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360 Degrees of Collaboration: An Autoethnographic Approach to Developing VR-Based Aviation Maintenance Training

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Leveraging 360-Degree Video for Aviation Maintenance Training: A Collaborative Autoethnography

1. Introduction

Aviation maintenance training demands a rigorous approach due to high safety standards, cost constraints, and limited opportunities for hands-on practice in real operational environments. Traditional classroom instruction and on-the-job shadowing are crucial in preparing maintenance technicians, but these methods can be resource-intensive and logistically complex [2]. Recent innovations in immersive technologies, particularly 360-degree video, offer a promising solution by providing realistic yet controlled training environments [3].

In this paper, we propose that 360-degree video can serve as a stepping stone toward fully immersive Virtual Reality (VR) training modules, reducing the barrier to adoption for organizations with limited budgets, technical expertise, or aircraft availability.

This study has two primary aims. The first aim is to document a collaborative autoethnography capturing our interdisciplinary project team's personal experiences and reflections. The second aim is to present a practical guide for those interested in implementing 360-degree video in aviation maintenance training, using the example of an aircraft tire change procedure.

The specific questions guiding the study are:

1. How did each team member's expertise shape the development of the 360-degree VR module?
2. What reflections emerged from the collaborative autoethnographic process?
3. What practical steps (how-to) are needed for effective 360-degree video production and implementation in training contexts?

2. Background

2.1 Aviation Training Challenges

Aviation maintenance training faces well-documented constraints: high operational costs, tight safety regulations, and limited aircraft availability for hands-on practice [4-6]. Traditional methods often rely on face-to-face instruction and supervised practice in hangars, but these can strain resources when dealing with large cohorts or geographically dispersed learners [7]. Several studies, including those listed above, highlight that aviation mechanics and technicians frequently encounter skill gaps, particularly when rapidly evolving aircraft technologies outpace training updates [8].

2.2 VR and 360-Degree Video in Training

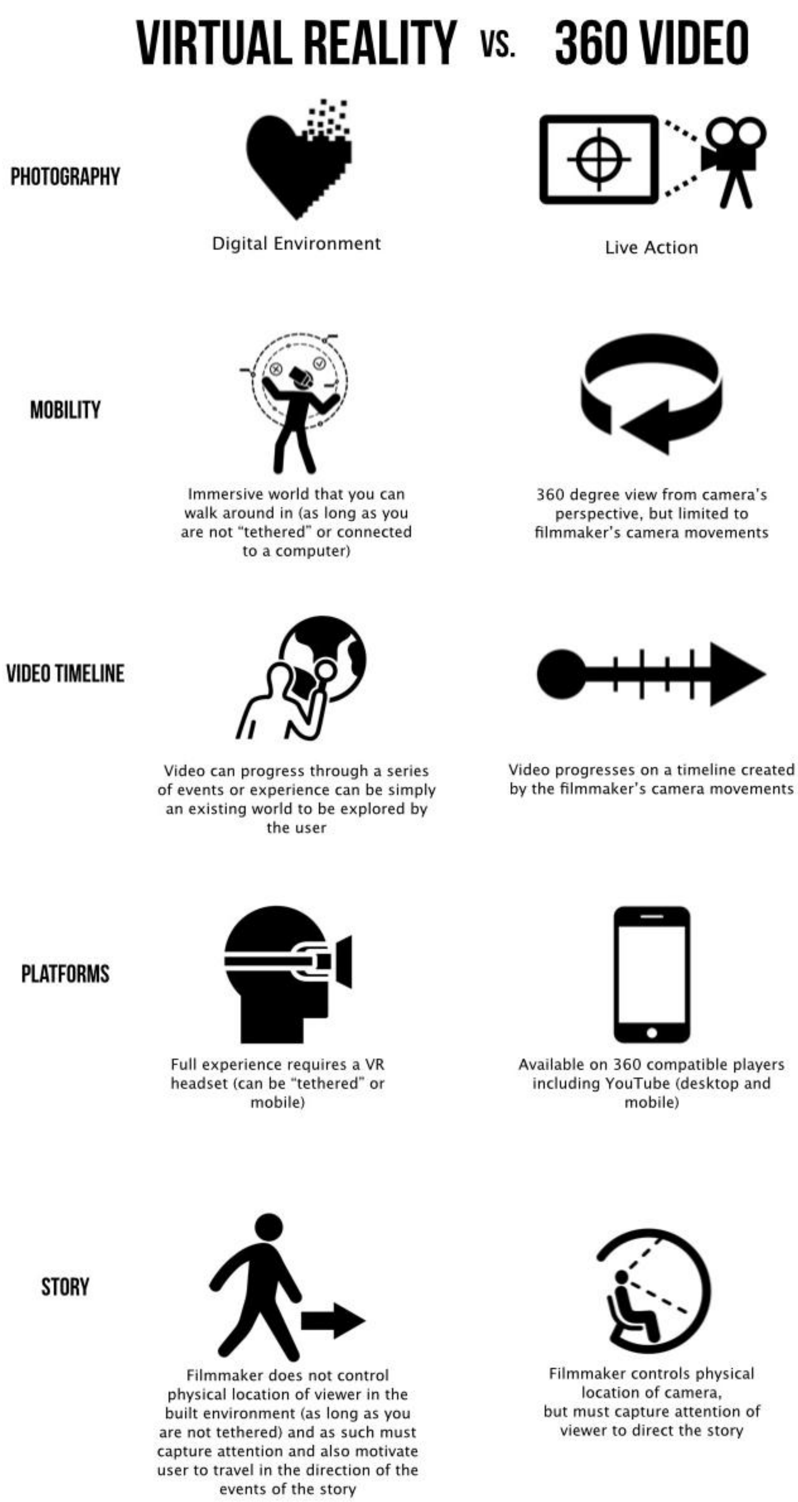


Figure 1. Summary of Differences Between VR and 360-Degree Video [1]

Virtual Reality (VR) encompasses a spectrum of immersive experiences, ranging from basic 360-degree video (where learners can look around a real-world scene) to highly interactive, computer-generated simulations. The benefits of fully immersive VR are well-documented, particularly in therapeutic and educational contexts. Research indicates that immersive VR can enhance learning outcomes and facilitate cognitive rehabilitation by providing realistic and engaging environments for users. The ecological validity of fully immersive VR experiences is significant, as they closely replicate real-world interactions, which can lead to improved transfer of skills learned in VR to real-life situations. However, the high costs associated with the necessary hardware and software can limit the widespread adoption of fully immersive VR solutions.

In contrast, 360-degree video provides a more accessible entry point, using spherical cameras to capture real environments for playback on headsets or even standard web browsers. This lower barrier to production and implementation can help organizations "prime" their workforce for eventual adoption of full-scale VR [9].

Studies have shown that immersive video can significantly enhance engagement and retention of information, making it a valuable tool in educational settings [10, 11]. Furthermore, the use of 360-degree video has been linked to improved learning outcomes, as it provides a more interactive and immersive experience compared to traditional instructional methods [12].

A summary of differences between VR and 360-degree video are provided in Figure 1.

2.3 Autoethnography as a Method

Autoethnography is a type of research that combines autobiography (personal experience) with ethnography (the study of cultures and societies). In other words, it's when a researcher uses their own lived experiences to analyze and reflect on cultural or social issues. It allows researchers to examine their experiences in a cultural or organizational context [13]. Collaborative autoethnography extends this approach to researchers or practitioners, each contributing personal narratives to form a composite understanding [14]. In recent STEM and engineering education contexts, collaborative autoethnography has provided rich insights into team dynamics, technology adoption, and pedagogical innovations [13].

2.4 Positioning 360 Video as a 'Stop Gap' Solution

Implementing fully interactive VR modules may be cost-prohibitive or technically daunting for many aviation training programs. In such cases, 360-degree video can act as a "stop-gap" or interim approach, offering immersive, context-rich experiences with minimal hardware requirements [10, 11]. This project exemplifies how a small team—consisting of an Aircraft Mechanic/Hangar Manager, a VR Specialist, and a Training/Education Specialist—collaborated to produce a 360-degree video module focusing on an aircraft tire change procedure.

3. Methods

3.1 Collaborative Autoethnography Design

We adopted a collaborative autoethnography to capture the multifaceted nature of developing a 360-degree video training module. This interpretive/qualitative model highlights the subjective experiences of team members, acknowledging that each participant's expertise and reflection provide unique insights into the project's challenges and opportunities.

3.2 Participants and Roles

- Aircraft Mechanic/Hangar Manager: Certified Airframe and Powerplant (A&P) mechanic, U.S. Coast Guard aviator, and supervisor with extensive experience in quality assurance and training new mechanics.
- VR Specialist: Experienced in immersive technology and media production, handling camera setup, video editing, and basic VR user interface design.
- Training/Education Specialist: Focused on instructional design, learning objectives, assessment strategies, and overall curriculum alignment.

3.3 Data Collection

The data was collected in the form of autoethnography. First, reflection was encouraged through (1) personal reflections, (2) focus group discussions were conducted at the mid-point and conclusion of the project, and (3) meeting notes from project check-ins. At the end of the project, each participant responded in writing to the following guiding reflection questions:

- “What challenges did you face related to your role?”
- “What surprised you during development?”
- “What advice would you give someone else in a similar position?”

3.4 Ethical Considerations

All team members provided informed consent for their reflections to be used in this study. Since this was an internally focused project, anonymity was not a primary concern; however, we agreed to keep specific organizational details (e.g., location, aircraft registration) confidential. We sought to ensure the authenticity of personal reflections by encouraging open dialogue and providing opportunities for members to review their narratives before publication.

4. Results and Reflections (Autoethnographic Narratives)

4.1 Aircraft Mechanic/Hangar Manager’s Perspective

Initial Thoughts: “My interest in developing a VR training module was immediately drawn to its potential in aviation maintenance, given my experiences as an A&P mechanic and a U.S. Coast Guard aviator. I’ve seen firsthand the challenges of maintaining aging aircraft fleets, mentoring junior mechanics, and overseeing maintenance quality assurance. The idea of using VR to streamline onboarding and reduce the burden on experienced mechanics intrigued me—especially given the growing workloads in the aviation industry 1818. New hires typically rely on mentorship, which consumes valuable labor hours. A VR module featuring an experienced A&P mechanic performing a specific maintenance task—discussing tools, consumables, potential pitfalls, and references to maintenance manuals—would let new hires access on-demand training and free up experienced personnel for other tasks. This approach could significantly boost productivity and reduce costs if properly implemented.”
Technical Aspects: “In developing the tire change module, we followed Piper Archer’s maintenance manual procedures to ensure we aligned with the manufacturer’s recommended methods. Emphasizing proper Personal Protective Equipment (PPE) use and regulatory compliance was another priority. We wanted trainees to see the entire maintenance evolution—from referencing the right technical manuals and preparing the aircraft, to performing the task, restoring the plane to flight-ready status, and documenting the work.”
Influence of Daily Experiences: “I know the realities of working on unfamiliar aircraft—locating tools, finding the right consumables, referencing manuals, configuring the aircraft, and updating logbooks. My day-to-day experiences influenced the content we included, making sure that the module addressed actual pain points mechanics face.”
Challenges in Translating Procedures to VR: “Initially, we wanted a hands-on VR environment for specific Piper Archer tasks. However, building this would have required

extensive modeling of aircraft parts, 3D printing physical components, and a much larger budget and timeline. Our goal wasn't to teach basic tool handling or assembly but to share insights that typically come from mentorship. So, we decided on 360 video to keep the project scalable and impactful. In the future, more advanced VR technologies may make the original concept more feasible by reducing costs and development time. But for now, a streamlined approach offered immediate value."
Significant Moment: "A turning point came when an aviation professor, who had developed aircraft VR programs, explained the complexities of creating fully interactive VR environments—needing specialized expertise, significant funding, and logistics. This discussion pushed us toward a low-cost, high-impact solution: recording an experienced mechanic with Insta360 cameras and overlaying step-by-step instructions. This method, though less hands-on than full VR, effectively substitutes for traditional mentorship in a fraction of the time. As VR evolves, this approach could evolve too, eventually incorporating more immersive and interactive elements."
Applying Insights to Other Industries: "The principles here can extend to any industry needing to onboard new hires efficiently. Instead of tying up mentors or supervisors, organizations can create on-demand training modules that reduce labor hours, expedite new-hire familiarization, and boost productivity. Ultimately, this means lowering training costs, raising confidence among new employees, and improving operational efficiency (Walter, 2000)."

4.2 VR Specialist's Perspective

Initial Impressions: "I've been passionate about VR for around eight years. … Working with the team helped me identify what tools we already had and how we could leverage them to meet the learners' needs."
Role and Responsibilities: "My role primarily relied on my technical knowledge of VR hardware and my experience in developing VR training. … I also handled initial video editing, splicing footage, adjusting audio, and syncing the 360 video with first-person POV clips."
Translating Reality to Virtual: "We debated whether to build a fully virtual environment or use 360-degree cameras. … We carefully chose camera angles so learners would have a feasible vantage point that mirrored real-world perspectives. … We integrated real checklists using OrchestrateVR's hotspot feature."
Technical and Logistical Hurdles: "Batteries were a surprising but recurring challenge. … On the software side, we initially wanted to share the full maintenance manual via a single hotspot, but discovered hotspots in our chosen platform only function at specific timecodes. We ended up incorporating the entire manual at the beginning, then adding snippets during the procedure."
Moments of Realization: "Our first breakthrough was finding a VR tool that we could use at low or no cost. … Over time, I've realized VR's power lies in the concept of 'experience'—social constructivism in action."
Future Outlook: "I see more industries adopting VR all the time. … Personally, I'd love to see greater interactivity within 360-photo environments, blending real-world images with digital assets."
Personal and Professional Growth: "This project came at a time when I was thinking about the VR job market. … I once thought I'd stay in VR language learning, but I'm now more drawn

to workforce training—meeting subject-matter experts, figuring out their unique challenges, and tailoring VR solutions to match."

4.3 Training/Education Specialist's Perspective

Initial Thoughts on the Project: "Initially, I was excited about creating a fully interactive VR experience. … As we examined the technical requirements, we realized … we should pivot to 360 video."
Instructional Design and Learner Engagement: "I leaned on experiential learning and task-based instruction. … I incorporated interactive elements like hotspots, embedded quizzes, and immediate feedback."
Aligning Educational Goals with VR Technology: "One major gap in adopting VR technology is aligning educational goals with what the available VR systems can do. … Instead of jumping straight into a fully interactive solution, we started with 360 video."
Feedback Mechanisms: "To assess engagement and effectiveness, we integrated real-time hotspots that provided additional info. Post-session quizzes and a feedback survey measured training effectiveness."
Educational Theory in Practice: "We used spaced repetition and scaffolding—introducing tire-changing in a step-by-step process. … Eventually, we envision a second phase where the student performs a virtual tire change in a simulated environment."
Future of VR in Education: "I'm optimistic about VR's future in education. … 360 video serves as a perfect interim solution. … This stepping stone is critical for widespread VR adoption."

4.4 Emergent Themes

From these perspectives, four cross-cutting themes emerged, as shown below.

1. Collaboration

Frequent communication was crucial to balance technical accuracy, production feasibility, and instructional design.

2. Safety Protocols

Filming in an active hangar heightened the need for vigilance and compliance with regulatory procedures and PPE.

3. Technical Adaptation

Team members adapted to hardware and software constraints (camera angles, battery issues, hotspot timecodes) and real-world maintenance manuals.

4. Iterative Improvement & Educational Alignment

Pilot testing and feedback loops guided script adjustments and refined both interactive design (hotspots, quizzes) and overall instructional strategy (scaffolding, spaced repetition).

These themes align with the broader literature on VR adoption in aviation, emphasizing iterative, stakeholder-driven development processes while underscoring the critical balance between pedagogical needs, logistical realities, and user experience considerations.

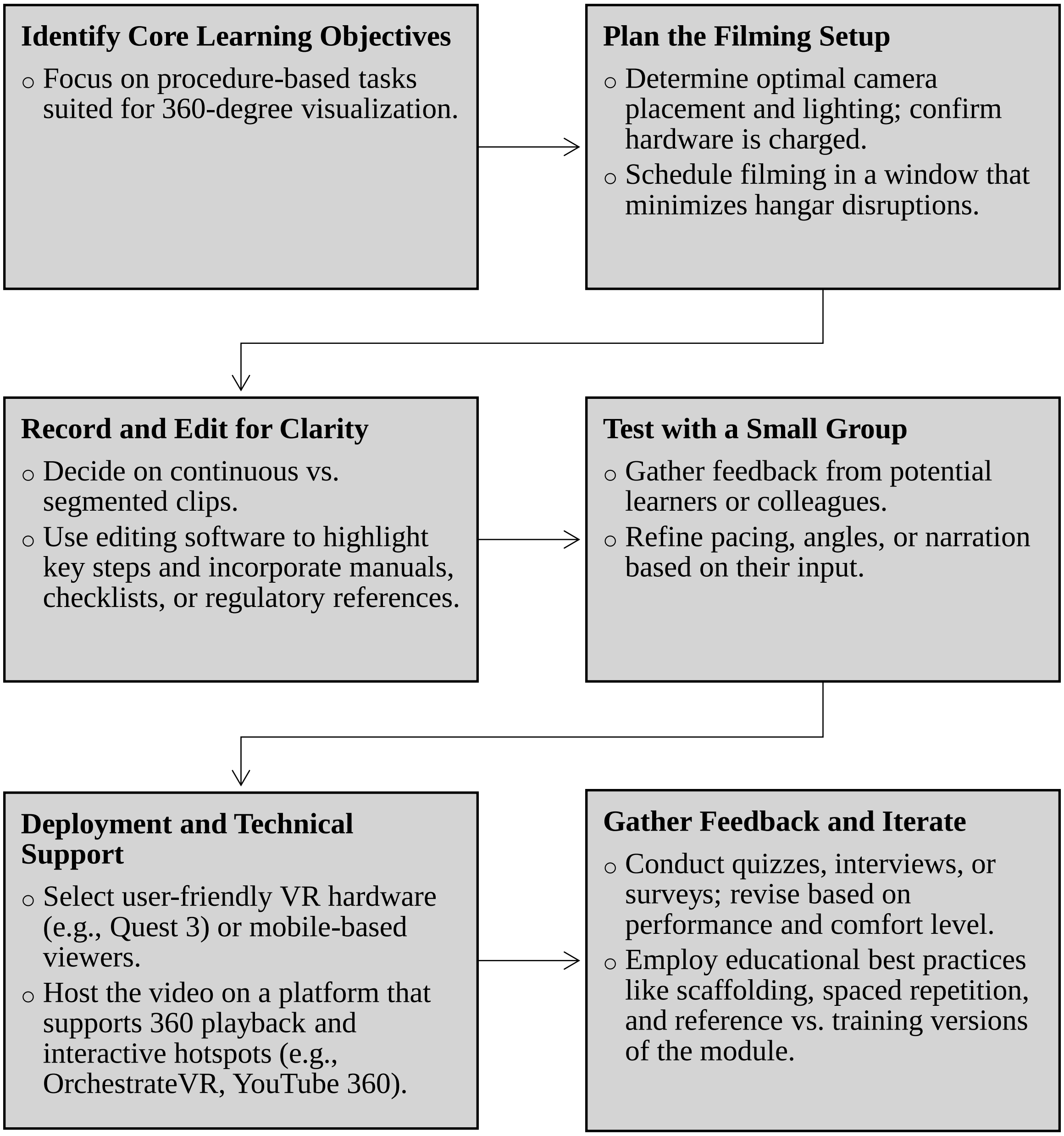
5. Discussion

5.1 Bridging Reflection to Practice

Our autoethnographic narratives illustrate how combining technical, managerial, and instructional perspectives enabled the efficient creation of a 360-degree training module. From the Mechanic/Hangar Manager’s insights into real-world procedures to the VR Specialist’s focus on hardware/software tools and the Education Specialist’s emphasis on instructional design, the project benefited from overlapping but distinct areas of expertise.

5.2 “How-To” Guide for 360-Degree Video Implementation

Based on our collective reflections, we propose the following roadmap, as shown below.



5.3 Advantages and Constraints of 360-Degree Video

- Advantages:
  - Lower cost and simpler production than fully interactive VR.
  - Faster adoption for organizations new to immersive training.
  - Safe environment for demonstrating high-risk procedures.
  - Basic interactivity (e.g., hotspots, embedded quizzes) can still be included.
- Constraints:
  - Limited interactivity; learners cannot manipulate virtual objects directly.
  - Potential for motion sickness if camera movement is abrupt.
  - Hardware/battery and software/platform limitations.

- It cannot fully replicate tactile, hands-on experiences.

5.4 Positioning 360 Video on the VR Continuum

As the Mechanic/Hangar Manager emphasized, 360-degree video can cut mentorship costs and provide on-demand reference material for new hires. This "stop gap" can evolve into fully interactive VR as the technology becomes more affordable and robust. Such a phased approach offers immediate value while allowing organizations to explore more complex simulations down the line.

5.5 Limitations of the Current Study

Being an autoethnography, these findings are context-specific, reflecting our unique blend of roles, organizational constraints, and time/budget factors. Due to the exploratory scope, we did not include quantitative performance metrics—such as the average time to complete a tire change or error rates. Future research might integrate autoethnographic narratives with more rigorous quantitative assessments (e.g., pre/post tests, retention rates over time).

5.6 Future Directions

1. Additional Maintenance Tasks: Expand 360 video modules to cover more procedures (e.g., engine checks, avionics troubleshooting).
2. Longitudinal Studies: Measure long-term skill retention, real-world performance, and cost savings.
3. Blended Solutions: Combine 360-degree video with fully interactive VR modules incorporating hands-on practice.
4. Multi-Industry Applications: Apply this approach to other sectors facing onboarding challenges, leveraging on-demand, mentor-substitute modules.
5. Instructional Perspectives: Expand the assessment beyond the direct instructional team to include perspectives of other instructors to understand the advantages and disadvantages of moving away from human interactions with mentors.
6. Student Perspectives: Expand the assessment beyond the instructional team to include student perspectives to understand the advantages and disadvantages of moving away from human interactions with mentors.

6. Conclusion

6.1 Summary of Key Insights

This collaborative autoethnography highlights how a team with varied expertise—mechanical, managerial, technological, and pedagogical—collaborated to create a 360-degree training module for an aircraft tire change procedure. Our reflections underscored the value of leveraging authentic maintenance insights, user-friendly VR tools, and sound instructional design practices. The result is a cost-effective "stop gap" that addresses immediate training needs while paving the way for more advanced VR integration in the future.

6.2 Practical Implications

For aviation trainers, educators, and industry stakeholders, 360-degree video modules can reduce mentorship burdens, expedite onboarding, and streamline training while maintaining safety standards. Organizations can offer new hires an on-demand learning resource that complements traditional instruction by incorporating best practices—such as referencing official maintenance manuals, emphasizing PPE, and embedding interactive hotspots.

6.3 Final Reflections

Immersive technologies, from 360-degree video to fully interactive VR, have transformative potential for aviation maintenance training. Our experience reveals the importance of team-based expertise, iterative design, and cost awareness. As VR technology advances, we anticipate even more sophisticated tools will become accessible, enabling richer simulations that further enhance safety, reduce costs, and support the aviation industry's evolving needs.

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