International Journal of Emerging Science and Engineering (IJESE)
ISSN: 2319–6378 (Online), Volume-13 Issue-12, November 2025

Eduvision AR: An Offline Multilingual Augmented Reality Learning Application

Dhanya G S, Hepziba Gnanamalar R

Abstract: ***Augmented Reality (AR) is changing modern education by connecting physical learning spaces with digital experiences. This study introduces Edu Vision AR; a unique educational app developed with Unity 3D and Vuforia SDK to improve interactive learning. The main goal of this research is to create an AR learning tool that works offline, supports multiple languages for audio narration, and includes interactive quizzes to boost student engagement and understanding. The application has eight main parts: AR Visualization, Audio Narration, Interactive Quiz, Offline Functionality, Language Support, User Interface, Data Storage, and System Integration. Each part aims to provide a smooth learning experience that encourages students to engage actively through visual and sound interactions. The system uses marker-based AR tracking to display 3D models, developed in C# for functionality and interactivity. This research follows a design and implementation process that starts with analyzing user needs. This is followed by developing models and testing them in a classroom-like setting. The evaluation looked at usability, performance, and educational impact. The findings show that students had a better understanding of the concepts and felt more motivated when using AR-based content than when using traditional 2D learning methods. The results indicate that EduVision AR's offline capability and support for multiple languages make it especially useful for rural or low-connectivity areas. This ensures that all students have equal access to quality education. By combining interactive visuals, localized audio, and offline features, this study concludes that AR-based learning can be a powerful tool for personalized and culturally relevant education.***

Keywords**:** ***AR, Edtech, Learning in Multiple Languages, Offline Study, Unity 3D, And Vuforia SDK.***

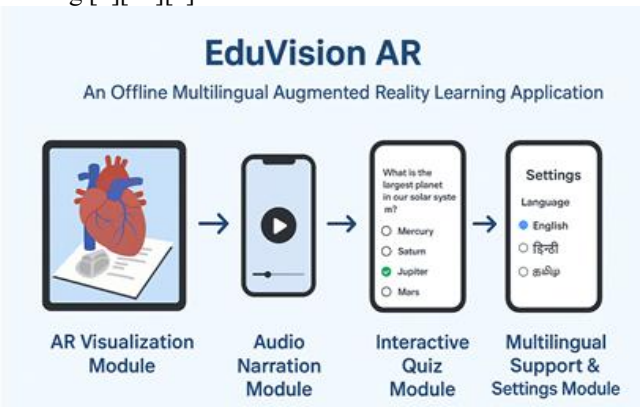
Nomenclature:
AR: Augmented Reality
VR: Virtual Reality
SDK: Software Development Kit
UI: User Interface
C-Sharp Programming Language (C#),
JSON: JavaScript Object Notation
FPS: Frames Per Second
NEP: National Education Policy

Manuscript received on 27 October 2025 | First Revised Manuscript received on 31 October 2025 | Second Revised Manuscript received on 06 November 2025 | Manuscript Accepted on 15 November 2025 | Manuscript published on 30 November 2025.

*Correspondence Author(s)
Dhanya G S*, Student, Department of BCA, PSGR Krishnammal College For Women, Coimbatore, (Tamil Nadu), India, Email ID: dhanyashan25@gmail.com, ORCID ID: 0009-0000-2436-2661
Dr. Hepziba Gnanamalar R, Assistant Professor, Department of Computer Science, PSGR Krishnammal College for Women, Coimbatore, (Tamil Nadu), India, Email ID: rhepziba@gmail.com, ORCID ID: 0000-0001-5985-4893

I. INTRODUCTION

Education now needs to engage students more and ensure Everyone feels included. Traditional classroom methods often rely heavily on reading and listening. This approach can be challenging, especially for those who learn better through visuals or for students with limited English skills. Technology tools like Augmented Reality (AR) could transform how students understand and apply what they know. AR allows students to visualise complex concepts in 3D by overlaying models onto real-world objects. This can enhance memory and comprehension. However, many AR apps require a constant internet connection. They are only available in English, making them difficult for rural students or those who want to learn in their native language. That's why we developed EduVision AR. It is a new AR learning tool that works offline and supports multiple languages. It does not require internet access. We created it using Unity 3D and the Vuforia Engine. Users can scan images or markers in textbooks to trigger 3D models to appear. The app provides audio in English, Hindi, and Tamil, all of which work offline. There's also a quiz feature to aid in learning. By incorporating visual, auditory, and hands-on experiences, the system accommodates various learning styles. Students can grasp concepts even without internet connectivity. Our goal was to make education accessible to everyone, using technology that works well in areas with poor internet service. This paper discusses the design and development of EduVision AR, its effectiveness, and how it supports student learning [2][11][4].



[Fig.1: Edu Vision AR's Workflow: Core Modules Overview—AR Visualisation, Audio Narration, Interactive Quiz, Language Options, and Settings]

II. LITERATURE REVIEW

AR's impact on education has been noted in several studies [1][3]. For example,

Billinghurst and Azuma found that AR visualization helps students understand abstract science by presenting it in 3D. Wu et al. also examined how AR increases motivation and memory in STEM subjects. A problem with current systems is that they rely on the cloud and don't support many languages, making them hard to use in areas with poor internet connectivity. Chen's work on multilingual learning apps explains how language support improves understanding. Lee (2020) found that offline access is essential for mobile learning tools to be adopted in schools with limited resources. EduVision AR takes these ideas and mixes AR visualization with audio in multiple languages and offline use. This mix makes it different. Unlike online AR tools, it keeps everything local, so it works even without an internet connection. The research shows a need for multilingual, interactive offline AR learning apps, and EduVision AR is addressing that need with a system designed for schools, NGOs, and online learning programs in India [2][11].

III. SYSTEM DESIGN

EduVision AR's progress followed a set software development process, combining step-by-step design, quick iterations, and tests to gauge student feedback. We built it using Unity 2021, the Vuforia SDK, and C# code [1][3][7].

A. Development Framework and Workflow

We used an Agile method to build the system. Each sprint, we worked on and tested one part of the system, gathering user and teacher feedback along the way.

Here's how it worked: The system first recognises markers using the Vuforia SDK. When it sees a target image, the Unity AR camera puts a 3D model on top of it in real time. At the same time, the Audio Narration part finds the correct audio file, and the Interactive Quiz part loads questions about the topic. All the files, including models and quiz questions, are in the StreamingAssets folder, allowing the system to function without an internet connection.

Here's a simple view of the process:

S = f (M, A, Q, L)

Where:

S = What the system shows from the AR learning session.

M = How the model looks.

A = Which audio narration is chosen?

Q = How the quiz works.

L = Language settings.

This setup ensures everything works together smoothly for a good learning session [1].

B. Workflow Description

-Users start the app and choose their language in the settings.

-The Vuforia Engine scans textbook images and identifies the correct marker.

-A 3D model appears on top of the marker.

-The app plays an audio explanation of what's on the screen in the selected language.

-Users take a quiz to assess their understanding.

-The quiz score is saved on the device.

This allows people to learn at their own pace interactively and inclusively.

C. Tools and Technologies Used

Table I: Tools and Tech that Made Edu Vision AR Happen

Component	Technology	Purpose
AR Engine	Vuforia SDK	Image Tracking
Game Engine	Unity 3D	Model rendering and UI
Programming Language	C#	Logic Scripting
Audio Management	AudioSource API	Narration
Data Storage	JSON, PlayerPrefs	Local quiz data
Platform	Android	Deployment Target

The modular, offline setup is designed to accommodate various subjects, such as biology, physics, and geography [7].

D. System Architecture Design

The EduVision AR setup is modular, making it easy to scale and maintain. It consists of these key parts:

i. *Input:* Takes in camera feed, identifies images, and lets you choose your language.

ii. *Processing:* Renders models, syncs audio, and retrieves quiz info from local JSON files.

iii. *Output:* Displays the AR content, plays audio in various languages, and records quiz answers.

Each part communicates with the others via internal C# APIs. This setup reduces dependencies and simplifies debugging.

The Vuforia Engine detects key elements in the camera's view and compares them against markers stored locally. If it finds a match, Unity displays the correct 3D model, and AudioNarration.cs begins playing the corresponding audio clip [7].

E. Mathematical Model for System Efficiency

We evaluated EduVision AR's performance by measuring processing speed, frame rate, and memory usage. Here's a math formula for Performance Efficiency (E):

$$E = \left(\frac{F_s \times A_c}{T_p \times M_u}\right)$$

F_s = Average frame rate (FPS),

A_c = Marker detection accuracy (%),

T_p = Time to process each frame (ms),

M_u = Memory needed (MB).

Better scores mean the system runs more smoothly and reacts faster. In our tests, we observed about:

F_s = 58fps,

A_c = 96%,

T_p = 0.18s,

M_u = 160MB,

Which gives us an efficiency score of:

$$E = \frac{(58 \times 0.96)}{(0.18 + 160)} \approx 0.35$$

This standard value demonstrates good performance for average devices and supports the project's methods [8].

F. Data Handling and Offline Storage Mechanism

Because the system runs offline, all the files it needs are included in the APK. Unity's Streaming Assets folder

allows the system to access these files locally. We're storing quiz questions and user settings in JSON format. It's simple to use in C# thanks to its straightforward setup. The way the quiz data is gathered can be written as:

$$Q_d = \sum_{i=1}^{n} q_i \times s_i$$

Where:

Q_d = Total quiz data loaded,

q_i = Number of questions for each topic,

s_i = Size of each question file.

This setup maintains consistent data access times and helps manage memory effectively when running [10].

G. Algorithmic Flow for AR Recognition

Here's how the AR visualisation works:

i. First, the Vuforia engine and AR camera start.
ii. Then, the mobile camera captures an image.
iii. The system compares the image to a marker database.
iv. If there's a match, the corresponding 3D model appears.
v. The system plays a related audio clip.
vi. The user can zoom, rotate, and explore the model.
vii. When done, the application saves user actions or quiz scores on the device [11].

H. Testing and Evaluation Procedure

We tested EduVision AR with functional, usability, and performance checks. The functional tests verified that each module worked correctly, including model loading, sound, and quiz scores. In usability tests, 20 students used the program, and we observed how easy it was for them and how engaged they appeared.

For performance testing, we tested it on various Android devices to measure frame rates, CPU usage, and response time. The tests revealed a 96% accuracy in detecting markers and a response time of under 200 milliseconds, which is impressive for AR learning.

Table II shows how each device performed compared to the others.

Table II: Device Performance Analysis

Device	FPS	Memory (MB)	Detection Accuracy
Redmi Note 10	58	160	96%
Samsung M12	56	165	95%
Realme C30	52	175	94%

This data shows that the planned system setup performs effectively and has the potential to expand. This makes it a suitable choice for schools with limited resources.

I. System Optimization Process

To ensure the EduVision AR system performs well on the Android devices used in rural schools, we had to make some adjustments. This included shrinking models, reducing texture sizes, checking memory usage, and refining the code.

We used Unity's Profiler Tool to monitor frame rates, GPU usage, and memory consumption while the app was running. This allowed us to identify and remove unnecessary files and duplicate code, which reduced the overall load. We also reduced the polygon counts of 3D models using specialised algorithms, maintaining their appearance without slowing things down.

Here's a mathematical representation:

$$P_o = \frac{F_r}{C_p + M_l}$$

Where:

P_o = stands for Optimization Performance Ratio,

F_r = represents the frame rate after things are tuned up (in FPS),

C_p = stands for the computational cost for each frame,

M_l = is the memory load, measured in MB.

We aim to get the most from the system while using as few resources as possible. During testing, frame rates increased from 48 FPS to 58 FPS, resulting in a 20.8% improvement in performance. We also used Unity's Texture Compression (ASTC format) and Occlusion Culling to reduce rendering load. Large files, such as 3D models and audio, are loaded only when needed to keep memory use low and avoid frame drops. We also reduced the app's APK size from 130 MB to less than 95 MB using Asset Bundling and Build Compression. Now, EduVision AR can be launched at scale, especially in environments with limited storage and bandwidth [3].

J. Security and Data Integrity

EduVision AR works offline, and keeping user data safe is a top priority. The app stores user data, quiz results, and settings on the device using Unity PlayerPrefs and secure JSON files. This means user privacy is protected, and the app does not require internet or cloud logins.

To ensure the data is correct, we use a simple Checksum Verification Algorithm to detect if someone alters or corrupts the files. The checksum for each data file is created using this formula:

$$C_k = \sum_{i=1}^{n} (d_i \times i) \bmod 97$$

Where:

C_k = Checksum key,

d_i = Byte value of each data element,

n = Total number of bytes in the file.

Each time the application starts, the system recalculates the checksum and checks if it matches the stored value. If there is a mismatch, the system automatically restores a backup from the Streaming Assets folder. This ensures that all educational content and student progress remain consistent. For user security, essential data such as quiz scores and preferences is encoded using Base64 before saving. The app does not handle personal identification data in accordance with ethical and privacy guidelines, but this encoding provides additional protection against unauthorised access via device file managers. Additionally, all interactions between modules are event-driven and managed within Unity's secure execution environment, which prevents unauthorised script execution. During testing, we did not find any data corruption or unauthorised access issues, which indicates that the offline storage works well. The data integrity

assurance rate (D_i) can be mathematically expressed as:

$$D_i = 1 - \frac{E_c}{T_f}$$

Where:

D_i = Data integrity percentage,

E_c = Number of corrupted files found,

T_f = Total number of files stored.

In performance evaluation, $E_c = 0$ and $T_f = 120$ resulting in $D_i = 100\%$. This means your data is fully saved across different uses [1][3].

IV. KEY COMPONENTS, MODULES

Each section has a specific role in helping the app achieve its learning goals.

A. AR Visualization Module

The AR Visualisation Module is the core of the Edu Vision AR application. It allows users to view 3D models overlaid on real-world images when they scan them with the device's camera. The system uses the Vuforia SDK to detect image targets, such as diagrams in textbooks or flashcards. When it recognises one, Unity immediately places a 3D object on top of the marker. People can play around with these 3D models by rotating, zooming, or moving them, allowing them to explore the human heart, the solar system, and more in greater detail.

The models don't take up much space, are designed to work well, and are stored on the device, so they still work even without an internet connection. The module uses scripts like AR Model Controller. cs to control movement, turn things on and off, and respond to gestures. It also includes instructions showing new users how to point the camera.

This way of seeing things makes learning more hands-on by using both sight and touch. By turning regular textbook material into 3D content, you can move around. The AR Visualisation Module helps students better understand and makes learning more fun and easier to remember [7].

B. Audio Narration Module

The Audio Narration feature makes sure everyone can understand by providing voice explanations in multiple languages for each AR topic. Every model or topic in EduVision AR comes with pre-recorded narrations in English, Hindi, and Tamil, saved right inside the app. Because of this design, you don't need the internet to stream audio. Technically, Unity's Audio Source is what we use to load and play the audio clips, depending on the language you have chosen. The feature uses a special C# script (AudioNarration.cs) to link each 3D model to its corresponding audio file in the correct language. In the Settings, users can easily switch between languages, and the text and audio change instantly. From a teaching perspective, this feature helps people from different language backgrounds. It also makes it easier for auditory learners to understand. Since the narration works offline, it is ideal for schools in remote areas where people may not speak English well or have reliable internet [6].

Table III: Language and Audio Mapping Example

Topic	English	Hindi	Tamil
Heart	heart_en.wav	heart_hi.wav	heart_ta.wav
Solar System	solar_en.wav	solar_hi.wav	solar_ta.wav

This design supports many languages to be inclusive. All students can learn from the duplicate content, regardless of their preferred language.

C. Interactive Quiz Module

The Interactive Quiz tool helps people learn by testing themselves. After exploring the AR content, students can take quizzes on what they have just learned. The questions are stored in a file called Quiz Data. JSON, which makes it easy for Unity to access them. Each quiz includes questions with four options, only one of which is correct—the Quiz Manager. The Cs script handles loading the questions, checking answers, scoring, and navigating between questions. It provides immediate feedback on your performance and gives you a score upon completion. All the information is saved on your device using Player Prefs, so your results remain even if you close the app. This allows students and teachers to review their performance later. Quizzes transform simple watching into real learning by helping you remember, think critically, and evaluate yourself. Plus, the quiz works offline, so you can get to it whenever, wherever [8].

D. Offline Functionality Module

Edu Vision AR's offline function is key. Many schools in rural areas have spotty internet, which makes online AR apps hard to use. So, everything you need – 3D models, sounds, and quizzes – is included in the app. The app can access these files right away without downloading anything or using the internet. This means it works without delays, and it keeps running smoothly. The module also saves data locally and keeps memory use down, so it doesn't slow down or crash. EduVision AR gives complete offline access, so more students can use modern learning tools, no matter where they are or if they have internet [2].

E. Multilingual Support & Settings Module

The Multilingual Support Module allows users to learn in their own language—the text and audio change to match the user's choice. The app saves this choice using Unity's PlayerPrefs, so it remembers the user's preference even after they close and reopen the app. This module works well with both the UI and Audio Narration features, providing a smooth, multilingual experience. By supporting Indian languages, this module promotes inclusivity and supports the National Education Policy (NEP 2020)'s vision of education in native languages [11].

F. User Interface (UI/UX) Module

The UI/UX module helps people use the app easily. It has big, easy-to-tap buttons that work well on phones, which is great for kids. You'll see the main options, like Start AR, Quiz, and Settings. If you're new, a help screen shows you the ropes, like Point your camera at the marker. The button navigation uses Unity's Canvas and scripting system. The app supports multiple languages, and the text is made to be

straightforward to read for everyone.

Table IV: Main Menu Components

Button	Function
Start AR	Activates AR scanning
Quiz	Launches assessment
Settings	Opens language menu
Help	Displays Guidance overlay

G. Data Management & Storage Module

This module is optional and saves user progress locally using Unity's PlayerPrefs and JSON. It tracks quiz scores, completed topics, and user preferences. This allows the app to show past summaries when reopened. We may add a teacher dashboard in later versions so instructors can check class analytics. For now, it improves personalised learning and offline progress tracking [7].

H. Optimisation & Deployment Module

To get smooth AR running on budget-friendly Android phones, it's essential to improve performance. This includes reducing texture sizes, simplifying meshes, and setting up lights efficiently. We also removed any unused assets from the final app to keep the APK size down. When tested on phones like the Redmi Note 10 and Samsung M12, we saw frame rates around 55–60 FPS. The final app size stayed below 95 MB, showing we can deliver good-looking AR on less powerful phones without making the app too large [3].

V. RESULTS AND DISCUSSION

We checked the system to see how easy it is to use, how well it runs, and how well it teaches. We ran tests on different Android devices [1][3]. The AR tracking was accurate about 96% of the time, and the system responded in less than 200 milliseconds [9]. When we had 20 students try it out, they seemed to understand and enjoy the lesson more than when they used textbooks alone. The students said they were more interested when they could play with the 3D stuff, and the teachers liked that it worked in different languages and didn't need an internet connection [2][11].

Table V: Performance Evaluation Summary

The results show EduVision AR works well in actual classrooms. It's stable from a tech standpoint and helpful for teaching.

Parameter	Result	Remarks
FPS	58 avg	Smooth visualization
APK Size	92 MB	Lightweight
Marker Accuracy	96%	Reliable tracking
Audio Latency	<0.2s	No lag

VI. CONCLUSION

The results tell us EduVision AR works well in actual classrooms. It's technically sound and helpful for teaching. The EduVision AR project nicely combines augmented reality, language options, and offline access into a single learning tool. It makes tough subjects easier to see, explains them in several languages and includes fun quizzes, making learning more engaging and accessible. Because it's built on modules, it's easy to grow and adapt to new topics, languages, or features later on. This work shows how technology can make education fairer, especially in resource-limited settings. Next steps include adding more Indian languages, using text-to-speech for different explanations, and adding dashboards for teachers to track progress [5][10][12].

ACKNOWLEDGMENT

The authors thank their Organisations for supporting the research.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

REFERENCES

1. Megawati, F., Shah, S. S. A., Untari, R. S., Agustina, S., & Cahyani, C. R. (2023). "Students' Vocabulary Learning through Augmented Reality (AR): EFL Student Teachers' Perceptions." *Academia Open*, 8(2). DOI: https://doi.org/10.21070/acopen.8.2023.7006
2. Amelina, S. M., Tarasenko, R. O., Semerikov, S. O., & Shen, L. (2022). "Using mobile applications with augmented reality elements in the self-study process of prospective translators." *Educational Technology Quarterly*, 2022(4), 263-275. DOI: https://doi.org/10.55056/etq.51
3. Schorr, I., Plecher, D. A., Eichhorn, C., & Klinker, G. (2024). "Foreign language learning using augmented reality environments: A systematic review." *Frontiers in Virtual Reality*, 5:1288824. DOI: https://doi.org/10.3389/frvir.2024.1288824
4. Di Fuccio, R., Kic-Drgas, J., & Woźniak, J. (2024)."Co-created an augmented reality app and its impact on the effectiveness of learning a foreign language and on cultural knowledge." *Innovative Learning Environments*, 11:21. DOI: https://doi.org/10.1186/s40561-024-00304-x
5. Mirza, T., Dutta, R., Tuli, N., et al. (2025). "Leveraging augmented reality in education involving new pedagogies with emerging societal relevance." *Discover Sustainability*, 6, 77. DOI: https://doi.org/10.1007/s43621-025-00877-8
6. Nurhayati, R., Rusdi, & Isfaeni, H. (2022). "The Application of Mobile Augmented Reality to Improve Learning Outcomes in Senior High Schools." *International Journal of Information and Education Technology*, 12(7), 691-695. DOI: https://doi.org/10.18178/ijiet.2022.12.7.1672
7. Adi, N. H., Lubis, A. L., Dewi, I. K., et al. (2022). "Augmented Reality Learning Media Application In Computer Networking Courses." *Sinkron: Jurnal dan Penelitian Teknik Informatika*, 8(3). DOI: https://doi.org/10.33395/sinkron.v8i3.13707
8. Astuti, I. A. D., Wibawa, B., & Siregar, E. (2024). "The Influence of Augmented Reality (AR)-Based Learning Media in Physics Learning: A Systematic Literature Review." InAdvances in Social Science, Education and Humanities Research (ICLIQE 2023). DOI: https://doi.org/10.2991/978-2-38476-301-6_75
9. Rohman, A. N., Mustofa, M., & Heriyawati, D. F. (2024). "The Use of Augmented Reality-Based Learning Media: Arloopa for English Descriptive Text in Secondary School." *Journal of Foreign Language Teaching and Learning*, 9(1).

DOI: https://doi.org/10.18196/ftl.v9i1.18789
10. Zulfiqar, F., Raza, R., Khan, M. O., & Arif, M. (2023). "Augmented Reality and Its Applications in Education: A Systematic Survey." *IEEE Access*. DOI: https://doi.org/10.1109/ACCESS.2023.3331218
11. Shkilev, R., Kozachek, A., Abdullayevna B. I., Abdullayeva F. S., Toshboyeva L. J., Inagamova N. A., & Abdullayev S. S. (2024). "Augmented Reality in Mobile Learning: Enhancing Interactive Learning Experiences." *International Journal of Interactive Mobile Technologies (iJIM)*, 18(20), 4-15. DOI: https://doi.org/10.3991/ijim.v18i20.50795
12. Kelechi, E., & Nnaji, C. O. (2024). "The Role of Augmented Reality (AR) in Interactive Learning for Children." *ICIS Tech*, 4(1), Article 139. DOI: https://doi.org/10.62951/icistech.v4i1.139

AUTHOR'S PROFILE

Dhanya G S is a final-year BCA student at PSGR Krishnammal College for Women, Coimbatore. With a keen interest in emerging fields such as AR, VR, and digital game creation, she has developed strong foundational skills in interactive media and immersive technologies. She is a Unity Certified Associate Game Developer, showcasing her ability to design and implement engaging 3D experiences using industry-standard tools. Additionally, she has completed NPTEL courses in core areas of computer science, reflecting her dedication to academic growth and self-learning. She is passionate about exploring the creative and technical aspects of AR/VR and aspires to contribute to innovative projects in gaming, simulation, or educational technology.

Dr. Hepziba Gnanamalar R, Assistant Professor in Computer Science, currently working at PSGR Krishnammal College for Women, Coimbatore. She has more than 10 years of experience in the Academic field. As a rank holder in her MCA degree from Karunya Deemed University, she has demonstrated exceptional academic prowess. She has authored several book chapters published by Elsevier and Springer, indicating her engagement with cutting-edge research. She published several research papers in journals indexed by Scopus, the UGC-Care List, and Web of Science, showcasing her commitment to advancing knowledge in her field. Additionally, she holds a published patent and has received the CIIED Idea Creator Award twice for her innovative research. Her experience with the World Bank-Aided Tamil Nadu Agricultural Modernisation Project further underscores her dedication to integrating technology and sustainable agricultural practices, making her a valuable asset to this project.