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Emerging Technologies in Education: Skill Development Through an Augmented / and Virtual Reality Bootcamp under the Government of India's FutureSkills Prime Initiative

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ABSTRACT

Augmented and Virtual are rapidly transforming education by creating immersive, interactive, and experiential learning environments. AR overlays digital information onto the real world, helping students visualize complex concepts more clearly, while VR offers fully simulated spaces for rich, hands-on experiences beyond traditional classrooms. As industry adoption grows, the skill gap between graduates and employer expectations has become more visible. To address this, universities are using project-based and experiential learning models with external partners to build both technical and soft skills. In alignment national skilling initiatives such as the Government of India's FutureSkills Prime, our AR/VR bootcamp used such activities to improve students' understanding of emerging technologies and career readiness. The study examined what skills students gained and what challenges arose when designing and implementing these bootcamp activities.

KEYWORDS: *Government of India's FutureSkills Prime, bootcamp*

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1. INTRODUCTION

Augmented Reality (AR) and Virtual Reality (VR) are transforming education by making lessons more engaging, visual, and hands-on. These technologies assist students in grasping complex concepts and experiencing scenarios that are hard to recreate in traditional classrooms. Despite this, a disconnect remains between the knowledge gained in college and the skills demanded by employers. As a result, educators are emphasizing project-based and experiential learning to help students develop both technical expertise and interpersonal abilities.

Literature Review and Motivation

Earlier studies indicate that AR and VR enhance students' interest, comprehension, and motivation. Nonetheless, research also identifies barriers such as high expenses, inadequate infrastructure, and insufficient teacher training. Additionally, strong partnerships between academia and industry are crucial to ensure that curricula align with real-world needs. However, there is a scarcity of research on well-designed AR/VR bootcamps that assess students' skills before and after training. This gap motivated the current study to examine how an AR/VR bootcamp could bridge the gap between academic instruction and industry expectations.

Methodology

The research was conducted during an experiential AR/VR course that included a focused bootcamp. Students engaged in hands-on AR/VR projects under the mentorship of industry professionals. Surveys were administered both before and after the bootcamp to evaluate improvements in students' technical abilities, soft skills, and understanding of AR/VR applications. The survey also gathered information on the challenges learners encountered throughout the training and module development process.

2. Course Details and Bootcamp Framework

AR/VR bootcamps come in various formats, but most emphasize hands-on, project-based learning using industry-standard tools and equipment. These bootcamps are designed to be intensive yet flexible, accommodating learners from diverse backgrounds.

Course Structure and Duration

Bootcamps are short, focused training programs tailored to fit the schedules of different learners. Typically, a bootcamp lasts around five days (40 hours), starting with two days of in-person sessions followed by three days of online learning.

Target Audience: Participants should have basic computer skills, and some familiarity with coding is advantageous**.** Students enrolled in technical disciplines like Engineering or B.Sc. are often preferred.

➢ **Curriculum Includes:**

- Basics of AR, VR, MR, and XR
- Programming using C# and Python
- 3D modeling and animation
- Development with Unity Engine
- Use of SDKs like ARCore, ARKit, and Vuforia
- UX/UI design for immersive environments
- Real-world projects such as building games, virtual museum tours, or industrial simulations

Delivery Modes

Bootcamps can be delivered in different ways, giving learners the flexibility to choose what suits them best.

➢ **In-Person (Offline):**

These sessions take place at physical locations like engineering colleges or training centers. Students benefit from a hands-on environment, immediate interaction with instructors, and teamwork with peers. This format works well for those who prefer structured schedules and face-to-face learning.

Additionally: Moodle platform is provided where video's and virtual lab work can be performed

Key Course Components

AR/VR bootcamps incorporate several critical elements that remain consistent regardless of the chosen delivery mode, ensuring a comprehensive learning experience for all participants:

Hands-on Projects: Practical, project-based work forms the central core of the bootcamp curriculum, where students undertake multiple smaller projects throughout the program and culminate in a substantial final capstone project, all of which contribute to building a strong, professional-grade portfolio suitable for job applications.

Mentorship and Support: Participants benefit from ongoing guidance delivered through regular weekly doubt-clearing sessions, personalized one-on-one mentoring from experienced professionals, and additional career support services designed to aid long-term success.

Industry-Standard Tools: The training curriculum employs precisely the same tools, software platforms, and workflows that are utilized by professionals working in the AR/VR industry, thereby equipping students with immediately applicable, job-ready skills from day one.

Hardware Access: During onsite or in-person sessions, students receive full access to essential hardware devices, including VR headsets and specialized controllers such as Sense XR, allowing them to gain authentic, practical experience with the equipment used in professional settings.

2.1. The Course and Student Teams

In AR/VR bootcamps, student teams are a central aspect of the learning experience, playing a vital role in developing essential collaboration, leadership, and communication skills that mirror real workplace environments. The course is structured to encourage students to learn through hands-on projects, enabling them to build strong, collective portfolios that reflect teamwork and practical application.

The Course and Student Teams

Teamwork is a key part of the AR/VR bootcamp. Instead of only focusing on theory, students work together to solve problems and develop real applications.

Team Formation and Structure

➢ **Project-Based Teams:**

Students are organized into small groups to undertake multiple projects, culminating in a final capstone project. Smaller teams facilitate active participation from all members and allow for personalized mentorship.

➢ **Individual Projects:**

Alongside team work, each student also completes their own hands-on mini-project. By the end of the bootcamp, every participant creates a functional individual project that can be improved or expanded later.

➢ **Diverse Skill Sets:**

Teams often include students with different strengths—such as design, coding, or creativity—just like real industry teams.

➢ **Mentorship:**

Instructors and industry experts continuously guide each team, offering feedback and support throughout different project phases.

Role of Student Teams in the Curriculum

Teamwork helps students understand the complete development process:

- **Collaboration and Problem-Solving:**

Students solve technical challenges together in a supportive environment, like real job situations where teamwork is essential.

- **Real-World Simulations:**

Some teams work on problems provided by industry partners. This gives students real project experience and helps them understand client requirements.

- **Portfolio Development:**

The projects created by each team contribute to a strong professional portfolio. Since each team approaches problems differently, students develop unique and creative project outcomes.

- **Soft Skills Development:**

Working in teams strengthens important soft skills such as communication, negotiation, conflict resolution, and decision-making, which are valuable in any workplace.

Benefits of Team-Based Learning

- **Enhanced Engagement:**

Working on group projects makes learning more interactive and enjoyable. Students stay more motivated compared to working alone.

- **Peer-to-Peer Learning:**

Students learn from each other's ideas, skills, and experiences. This helps them understand concepts better and creates a supportive learning environment.

- **Industry Workflow Exposure:**

Team activities follow real industry methods such as Agile or Scrum. This prepares students for how professional teams work in the tech industry.

Overall, team-based learning makes education more practical, collaborative, and career-oriented. It helps students build not just technical skills but also the real-world abilities needed to become job-ready professionals.

2.2. The Bootcamp and External Stakeholders

The bootcamp is a five-day event conducted during the semester. Its main goal is to encourage students to create practical solutions and basic business ideas by developing Minimum Viable Product (MVP) prototypes. These prototypes can be tested in real-world situations both during and after the course.

Instructors support students throughout the process and guide them in shaping their future career paths. This experience may also inspire some students to explore startup opportunities.

Bootcamp Phases

Phase 1: Orientation

Students are introduced to Augmented Reality (AR) and Virtual Reality (VR). They learn how these technologies blend digital and physical worlds, encouraging creativity, innovation, and practical learning.

The session also explains the benefits of learning AR/VR—such as improving hands-on skills, enhancing academic learning, and opening new career opportunities in emerging technology fields. Through this collaboration, students understand how immersive technologies can strengthen their creativity, technical knowledge, and industry readiness.

Further, a survey was designed where students rated their skill levels at two different points—before and after the bootcamp.

- **Initial ratings** were given on Day 1 after the coordinators explained the tasks and challenges.
- **Final ratings** were collected on Day 5, when students submitted their final project draft for presentation.

The four-day gap allowed comparison of how students' perceptions and skills changed.

The results showed that students felt more confident and technically stronger after the bootcamp. Their teamwork spirit and enthusiasm also improved noticeably.

However, some challenges were identified:

- Students need continuous access to AR/VR infrastructure.
- They benefit greatly from regular faculty mentorship.
- Many students felt that the extra time and effort required for advanced technologies are not always acknowledged within regular academic assessments.

3. Survey

The study used a quantitative approach where the same group of students was surveyed at multiple points in time to measure changes in learning and perceptions.

3.1. Survey Design

Students completed two online questionnaires:

- one after the initial bootcamp session (Day 1)
- one after the first MVP prototype was created (Day 5)

They rated different dimensions of technical challenges and learning progress on a scale of 1 to 5. The survey also included questions about:

- growth in AR/VR knowledge

- relevance of the syllabus
- usefulness of expert sessions
- additional suggestions for improvement

3.2. Data Collection

Data was collected using multiple methods:

- **Questionnaires and Surveys:**

Standard tools like the System Usability Scale (SUS) were used to measure satisfaction, effectiveness, and user experience.

- **Interviews:**

Semi-structured interviews with students and instructors helped gather deeper insights into their challenges and experiences.

- **Observations:**

Trainers used checklists to observe student progress and soft skills, especially during guided sessions.

- **Pre- and Post-Assessments:**

Tests and practical tasks conducted before and after the bootcamp measured improvements in knowledge and skills.

3.3. Data Analysis

Analysis of augmented and virtual reality (AR/VR) bootcamps shows that these programs effectively help participants gain job-ready skills. There is strong demand for talent in the growing AR/VR industry. Students improve both their technical knowledge and practical abilities, creating a skilled workforce ready for future opportunities.

Key Findings

- **High Demand for Skills:** AR/VR jobs are rapidly growing in areas like architecture, healthcare, education, and entertainment. Job postings for AR/VR engineers are increasing, showing that the industry needs trained professionals.
- **Effective Learning:** Participants in AR/VR bootcamps show significant improvements in knowledge, confidence, and intention to apply skills compared to those who don't attend. The hands-on, project-based approach makes learning engaging and practical.
- **Comprehensive Curriculum:** Bootcamps cover essential skills, including:
  - **Programming**: Commonly C# and Python.
  - **Development Tools:** Unity Engine, Unreal Engine, ARCore, and ARKit.
  - **Design Skills:** 3D modeling, animation, and user experience (UX) design.
- **Industry Recognition:** Many programs are aligned with industry standards and offer certifications (e.g., FutureSkills Prime, NPTEL) that employers value. Graduates often report positive career impacts.
- **Real-World Projects:** Students work on practical applications like game development, medical training simulations, military training, and data visualization.

Data & Metrics from Specific Bootcamps

- An initiative by C-DAC completed 16+ bootcamp batches, with over 1,750 participants, showcasing the extensive scope of the program.

Summary: AR/VR bootcamps are highly effective for bridging the gap between current skills and industry needs.

The study suggests creating a **Center of Excellence (CoE)** to provide long-term support, mentorship, and infrastructure. Students also gained valuable hands-on experience by designing and developing working prototypes in multidisciplinary teams.

REQ 2

How does the AR/VR bootcamp impacted on us as an enabler through this experiential approach of bootcamp on AR VR

An AR/VR bootcamp impacts enablers by providing them with the tools and skills to create more **engaging, immersive, and effective learning experiences**

1. **Brand Recognition & Credibility**
   - Being selected by the government to conduct such programs establishes your organization as a trusted and credible training partner.
   - Builds your reputation as an expert in emerging technologies like AR/VR, which can attract future collaborations or clients.
2. **Networking & Partnerships**
   - Opportunity to connect with colleges, universities, and industry stakeholders.
   - Opens doors for long-term partnerships, research projects, and placement tie-ups with institutions.
3. **Portfolio & Case Studies**
   - Successful bootcamps give you demonstrable outcomes and metrics (e.g., number of students trained, skills gained, project portfolios).
   - These can be showcased in marketing, proposals, and bids for future government or private projects.
4. **Skill Development for Trainers**
   - Your internal team gains experience in conducting large-scale immersive technology training programs.
   - Enhances our organization's internal capabilities and strengthens your trainer pool.

5. **Market Positioning**
- Positions our organization as a leader in AR/VR education and training.
- Increases credibility for other technology training programs or services we offer.

6. **Social Impact & CSR**
- Contributing to skill development and employment readiness aligns with social responsibility goals.
- Strengthens relationships with government bodies and enhances your organization's public image.

7. **Future Business Opportunities**
- Being part of government-funded programs can make it easier to win other projects, including industry-funded or private-sector training programs.
- Establishes a track record for scaling programs nationally or regionally.

Discussion

AR/VR bootcamps are an innovative educational model that offers significant benefits in skill development and career readiness compared to traditional learning.

Effectiveness and Learning Outcomes
- **Better Engagement and Retention:** Immersive VR experiences hold attention better than traditional lectures. VR training can result in retention rates up to 80% after a year, compared to 20% after one week for traditional methods.
- **Practical Skills:** Hands-on, project-based learning allows participants to practice in safe, simulated environments before applying skills on the job, improving real-world performance and reducing errors.
- **Career Preparedness:** Graduates are ready for roles like AR/VR developer, XR designer, and simulation engineer. They gain problem-solving, critical thinking, and digital skills that employers value.

Curriculum and Learning Experience
- **Core Technologies:** Courses cover AR, VR, MR, XR, C# programming, and platforms like Unity and Unreal Engine.
- **Experiential Learning:** Students build portfolios through capstone projects, offering a flexible and personalized learning path that contrasts with traditional theory-focused education.

Impact

College Name	Participants	Impact of Bootcamp
MKSSS's Cummins College of Engineering for Women, Pune	**127**	The bootcamp created a strong interest among students, leading to the formation of an **AR/VR Club** and the establishment of a dedicated **Excellence Lab** for immersive technologies. Students took their learning to the next level by developing an innovative **VR-based Fire Hydrant System** project.
Vishwakarma Institute of Information Technology (VIIT), Kondhawa, Pune	**166**	The bootcamp inspired students to form an **AR/VR Exploration Club**, actively promoting and experimenting with immersive technologies. The initiative encouraged cross-departmental participation and enhanced awareness of AR/VR applications in real-world problem-solving.
P.E.S. Modern College of Engineering, Pune	**101**	The bootcamp motivated students to create an **AR/VR Club**, providing a platform to explore emerging technologies and conduct peer-learning sessions. The initiative helped students gain hands-on experience and boosted their confidence to pursue AR/VR-based projects and research.

Challenges in AR/VR Bootcamps

Even with their benefits, AR/VR bootcamps face some challenges:
- **High Costs:** Expensive hardware (like VR headsets and powerful computers) and specialized software can be a barrier for individuals and institutions.
- **Technical Issues:** Learners may experience problems using different devices and platforms, which can affect their learning experience.
- **Need for Standardization:** Curricula and assessment methods must continue evolving to match fast-changing industry standards and to integrate AR/VR fully into education and training.

Conclusion on Challenges:

Despite these challenges, AR/VR bootcamps are a promising and effective way to learn. As technology becomes more accessible and the demand for skilled professionals grows, these programs are likely to expand. They offer a practical approach to learning, bridging the gap between theory and real-world skills.

4. Conclusion and Future Work

Augmented Reality (AR) and Virtual Reality (VR) bootcamps serve as powerful training platforms that connect classroom education with the real-world demands of the booming immersive tech sector. Research indicates these initiatives boost knowledge retention by up to 80% after a year, enhance skill acquisition, and improve problem-solving capabilities well beyond those of standard training formats. Through direct practice with platforms like Unity and Unreal Engine, participants gain readiness for sought-after positions in fields ranging from healthcare and manufacturing to gaming and media. In essence, such immersive programs go beyond passing fads, establishing themselves as essential tools for developing versatile, proficient teams equipped for tomorrow's challenges.

Future Work

To further enhance AR/VR bootcamps, future efforts should focus on:

Improving Accessibility and Affordability: The cost of high-end hardware, such as VR headsets and powerful computers, remains a major barrier. Exploring more affordable alternatives, including web-based AR/VR (WebAR) platforms, can make these programs accessible to a broader audience.

Curriculum Updates and AI Integration: The AR/VR industry is rapidly evolving, and curricula must keep pace. Integrating Artificial Intelligence (AI) and Machine Learning (ML) can provide more personalized learning experiences and adaptive training paths. Continuous research is needed to establish best practices for curriculum design, content development, and assessment strategies**.**

Addressing Health and Ethical Concerns: Prolonged use of immersive technologies can cause issues like eye strain, motion sickness, or discomfort. There are also ethical considerations, including data privacy and responsible use of AR/VR applications. Future programs should develop ergonomic standards, health guidelines, and robust data protection measures to ensure learner well-being.

Long-Term Impact Studies: While short-term learning outcomes are promising, long-term research is needed to understand the career trajectories of bootcamp graduates and the sustained effect of AR/VR training on industry innovation and workforce development.

Inclusive Training Programs: Bootcamps should be designed to include learners from diverse backgrounds, including older employees, beginners with limited technical experience, or those from underrepresented communities. This will help prevent digital exclusion and ensure a broader talent pool for the industry.

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