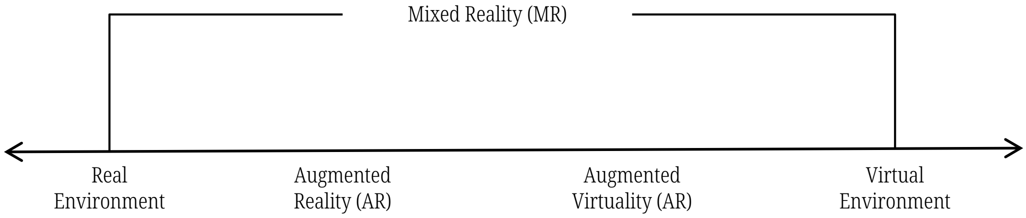

Fig. 1. The relationships that milgram distinguished as real and virtual

The differentiation between the two is situated in the realization that virtual reality (VR) is built around the expectations of users to develop a fully virtual circumstance, wherein an assortment of simulated components become tangible, therefore offering an immersive and life-like experience. AR is not reliant on any one somewhat apparent technology. By affording learners additional background and affirming their real-world experiences, it gathers inspiration from real-world circumstances. Milgram considers virtual and real as two sides and utilizes simple illustrations in Figure 1 to explain how reality and virtual are closely associated [2].

This essay has been composed just in this format. The appropriate atmosphere for mobile learning is enabled by mobile technology, as explained in the second half of this paper. A detailed introduction to AR in a mobile learning framework will be presented in Section 3. In Section 4, a live illustration of how the AR platform reacts to this unique planning is shown. Section 5 finishes with an appraisal of the more beneficially designed services for dynamic mobile learning utilizing virtual reality.

2 RELATED WORKS

As the elements of the hybrid reality continuum, AR and VR both rely on human-computer interaction [3]. They accomplish this by combining the delivery of 3D virtual important that are grounded in time and location with environment mapping. Therefore, all those variables affect AR and VR, which in essence affect MR, regardless of the definition of MR that is utilized. This is especially significant in connection with contemporary and growing definitions of the MR paradigm that incorporate principles concerning interaction, immersion, and input and output of information. The current study discovered that the integration of MMR in the classroom may contribute to a more successful educational setting that grants students stimulating possibilities for learning and learning experiences that are as opposed to their classmates. The enhanced learning characteristics of this transmission technique encompass some of its primary aspects, notably stronger motivation and engagement, enhanced communication, and additional fun and enjoyment. The implementation of these strategies into the curriculum has contributed to superior learning environments and, as a result, greater advanced learning accomplishments, specifically in the framework of architectural and construction education. This investigation prepares the path for further study on variables that lead to the growth of superior learning environments and additionally provides strategies for teachers to increase outcomes for learners. Future research attempts need to include longitudinal studies with greater numbers of participants and comparison to a typical delivery control group to get accurate results and greater knowledge of benefits and optimal utilization of technologies to build upon learning.

Given that the students adore playing games, many games are tapped in the educational settings for happiness and with no methodological approach [4]. In contrast, a lot of educational resource games fail consumer interest and are not interesting to play. Both of these are inadequate in promoting administrators in generating an environment that encourages and spurs individuals to attain educational goals. For the reason to achieve successful assimilation of games in the pedagogical procedure, the instructors must use a relationship that exists between pedagogical methodologies and entertainment. Creative thinking-based study recommendations described in this work verified that captivating enjoyment competitions, with attributes preferred among scholars, can be exploited as the platform for the construction of an entertaining pedagogical game that inspires the completion of learning outcomes. According to the feedback provided by the students, the instructional game should be built during phase two, with educational aspects added to the game's play values. By accomplishing this, we can ensure that multiple state elements—such as functionality, practicality, student attitudes and motivation, and the correct positioning of informative game components—are supplied, which would enhance the quality of learning for students.

To support museum guests, this paper describes the mobile AR touring system (M.A.R.T.S.) [5]. M.A.R.T.S. corresponds to the premises of instruction in museums looking forward by notable researchers. The objective of this study is to investigate the fact that M.A.R.T.S. is nonetheless applicable as an interface for characterizing museum exhibitions. The findings from the investigation proved that the usage of the "Selection" and "Documentation" paradigms increases understanding. Moreover, it was cheaper for visitors to grasp how the exhibits and descriptions complemented their surroundings. This leads to the conclusion that AR can pay attention to the visitor's attention by stressing and superimposing. Its magnifying and sensitive changes are well witnessed and appreciated by customers; from this standpoint, M.A.R.T.S. contributes to an advantageous learning experience. Visitors have, however, flagged some minor faults with the M.A.R.T.S. system interface's layout. The root cause of the user's attention deviations could be captured in the virtual guide's visualization. To ease the use of the interface, the human guide copresence simulation will only be obtainable in conversational mode (audio only). In addition, further investigation will be completed to improve the user interface design's ergonomics. The reconstruction paradigm module will be introduced to M.A.R.T.S., and much more study is needed to verify the viability of this mediation system and its extra significance value for museum visitors' knowledge acquisition.

The present paper conveyed a preliminary case investigation on the incorporation of AR-based mobile resources for learning EFL English composition [6]. With the support of this learning substance, English language learners gained the ability to explain information more efficiently, express it in order, and access it with less difficulty. That follows an organized learning activity; the participants' designed language and subject knowledge, meaningful essays, and involvement in the learning circumstances were all evidenced by results. Many investigations have to be done for future research to back up the outcomes achieved while supplying further understanding of the key issues tackled in the results reported. In the final analysis, the impact of language learning may be boosted by implementing AR-based mobile education resources associated with multiple learning scenarios.

About the first research question, we can conclude that usability findings gathered from questionnaires were very positive [7]. They gave an example of how technology could be utilized as a fresh instrument in educational procedures. In every instance, students have expressed satisfaction and motivation with these new approaches. Regarding the second study question, data demonstrated that AR technology can aid in boosting students' academic performance. Experimental groups consistently saw higher post-qualification gains. Thus, it appears that students feel more motivated, their graphic competencies and spatial skills rise in shorter learning times, and their academic performance improves significantly by combining an attractive technology with the user-machine interconnection that involves AR. Meanwhile, further investigations deserve to be done to completely confirm these outcomes. In final form, we might argue that AR technology, when integrated with mobile phone use, exhibits an assortment of advantages for on-site evaluation for architectural projects, urban planning, construction operations, and historical heritage studies. AR can improve the awareness of design proposals. AR also makes it easier for information to spread socially while displaying its actual size and location in real-time. This makes it possible to simultaneously examine and contrast multiple real-world or virtual ideas before construction, and it likewise renders citizen participation feasible.

We demonstrated a mobile AR education tool based on a serious treasure hunt game in this paper. This software application takes full advantage of the ARLectio® framework's capacities to assist instructors in designing AR-based learning experiences [8]. Through semi-structured interviews, an exploratory investigation of the students' observations demonstrated that implementing AR technologies improved the students' level of involvement with the treasure hunt pilot. Students in particular conveyed thankfulness for the immersive experience they had with AR technology. The possibility to make use of their mobile device—which is seldom allowed in the classroom amid traditional learning activities—was a further advantage that they loved. Ultimately, irrespective of the truth that the people in this group are students who use smartphones regularly, they were not extremely acquainted with AR, so gaining the capability to engage with 3D virtual items was extremely helpful. A further study incorporating quantitative analysis will be executed to establish the usefulness of AR technology in these fields of education. To accumulate insights and show validation of the learning processes that the AR technology encourages, the ARLectio® framework will make use of learning analytics strategies. Indeed, utilizing the xAPI standard, additional work will be rendered to include learning analytics approaches in AR classes.

The objective of the above investigation was to learn about cutting-edge, successful procedures for training for this new era of learning by utilizing AR applications for individualized mobile learning [9]. AR technology has been proven to be excellent in assisting students to absorb computer science suggestions that are challenging for normal people to understand on average. With AR, instruction is currently taking on an additional aspect where children may understand complex notions and check what is happening with clarity. Students are offered the opportunity to become more self-reliant learners who can absorb material at their speed by undertaking the utilization of this learner-centered procedure. Both marker less and marker-based visuals can be hunted and captured by the low-cost system that has been invented. To support students further, both textual and video overlays are provided on the marker scan, permitting students to pause and keep up the video as desired. Numerous difficulties were encountered throughout the AR application's advancement; nevertheless, solutions have been established. In addition to the challenges that were observed, the failure to use MP4 shows limitations on the kinds of files that could be used for graphical overlays to MD2, OBJ, and FBX. However, students can utilize the appropriate converter to first convert the FBX file to a binary format. Study on AR, an expansive field, is still progressing. AR for mobile learning can be applied in an abundance of ways. This final product is just a glimpse of what we feel to be an appealing learning aid to help students minimize the dullness of traditional education methods.

3 METHODS AND MATERIALS

This section presents a revolutionary mobile knowledge-learning technology that is based on AR. For a great deal of users, including K–12 youths, a recommended AR system strives to further improve the overall value of the educational procedure. The AR software is embedded into the handheld device technology to construct various 3D elements in a blended and collaborative environment. Our AR system integrates virtual components with actual video or image streams. Despite the vast majority of existing AR systems as a whole, these cloud-based elements can instantly communicate with those real-world disagreements and personal endeavors as if they were present in the real world. Any mobile device can be deployed to carry out the specified AR system, and no extra hardware will be needed. As perceived in Figure 1, mobile users communicate with the AR system via a control panel. The system environment initially has two modes of operation on a blank canvas: (a) Rendering of 3D components. In this mode, a printed page with the appropriate text description may incorporate an automatically yielded 3D virtual model on top of it. (b) Pictorial Expression of Practical Ideas: The given approach involves interaction between a virtual object and divergent scene sections to depict physical notions. Static images and video channels can both be employed as the system's input source for these two modes. Meanwhile, the ability to manage real-time video facilitates user-AR system interaction, enabling a more interactive atmosphere for instruction. There are four vital functional components of the suggested accessible AR system:

1. Motion estimation: The AR system on a handheld gadget improves the study of physical occurrences, encompassing gravity and mechanical concepts such as reflection. The motion of computer-generated entities in actual-life scenarios when they interact with different components, such as seats, whiteboards, and human bodies, is predicted utilizing a physics engine.

2. Page determination: The largest convex quadrilateral in a given Figure or video frame is determined to accurately identify and determine the extent of a page in a printed publication (such as a book, magazine, or journal). This technique is essential for factual text recognition and proper model rendering.
3. Text recognition: Optical character recognition (OCR) is employed for the conversion of written form on a detected page through machine-encoded characters. Using resembled perspective transformation, the printed page is curled into a new page with a standard viewing angle for more effective recognition.
4. Model rendering: Numerous simulated objects are superimposed over a currently real-world picture or video stream based on an analysis of the real-life environment. A computer-generated ball will be created to recreate the ball's interaction with various objects in nature if no printed material is identifiable. A 3D virtual model might automatically render and erupt from an identifiable printed page when the AR system discovers it and understands the connected text.

Users may also operate their mobile devices to see the 3D model from different viewpoints.

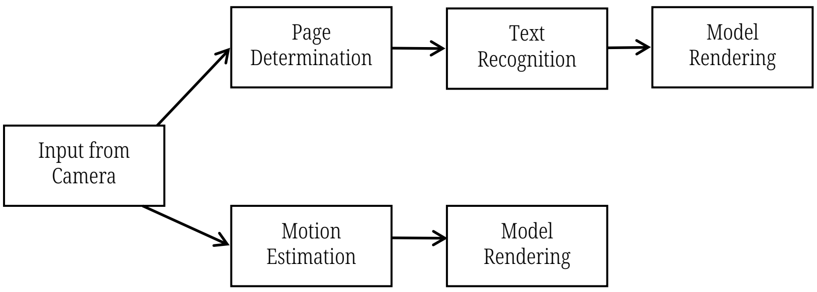

Fig. 2. Physical concept demonstration in the omission of any observed printed version

Figure 2 illustrates the physical concept demonstration in the omission of any observed printed version in a unique manner. This will enhance the AR concept in the mobile learning structure. The high-level logic overview of the mobile AR system is presented in figure. The three-dimensional computing determined by the recognized text on a detected page is performed by page calculation, text recognition, as well as model rendering modules. Based on the motion estimation for any specific virtual entity, the motion forecasting and model rendering modules support the physical creative demonstration.

3.1 Rendering of 3D images

The real-time display of 3D models is usually accomplished by utilizing video streams. Every individual video frame that is removed from a live video is managed autonomously. We explain in tremendous detail regarding what it takes to render a 3D model in one specific video frame, with Figure 2 highlighting the important sections of our strategy. First, the page determination module establishes the largest convex quadrilateral in each footage frame employed to acknowledge one page in a printed book or magazine. More particularly, a canny edge detector is used to observe all principal edges in a video frame. Keep an eye out that all video frames are minimized in size to enable swift processing and decrease noise. We then smooth and communicate those observed edges employing mathematical morphological techniques. The printed page, which is the largest area in this current scene and a convex polygon with four corners, is found by examining all image locations connected by those edges. Numerous OpenCV algorithms can be used to put the activities mentioned earlier. The text recognition module then employs Tess4j, a Java binding for tesseract OCR software, to retrieve words from the recognized page using the OCR proximity. For future reference, each word that was previously retrieved has been laid out and attributed to its tesseract confidence level. At last, a 3D virtual model is dynamically produced by the model rendering module on top of a printed page that was successfully recognized as the current scene. OpenGL leverages a 4 × 4 model view matrix to depict the transformation from the world working together to the camera coordinate, rendering it achievable to locate the 3D model being rendered precisely in the camera coordinate system. The rotation matrix R in addition to the translation matrix U can be merged to get the model view matrix *W*, or to put it in a different context: $r_{11}r_{12}r_{13}r_{21}r_{22}r_{23}r_{31}r_{32}r_{33}$

$$W = S + U = \begin{bmatrix} s_{11} & s_{12} & s_{13} & 0 \\ s_{21} & s_{22} & s_{23} & 0 \\ s_{31} & s_{32} & s_{33} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & u_y \\ 0 & 0 & 0 & u_z \\ 0 & 0 & 0 & u_a \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} s_{11} & s_{12} & s_{13} & u_y \\ s_{21} & s_{22} & s_{23} & u_z \\ s_{31} & s_{32} & s_{33} & u_a \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

In this instance, the translation matrix demonstrates the way to convert from the point of origin in the world to the camera coordinate, and the rotation matrix illustrates how to revolve from the world to the camera coordinate. Assuming that the Y and Z axes in OpenGL and OpenCV look in distinct paths, the model view matrix *W* in OpenGL requires to be inverted as outlined below:

$$W' = \begin{bmatrix} s_{11} & s_{12} & s_{13} & u_y \\ -s_{21} & -s_{22} & -s_{23} & -u_z \\ -s_{31} & -s_{32} & -s_{33} & -u_a \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Based on the real-time estimated camera pose, a 3D model is produced at a precise location in the lens's coordinate system for each character in the video frame. In addition, the most meaningful 3D model for the recognized word in the current video frame with the greatest assurance level has been identified by browsing a local model database. Based on the real-time estimated camera pose, a 3D model is created at exactly where it is in the lens's coordinate system for each participant in the video frame. In addition, the most applicable 3D model for the recognized word in the current video frame with the highest confidence level has been determined by searching a local model database. Users of our mobile AR technologies can understand physical concepts including gravity and reflection, which are frequently addressed in K–12 education courses. Particularly, physical relationships concerning a virtual ball and other objects might be spotted in both VR and real-world situations. The proposed setup has the knack of storing both live video streams and formerly saved imagery. In this case, a real-time footage clip produced by the webcam accessible on a significant number of mobile devices is used to obtain each distinct frame. To simulate most real-world physical processes, the motion estimation module uses a physics engine. Examples of this include the physics engine that enforces the Sobel filter to detect interactions between a computer-generated ball and the edges of numerous objects in the current scene. The model rendering module is then set up to impose the virtual ball and its analogous motion over an individual photograph or video stream. Ultimately, the motion estimation and model rendering courses function together to assist in the visual representation of many physical notions covered in K–12 courses [10].

4 IMPLEMENTATION AND RESULTS

Table 1. An introduction of user satisfaction with both web and native applications

Factor	Native App	Web App
Lesson Attractiveness	5.02	4.78
Assistance In Course Understanding	4.89	4.86
Entertainment	5.26	4.77
Satisfying The Learner Needs	4.97	4.85
User Ratings	4.8	4.89

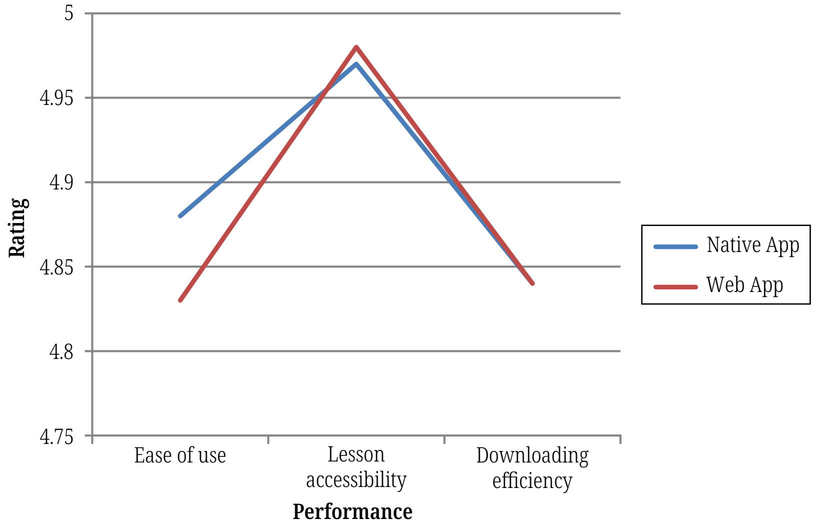

Fig. 3. A prime instance of consumer fulfillment for a web or native application

In both m-learning applications, Table 1 demonstrated user satisfaction. As shown in the table, the native application's AR technology—which delivers interactivity and aesthetic appeal—has earned an increased degree of fulfillment toward learners. The majority of scholars, however, benefit from the web-based application over its native counterpart (a slim benefit at 0.08 points). According to an interview, a vast majority of college pupils choose apps that are web-based over their native different forms, which consume up time and space right through installation (which may prove problematic for pupils with a small phone performance and space). On the contrary, web apps do not occupy more space on handheld gadgets and may be readily accessible in the form of extremely useful URL associations, which are shown in Figure 3 Under the summary, activities ought to think about loading speed and file size along with performance, download speed, and file size.

Table 2. A survey of the performance of web and native applications

Performance	Native App	Web App
Ease of use	4.88	4.83
Lesson accessibility	4.97	4.98
Downloading efficiency	4.84	4.84

Table 2 conveys that, in the realm of performance, the vast majority of pupils appreciated the digital application's lesson accessibility and ease of use mainly because it was equivalent to conventional web surfing. The usefulness of downloading was assessed equally because, in the modern era, mobile internet is powerful due to Wi-Fi and cellular benefits, suggesting that there is a minor distinction between the two types of programs. Figure 4 showcases the M-learning quality appearance utilizing a parameter learning mode.

Table 3. M-learning excellence adapting to learning mode

	Sequential	Active	Sensing	Viral
Pre-Test	7.05	3.98	5.43	6.34
Post-Test	9.4	9.7	9.2	8.12
Incremental percent	48.53%	286.69%	98.61%	35.14%

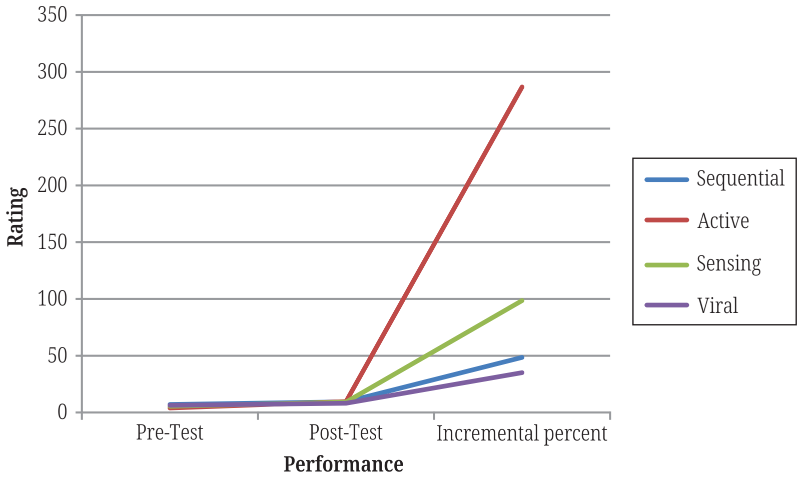

Fig. 4. Projection of m-learning quality: changing with the learning mode

Table 4. UX M-achievement in learning (augumented reality-enhanced native app)

	Sequential	Active	Sensing	Viral
Pre-Test	7.05	3.98	5.43	6.34
Post-Test	8.06	8.63	9.68	8.78
Incremental percent	27.83%	271.32%	99.49%	57.76%

Table 4 implies that along with all groups showing improvement, the sensing and visual groups showed a larger improvement than with the traditional media. This may be owing to the sensing group understood by behavior and selected combination to the actual environment, and the visual group preferred visual information in the form of animation, flowchart, or video, especially with voiceover. Conforming to Table 3, all four types of learners had increased learning achievement subsequently the UX m-learning with learning materials tailored to learner styles. The AR-enhanced native program attracted the interest of both groups. Students can access the lesson as an interactive animated film by scanning an AR code. It can be employed to supply results. This could be a reflection of the greater educational outcomes for both groups of learners [11].

5 CONCLUSION

In this work, we provide an epic AR-centered comprehension educational platform developed to boost student engagement and the learning process. Our mobile AR system possesses the capability to develop simulated items on its own and patch them on real-time audio or image streams. These virtual organisms can connect with tangible objects and reply to human behaviors in any number of real-time circumstances. For the input of static photographs or video notifications, the mobile platform delivers a showing of physical theories and the development of 3D models. The effectiveness and efficiency of the AR depiction process in varying settings are used to evaluate the system's performance. The outcomes of our experiments show that our mobile AR system can accurately determine pages and recognize text. Furthermore, the method allows interactive learning experiences for users with distinct histories, including K–12 students, and solves the real-time AR rendering requirement. The AR system's robust 3D portrayal of abstract concepts in an interactive learning environment has shown to be appealing to a substantial number of users. Soon after reviewing both applications to decide their stage of satisfaction, the four different teaching teams determined that the AR-based native application presented a more compelling and attractive user experience, generating a good first impression and enhancing user engagement. Our findings demonstrate that AR is potentially effective in the development of user encounters, as the various groups' learning achievement spiked with the sensing and visual groups displaying the most improvements. One noteworthy obtaining nevertheless is that internet-based apps are favored above native ones, with a slight 0.09-point rating difference. Due to the sample group being set up of students, some of them possessed phones that were sufficient for the native course, which demanded a great deal of bandwidth. The native application failed to be fully adopted owing to such an issue. As a way to develop a greater diversity of m-learning media that might improve learning accomplishment, the researcher will conduct study into further components and improvements in technology that could be employed in UX m-learning innovation in the future.

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