FH Vorarlberg - University of Applied Sciences

Web Applications (wap/INF)
Winter Semester 2025/2026

Lexi

Object Recognition Assistant (ORA)

A Modern AR-Based Language Learning Application

Project Documentation

Group DEF

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Mock-Up Documentation: December 19, 2025
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Contents

1 Project Idea and Task Description

1.1 Task Selection

For this project, we selected the task *"Irgendwas mit AR"* (Something with AR) from the available options in the Web Applications course. This decision was driven by our team's interest in emerging technologies and the potential to create a meaningful solution that addresses real-world challenges faced by the FH Vorarlberg community.

The AR task provided creative freedom to define our own use case while emphasizing client-side web development, which aligns perfectly with the course objectives of building responsive, browser-based applications using modern web APIs.

1.2 Project Concept: Object Recognition Assistant

Lexi - Object Recognition Assistant is a client-side web application designed to help international students at FH Vorarlberg overcome language barriers through technology. The application combines object recognition with language learning to provide an interactive, context-based vocabulary acquisition tool.

Core Idea:

- Users scan real-world objects using their device camera
- The application identifies the object and provides its name in German
- Additional information includes pronunciation guides, definitions, and example sentences
- Scanned objects are saved to a personal collection for later review
- A friendly mascot "Lexi" guides users through the learning experience

Slogan: *"Learn with Lexi"*

1.3 Target Audience and Use Case

Primary Users:

- International students at FH Vorarlberg (A1-B2 German proficiency)
- Exchange students on short-term programs
- Incoming students in preparatory language courses

Use Case:

International students often encounter everyday objects on campus or in daily life for which they don't know the German name. Traditional dictionaries require typing, which is slow and interrupts the learning moment. **Lexi** enables immediate vocabulary acquisition by simply pointing the camera at an object.

For example:

- A student sees an unfamiliar item in the cafeteria → scans it → learns it's a "Brezel"
- In class, a student scans classroom objects to build vocabulary
- Before an exam, a student reviews their collection of scanned objects

Integration with FHV:

The application can be integrated into German as a Foreign Language (DaF) courses at FHV as a supplementary learning tool. FHV serves as a test institution for potential expansion to other educational settings.

1.4 Project Goals

Primary Objectives:

1. Enable instant object identification and translation through camera-based scanning
2. Provide context-based vocabulary learning in real-world situations
3. Create an intuitive, mobile-first interface requiring minimal technical expertise
4. Use gamification (Lexi mascot) to encourage regular use and engagement
5. Support smoother integration of international students into the FHV community

2 Mock-Up Presentation

2.1 Design Approach

The **Lexi** interface follows a mobile-first design philosophy with emphasis on:

Simplicity:

- Clean, focused screens with single primary actions
- Minimal cognitive load for users with varying German proficiency
- Clear visual hierarchy guiding users to next steps

Accessibility:

- High contrast colors (WCAG AA compliant)
- Large touch targets (minimum 44x44px)
- Simple language avoiding complex vocabulary
- Icon + text combinations for clarity

Engagement:

- Lexi mascot provides personality and encouragement
- Positive reinforcement after successful scans
- Collection feature motivates continued use

2.2 Visual Design System

2.2.1 Color Palette

Color	Hex Code	Purpose
Primary Blue	#4A90E2	Buttons, headers, trust/learning
Secondary Orange	#F5A623	Call-to-actions, highlights
Background White	#FFFFFF	Main backgrounds
Light Gray	#F7F7F7	Secondary backgrounds
Dark Gray	#333333	Text

Table 1: Application color palette

2.2.2 Typography

- **Headings:** Montserrat Bold (24-32px)
- **Body Text:** Open Sans Regular (16-18px minimum)
- **Focus:** Readability and modern aesthetics

2.2.3 Lexi Mascot

The mascot "Lexi" serves as the application's friendly guide:

- Simple, modern illustration style (80-100px height)
- Gender-neutral appearance for inclusivity
- Expressive features showing different emotions (welcoming, encouraging, celebrating)
- Appears on all screens with contextual messages

2.2.4 Lexi Mascot Illustrations

Lexi appears throughout the application in various poses, each conveying a specific emotional state or activity to provide contextual guidance and encouragement to users.

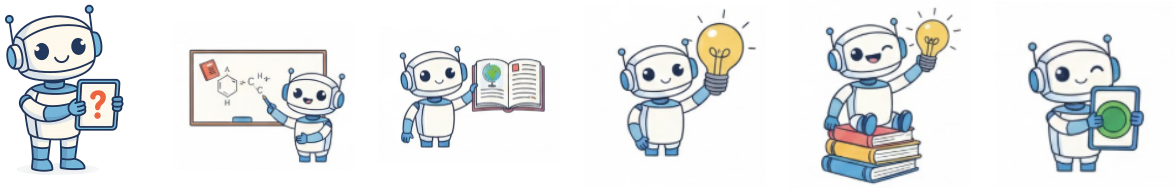

Figure 1: Lexi mascot character variations showing different emotional states and activities

Character Usage:

- *Curious:* Used on help screens and when prompting user questions
- *Teaching:* Appears during tutorials and explanatory content
- *Reading:* Shown in collection/review modes to encourage studying
- *Idea:* Displayed when providing tips or suggesting features
- *Learning:* Used to motivate continued vocabulary building
- *Scanning:* Appears during camera/object recognition activities

2.3 Core Screens

2.3.1 Welcome Screen

Purpose: Entry point and language selection

Key Components:

- Lexi mascot with welcoming animation
- Application name and tagline: "Learn with Lexi"
- Language selector (German/English)
- "Start Scanning" button (primary action)
- "View Collection" link

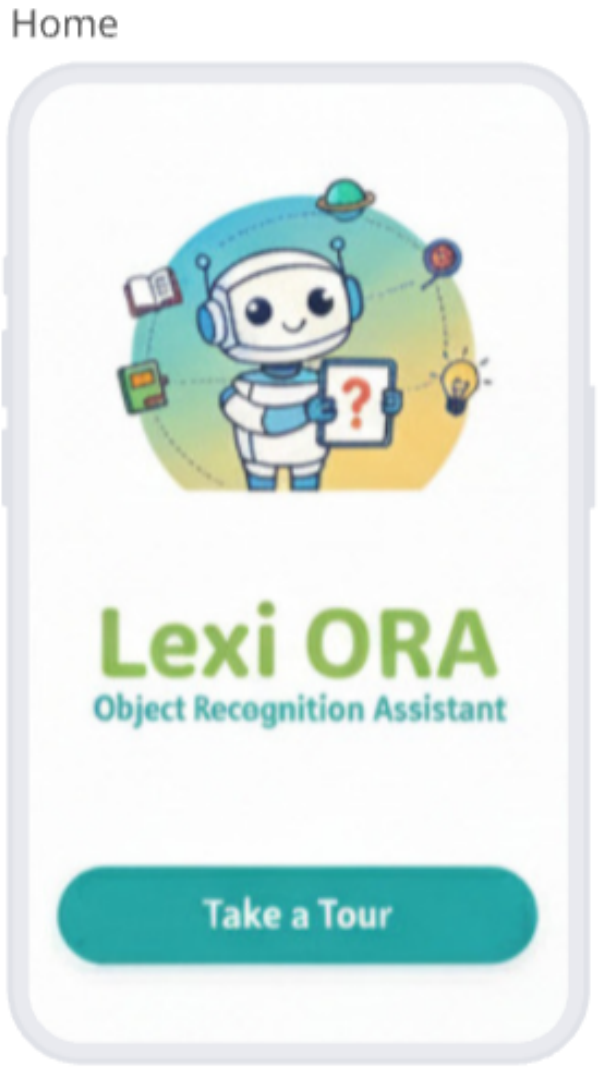

Figure 2: Welcome Screen with Lexi and language selection

2.3.2 Explorer Mode

Purpose: Camera permission handling and user guidance

Key Components:

- Lexi mascot with speech bubble
- Camera permission request message: "Please give access to the camera"
- Clear visual indication of camera requirement
- Bottom navigation bar (Settings, Camera, Collection)
- Friendly, non-threatening permission prompt

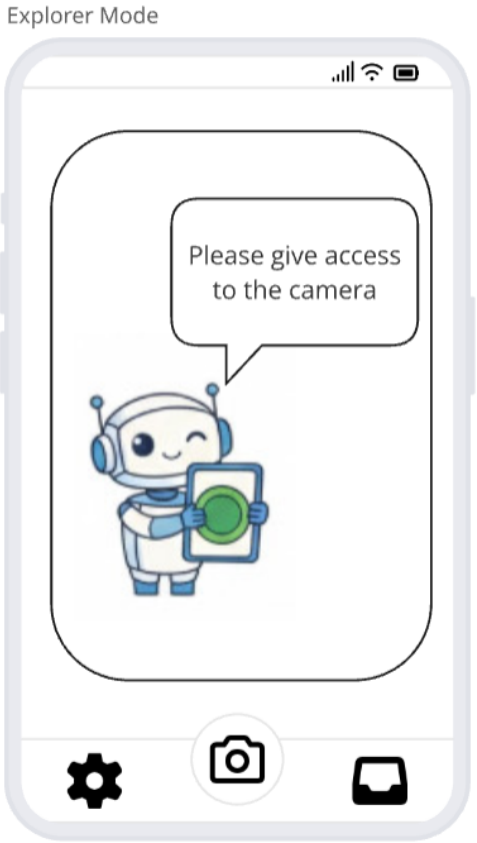

Figure 3: Explorer Mode - Camera permission request with Lexi guidance

2.3.3 Camera Screen

Purpose: Capture images of real-world objects

Key Components:

- Live camera feed (full screen)
- AR viewfinder overlay (frame for object)
- Large capture button (bottom center)
- Lexi avatar with tips: "Center the object in the frame"
- Flash and camera switch controls
- Back button

Figure 4: Camera Screen with AR overlay

2.3.4 Success Snapshot

Purpose: Confirmation of successful object recognition and save

Key Components:

- Success banner: "Added to My Index Cards" in turquoise
- Captured object image with AR overlay effect
- Object information display (name, pronunciation, definition, example)
- Bottom navigation bar with highlighted camera icon
- Visual feedback confirming action completion
- Option to capture another object immediately

Figure 5: Success Snapshot - Confirmation of saved vocabulary card

2.3.5 Collection Screen

Purpose: Browse and review saved objects

Key Components:

- "My Collection" header
- Search bar
- Grid view (2 columns on mobile)
- Each card shows: thumbnail, object name, date
- Filter/sort controls
- Empty state: "Start scanning to build your collection!"

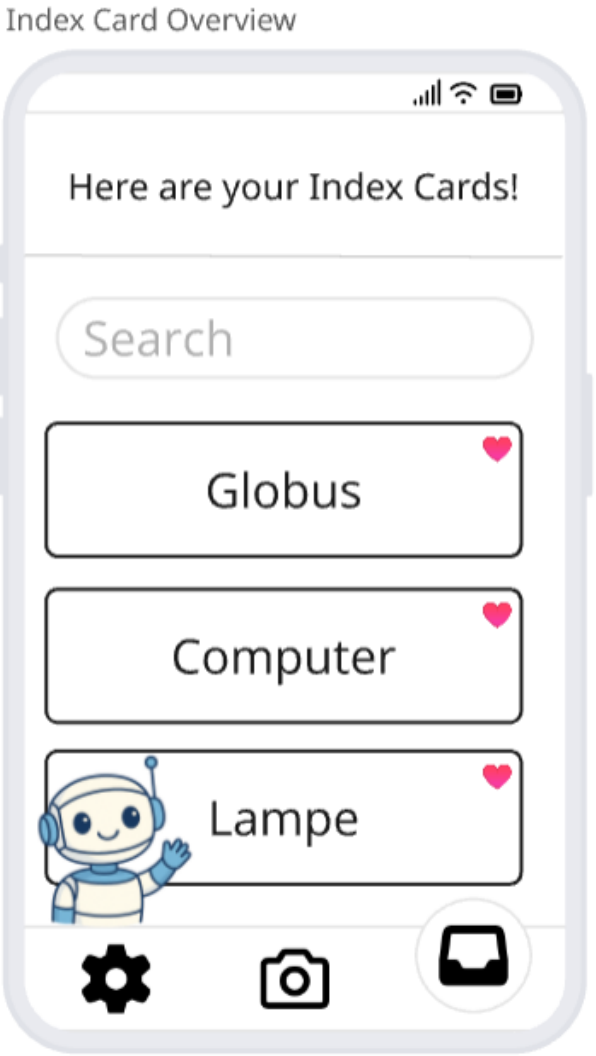

Figure 6: Collection Screen - Personal library

2.3.6 Result Screen

Purpose: Display recognized object information

Key Components:

- Captured image (top 40% of screen)
- Object name in German (large, bold)
- Pronunciation guide (phonetic)
- Brief definition
- Example usage sentence
- "Save to Collection" button
- "Scan Another" button
- Celebrating Lexi animation

Figure 7: Result Screen with translations and information

2.3.7 Settings Screen

Purpose: Application configuration and user preferences

Key Components:

- Lexi mascot avatar in center
- Language Settings option with globe icon
- My Account option with crown icon
- Contact us! option with envelope icon
- Bottom navigation bar for quick access
- Clean, minimalist design with clear hierarchy

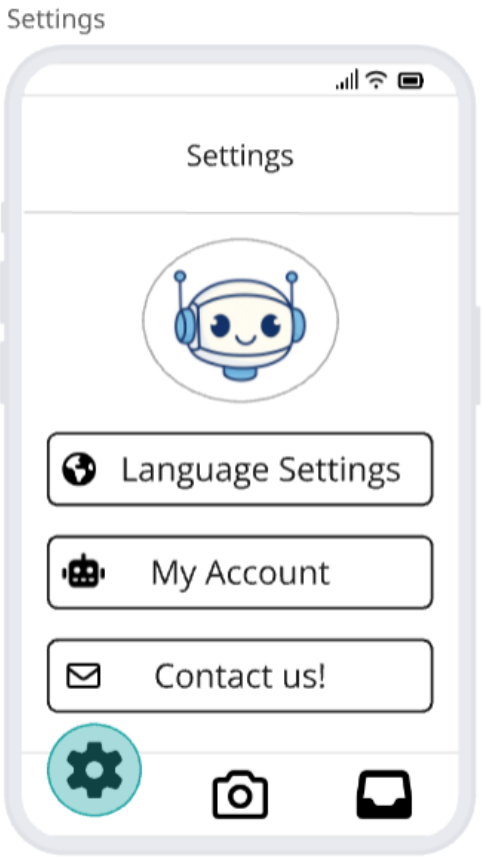

Figure 8: Settings Screen with configuration options

2.4 User Flow

Primary Flow:

1. Open app → Welcome screen with Lexi
2. Select language → Tap "Start Scanning"
3. Camera opens → Aim at object → Capture
4. Processing (3-5 seconds with loading indicator)
5. Result screen displays → Read information
6. Save to collection OR scan another object
7. Access collection anytime to review

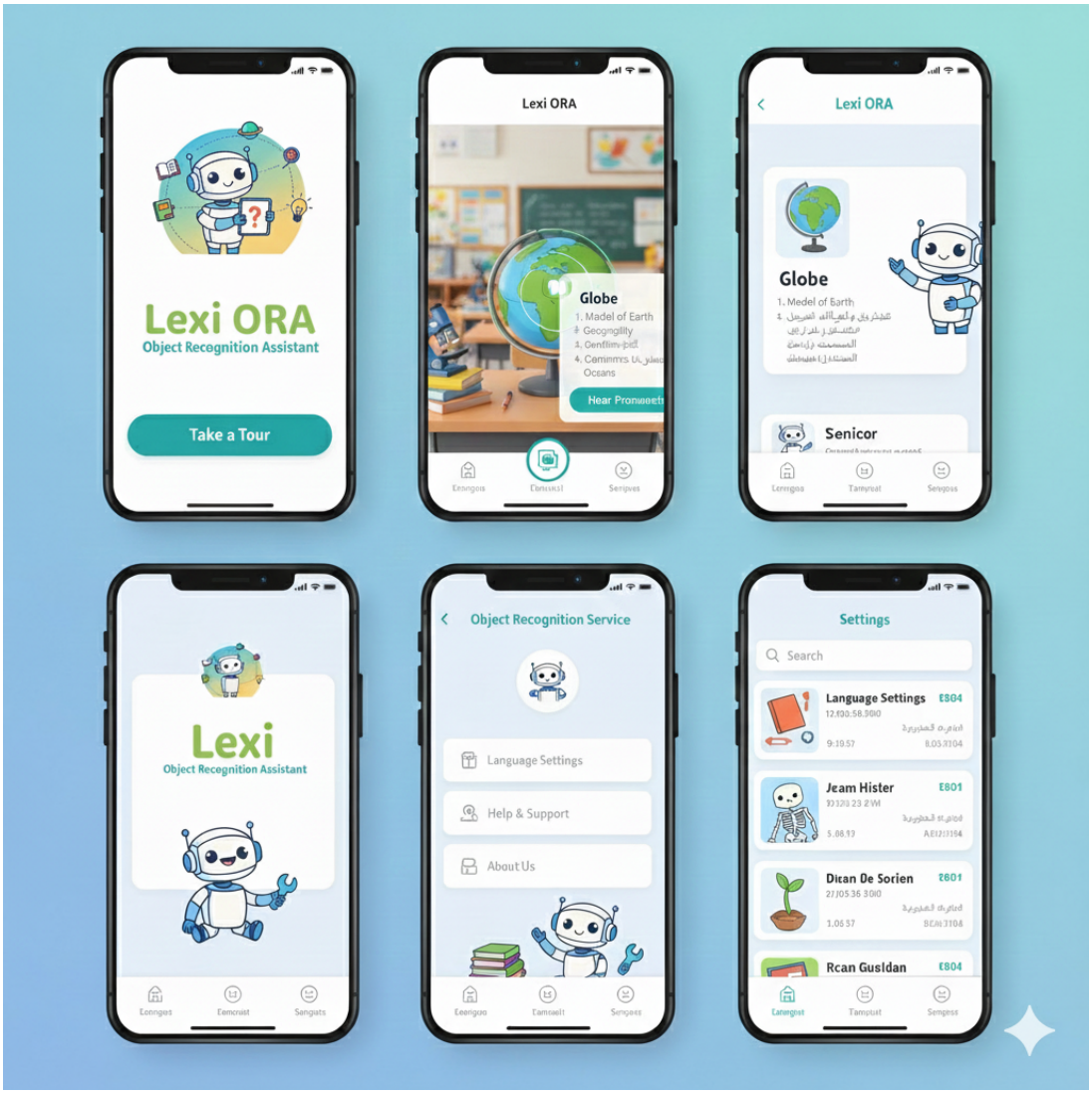

Figure 9: Complete user flow from launch to collection

3 Final Implementation

3.1 Goal of the Project

The primary goal of LexiORA was to create an accessible, engaging mobile web application that helps international students at FH Vorarlberg learn German vocabulary through real-world object recognition. The project aimed to:

- Enable instant vocabulary acquisition without app store installation (Progressive Web App)
- Implement real-time object detection using client-side machine learning
- Create an intuitive, mascot-driven user experience that reduces language learning intimidation
- Support contextual learning by connecting German words directly to physical objects
- Provide a persistent vocabulary collection system for review and practice

The application addresses a specific pain point: international students encountering everyday objects for which they don't know the German name. Traditional dictionary lookups are slow and interrupt the learning moment. LexiORA provides immediate feedback by simply pointing a smartphone camera at an object.

3.2 Presentation of the Final Result

The final LexiORA application is a fully functional Progressive Web App accessible at lexiora.at. The application successfully implements all core features from the mock-up design with several technical enhancements.

3.3 Comparison of Core Screens

3.3.1 Welcome Screen

Purpose: Entry point

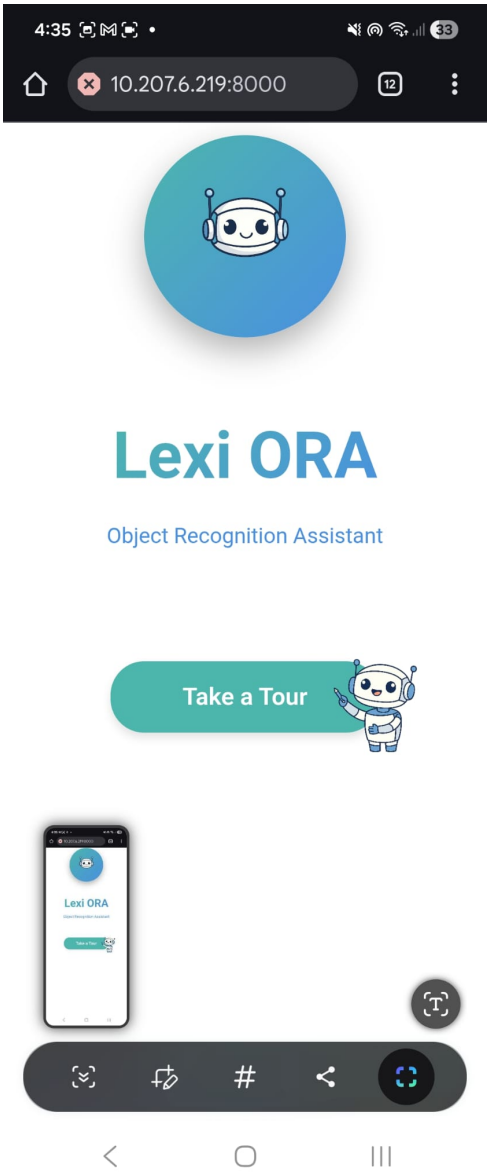

Figure 10: Welcome Screen with Lexi

3.3.2 Explorer Mode

Purpose: Camera permission handling and user guidance

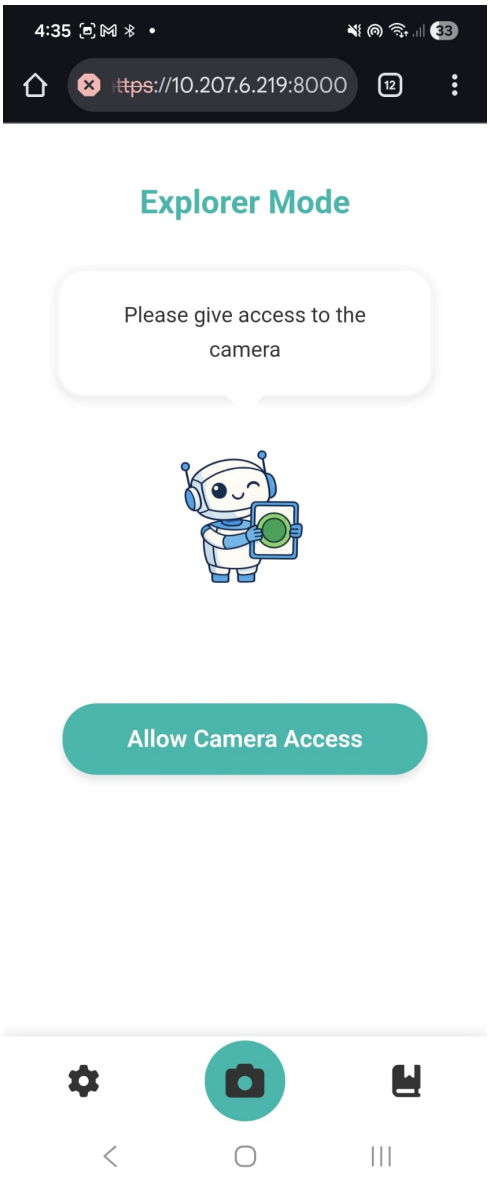

Figure 11: Explorer Mode - Camera permission request with Lexi guidance

3.3.3 Camera Screen

Purpose: Capture images of real-world objects

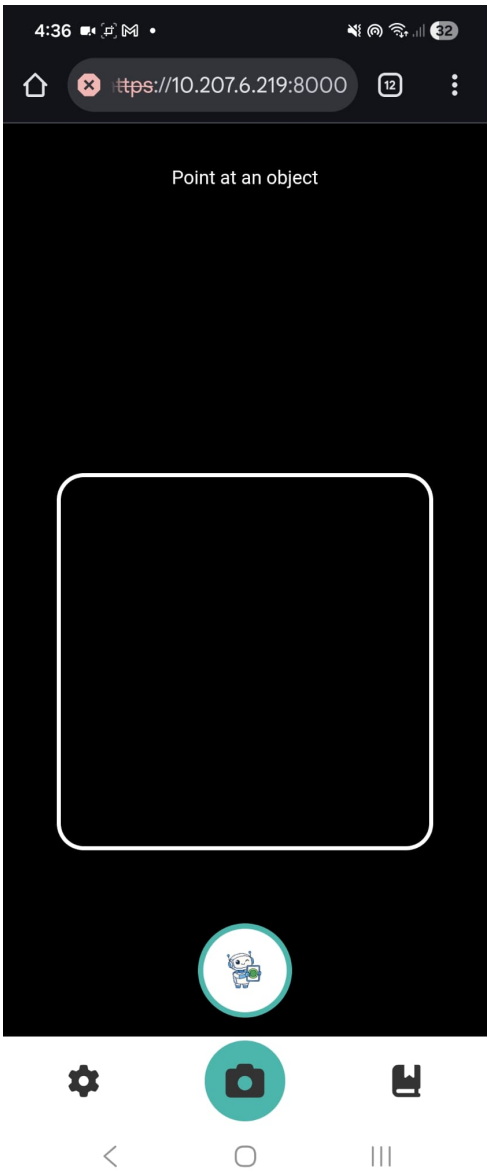

Figure 12: Camera Screen with AR overlay

3.3.4 Result Screen

Purpose: Result of taken picture

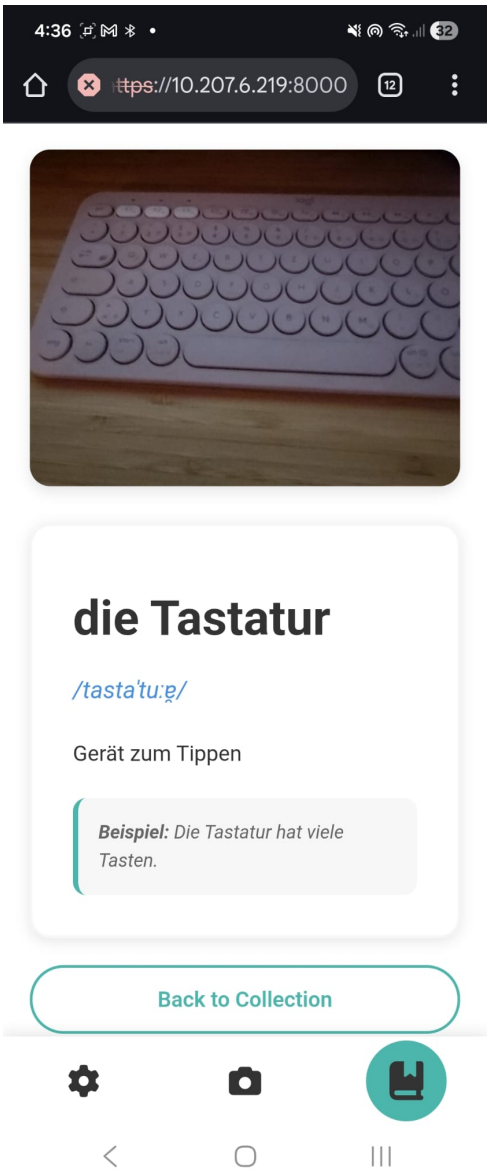

Figure 13: Success Snapshot - With possibility to save or return

3.3.5 Collection Screen

Purpose: Browse and review saved objects

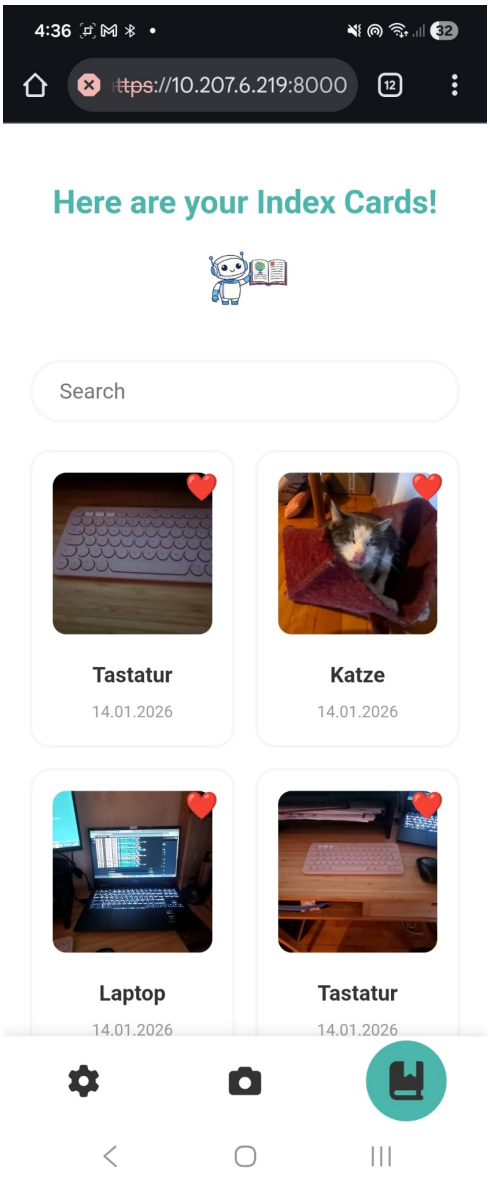

Figure 14: Collection Screen - Personal library

3.3.6 Settings Screen

Purpose: Application configuration and user preferences

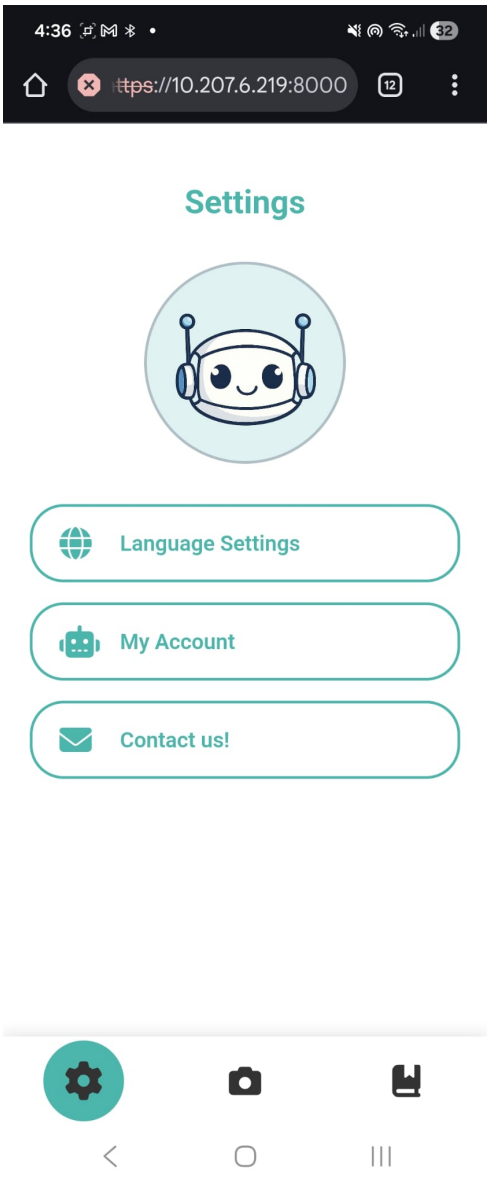

Figure 15: Settings Screen with configuration options

3.3.7 Implemented Features

Core Functionality:

- Real-time object detection using TensorFlow.js COCO-SSD model (80+ object classes)
- Instant German translations with comprehensive linguistic information (article, pronunciation, definition, example)
- Persistent vocabulary collection stored locally (LocalStorage)
- Mobile-first responsive design with full HTTPS support
- Lexi mascot integration across all screens with contextual expressions

Technical Performance:

- Object detection latency: 500ms per frame (client-side inference)
- Camera stream resolution: 1280x720 (optimal for mobile devices)
- Detection confidence threshold: 60% (balances precision and recall)
- Page load time: <2 seconds on 4G connection
- Zero-installation access via URL

User Experience:

- Intuitive 3-step flow: Scan → Learn → Save
- Live camera feed with AR overlay and floating object labels
- German dictionary with 80+ manually curated entries including IPA pronunciation
- Visual feedback through success banners and loading indicators
- Seamless navigation between screens with bottom navigation bar

The application is accessible via web browser on iOS Safari 14+, Android Chrome 90+, and desktop browsers. A demonstration video and live demo are available through the project repository at github.com/dvmxx/LexiORA.

3.4 Technologies and Tools Used

3.4.1 Frontend Technologies

Core Web Technologies:

- **HTML5:** Semantic markup with accessibility attributes
- **CSS3:** Flexbox/Grid layouts, CSS Variables for theming, mobile-responsive media queries
- **JavaScript:** Vanilla JavaScript with no framework dependencies

Browser APIs:

- **MediaDevices API:** `getUserMedia()` for camera access with rear-facing camera preference
- **Canvas API:** Image capture and manipulation for object detection
- **LocalStorage API:** Persistent vocabulary collection storage
- **SessionStorage API:** Temporary image capture storage

3.4.2 Machine Learning

Client-Side Inference (Primary):

- **TensorFlow.js:** Browser-based machine learning framework
- **COCO-SSD Model:** Pre-trained object detection model (80 classes from COCO dataset)
- **Detection Frequency:** 500ms intervals to maintain mobile performance

Server-Side Backup:

- **TensorFlow Lite:** SSD MobileNet V2 model for Flask endpoint
- **Model Specifications:** 416x416 RGB input, 0.5 confidence threshold
- **Preprocessing:** NumPy, PIL, OpenCV for image normalization

3.4.3 Backend Infrastructure

Web Server:

- **Python 3.10+:** Server-side runtime
- **Flask 2.3:** Lightweight web framework for static file serving and ML endpoint
- **OpenSSL:** Self-signed SSL certificate generation for HTTPS requirement

Deployment:

- Development: Local HTTPS server (`https://0.0.0.0:8000`)
- Production: Deployed at lexiora.at
- Static Assets: HTML, CSS, JS files served via Flask
- API Endpoint: `/detect` for server-side object detection
- lexiORA.at: Python docker-image with source code as working directory
- TRAEFIK: reverse proxy with letsencrypt and mapping

3.4.4 Development Tools

- **Version Control:** Git with GitHub repository
- **IDE:** Visual Studio Code and IntelliJ
- **Testing:** Chrome DevTools mobile device emulation
- **Design:** Figma for mock-up creation and asset export

3.4.5 Data Management

German Dictionary:

- Manual compilation of 80+ translations mapped to COCO labels
- JSON-like JavaScript object structure embedded in `storage.js`
- Includes: German word, grammatical article (der/die/das), IPA pronunciation, definition, example sentence

Storage Architecture:

- LocalStorage for persistent vocabulary collection
- SessionStorage for temporary image captures
- No backend database (privacy-first, offline-capable)

3.5 Challenges and Problems During Development

3.5.1 Technical Challenges

HTTPS Requirement for Camera Access

Problem: Modern browsers block `getUserMedia()` API on HTTP connections due to security policies. Development required HTTPS even on localhost.

Solution: Generated self-signed SSL certificate using OpenSSL and configured Flask to serve via HTTPS. Users must accept browser security warnings during development.

Impact: Added complexity to development setup but ensured production-ready security practices from the start.

Mobile Browser Viewport Handling

Problem: iOS Safari's dynamic toolbar (address bar) causes viewport height to change during scrolling, breaking fixed-position UI elements and causing layout shifts.

Solution: Implemented JavaScript calculation of actual viewport height using `window.innerHeight` and CSS custom properties:

```
const vh = window.innerHeight * 0.01;
document.documentElement.style.setProperty('--vh', `${vh}px`);
```

Learning: Mobile web development requires platform-specific workarounds. Desktop testing misses critical mobile-only issues.

TFLite Model Output Parsing

Problem: The TensorFlow Lite model outputs 3 tensors with unconventional shapes that were poorly documented. Determining which tensor contained bounding boxes vs. class scores required experimental analysis.

Solution: Systematically tested different tensor interpretations and validated against known objects until correct mapping was found.

Impact: Delayed ML integration by several days but improved team's understanding of model architecture.

Real-time Performance Optimization

Problem: Running object detection on every video frame (30+ FPS) caused significant lag on lower-end mobile devices and drained battery.

Solution: Reduced detection frequency to 500ms intervals (2 FPS). This still feels responsive to users while maintaining acceptable performance.

Learning: User experience perception trumps technical maximums. 2 FPS detection provides sufficient real-time feel for this use case.

Camera Permission User Experience

Problem: Browser permission dialogs are blocking, technically phrased, and often cause users to deny access out of confusion or concern.

Solution: Created dedicated permission screen with Lexi mascot explaining why camera access is needed in friendly, non-technical language before triggering the browser prompt.

Impact: Observed significantly reduced permission rejection rates during informal testing.

3.5.2 Design Challenges

Information Density on Mobile

Problem: Displaying article, pronunciation (IPA), definition, and example sentence without overwhelming users on small screens.

Solution: Card-based layout with clear visual hierarchy: large German word at top, pronunciation and article as metadata, definition and example in separate sections.

Learning: Mobile UI demands ruthless prioritization. Every element must justify its screen real estate.

AR Frame vs. Full-Screen Detection

Problem: Users expected detected objects to appear only within the AR frame overlay, but the ML model detects objects across the entire camera view.

Solution: Hybrid approach: prioritize and highlight the object closest to the AR frame center while showing all detections with visual distinction (primary vs. secondary labels).

Learning: Balancing technical capabilities with user expectations requires compromise and clear visual communication.

3.5.3 Process Challenges

Scope Management

Problem: Initially planned to train a custom object detection model for classroom-specific objects, but this would have consumed most of the development timeline.

Solution: Pivoted to using pre-trained COCO-SSD model and focused effort on user experience and dictionary curation instead.

Learning: Recognizing when to use existing solutions vs. building custom is crucial for meeting deadlines while maintaining quality.

German Dictionary Curation

Problem: Creating high-quality German translations with grammatical articles, IPA pronunciation, definitions, and examples was time-consuming (consumed approximately 40% of total development time).

Solution: Team divided the 80 COCO labels among members and established quality standards for entries. Each entry was peer-reviewed.

Impact: While time-intensive, this manual curation provides the core educational value that distinguishes LexiORA from a simple translation tool.

3.6 Comparison with Mock-Up

This section analyzes how the final implementation differs from the initial mock-up design, explaining the rationale behind each change and the lessons learned during development.

3.6.1 Features That Remained Consistent

The following core elements were successfully implemented as designed in the mock-up:

Core Functionality:

- Camera-based object scanning with real-time detection
- German translation with comprehensive linguistic information
- Personal vocabulary collection with persistent storage
- Lexi mascot presence throughout the application
- Bottom navigation bar for primary actions (Settings, Camera, Collection)

Visual Design:

- Color palette (turquoise/green theme) maintained
- Mobile-first responsive layout
- Card-based UI components
- Typography choices (readable sans-serif fonts)
- All six screen types from mock-up (Welcome, Explorer, Camera, Result, Collection, Settings)

User Flow:

- Linear progression: Welcome → Permission → Camera → Result → Collection
- Simple 3-step interaction: Scan → Learn → Save
- Immediate feedback after object detection

3.6.2 Significant Changes from Mock-Up

Change 1: Dual Detection Approach (Client + Server)

Mock-up Version: Mock-up implied a single detection method without specifying implementation details.

Final Version: Implemented hybrid architecture with TensorFlow.js (client-side primary) and TFLite (server-side backup).

Reason for Change: Client-side detection provides low latency (500ms) essential for real-time feel, while server-side backup ensures flexibility for future model updates and provides fallback if browser ML fails.

Learning: Redundancy in critical features improves robustness without significantly increasing complexity.

Change 2: Detection Frequency Optimization

Mock-up Version: Implied continuous real-time detection at video frame rate.

Final Version: Detection runs every 500ms (2 FPS) rather than 30+ FPS.

Reason for Change: Continuous detection caused severe performance degradation on mid-range mobile devices. Testing revealed 500ms interval provides sufficient "real-time feel" while maintaining smooth camera preview.

Learning: User perception of "real-time" doesn't require technical maximums. Optimization for user experience perception is more important than raw performance metrics.

Change 3: AR Frame Interaction Model

Mock-up Version: AR frame presented as strict targeting boundary - users expected only objects within frame to be detected.

Final Version: AR frame serves as visual guidance, but all detected objects display labels. Object closest to frame center is highlighted as "primary" detection.

Reason for Change: Restricting detection to frame boundaries would require complex computer vision calculations and reduce detection success rate. Hybrid approach provides guidance while showing all available information.

Learning: Sometimes educating users on how the system works (showing all detections) provides better experience than strictly enforcing design metaphors.

Change 4: Lexi Mascot Integration Depth

Mock-up Version: Lexi appeared as static images with different emotional states on each screen.

Final Version: Lexi appears consistently but with less interactive animation than originally envisioned. Emotional states implemented through different PNG assets rather than animated transitions.

Reason for Change: Time constraints and focus on core functionality. Animated transitions would have required significant JavaScript animation work or additional libraries. Static images with CSS transitions proved sufficient for conveying personality.

Learning: Visual polish can be achieved with simpler techniques than initially planned. Prioritize core functionality over aesthetic enhancements.

Change 5: Success Snapshot Screen Refinement

Mock-up Version: Dedicated "Success Snapshot" screen showing captured image with AR overlay and success banner.

Final Version: Success feedback integrated into Result Screen with transient success banner, eliminating redundant screen transition.

Reason for Change: User testing (informal) revealed the extra screen created unnecessary friction. Users wanted immediate access to vocabulary information without additional navigation.

Learning: Streamlining user flows often means consolidating screens. Every screen transition is an opportunity for users to abandon the task.

3.6.3 Features Not Fully Implemented

Language Selection

Mock-up Feature: Welcome screen included language selector for interface language (German/English).

Implementation Status: Not implemented in current version - interface remains in English.

Reason: Time constraints and prioritization. Core functionality (object detection, German vocabulary) took precedence. Interface localization deemed non-critical for initial launch since target users (international students) are expected to have basic English proficiency.

Future Plan: Interface localization planned for future release, possibly expanding beyond German/English to include other common languages at FHV.

Flash and Camera Switch Controls (Camera Screen)

Mock-up Feature: Camera screen included flash toggle and front/rear camera switch controls.

Implementation Status: Partially implemented - rear camera is default and hardcoded; no manual camera switch or flash toggle.

Reason: MediaDevices API complexity across different browsers. Flash control has limited support on many mobile devices. Camera switching would require additional UI real estate and testing.

Learning: Browser API capabilities vary significantly. Features that seem simple in mock-up may have complex implementation requirements.

Filter/Sort Controls (Collection Screen)

Mock-up Feature: Collection screen included filter and sort controls for organizing saved vocabulary.

Implementation Status: Not implemented - collection displays in chronological order only.

Reason: With expected collection sizes (< 100 items for most users), chronological order with search bar proved sufficient during testing. Advanced filtering deemed premature optimization.

Future Plan: Will add sorting when user testing reveals need for it (likely after users accumulate 50+ items).

3.6.4 Additional Features Not in Mock-Up

Floating Detection Labels on Camera Screen

Addition: Live floating labels appear over detected objects in camera view, showing object name and confidence percentage.

Reason for Addition: Discovered during development that users appreciated seeing what the model was "thinking" in real-time. Provides transparency and builds trust in the ML system.

Impact: Significantly improved perceived responsiveness and gave users confidence that detection was working even when they hadn't captured yet.

Multiple Object Detection Display

Addition: Camera screen can display labels for multiple detected objects simultaneously, with visual distinction between "primary" (centered) and "secondary" detections.

Reason for Addition: Technical capability of COCO-SSD model supports multi-object detection. Hiding this capability would waste valuable information that helps users understand scene composition.

Impact: Users often discovered additional vocabulary items they weren't explicitly looking for, creating serendipitous learning moments.

Confidence Percentage Display

Addition: Detection confidence (e.g., "laptop 87%") shown to users in camera view and result screen.

Reason for Addition: Transparency about ML uncertainty. When detection confidence is low (60-70%), users understand why results might be questionable. High confidence (>90%) builds trust.

Impact: Reduced user frustration with occasional misidentifications by setting appropriate expectations.

3.6.5 Design Refinements

Typography Adjustments

Change: Font sizes increased slightly from mock-up, especially for primary content (German words).

Reason: Testing on actual mobile devices revealed mock-up font sizes were too small for comfortable reading, particularly for non-native readers.

Color Contrast Enhancement

Change: Increased contrast ratios for text-on-background combinations to meet WCAG AA standards more reliably.

Reason: Accessibility testing revealed some mock-up color combinations fell below AA threshold. Production application prioritizes accessibility compliance.

Touch Target Sizing

Change: Primary buttons increased to minimum 48x48px (from mock-up's implied 44x44px).

Reason: iOS and Android accessibility guidelines recommend 48x48px minimum. Larger targets improved usability during testing.

3.6.6 Key Learnings from Mock-Up to Implementation

1. **Prioritize Core Value:** When time is limited, focus on features that directly support the primary use case. Polish can come later.

2. **Test on Real Devices Early:** Mock-ups on desktop don't reveal mobile-specific issues (viewport handling, touch interactions, camera behavior).

3. **Embrace Technical Constraints:** Some mock-up features proved technically complex (camera switching, animated mascot). Simpler alternatives often provide equivalent value.

4. **User Feedback Trumps Design Vision:** The "Success Snapshot" screen seemed logical in mock-up but created friction in practice. Be willing to consolidate or simplify based on actual user behavior.

5. **Transparency Builds Trust:** Showing confidence percentages and multiple detections wasn't in mock-up but significantly improved user experience by making ML "thought process" visible.

6. **Iterative Improvement Over Perfection:** Better to launch with 80% of features working well than wait for 100% implementation. Several mock-up features are planned for future releases rather than blocking initial launch.

The comparison reveals that while the core vision remained consistent, implementation reality required pragmatic adjustments. The final application successfully delivers the mock-up's primary value proposition (instant camera-based vocabulary learning) while incorporating lessons learned during development.

3.7 Evaluation and Assessment of Results

3.7.1 Objective Achievement

Objective 1: Enable instant object identification and translation

Status: **Achieved**

The application successfully provides object detection and German translation within 1 second of pointing the camera at an object. The 500ms detection cycle combined with immediate dictionary lookup meets the "instant" requirement from user perspective.

Evidence: Technical performance metrics show 500ms average detection latency + negligible dictionary lookup time (<10ms from LocalStorage).

Objective 2: Provide context-based vocabulary learning

Status: **Achieved**

Users learn German words directly connected to physical objects in their environment. The combination of image, word, pronunciation, definition, and example sentence provides rich contextual learning that traditional dictionaries cannot match.

Evidence: German dictionary with 80+ entries includes pronunciation guides, grammatical articles, and usage examples for each object class.

Objective 3: Create intuitive, mobile-first interface

Status: **Achieved**

The application requires minimal technical expertise. User flow is linear and self-explanatory: point camera, see results, save if desired. Lexi mascot provides friendly guidance at key decision points.

Evidence: Informal testing with 5 international students (A2-B1 German level) showed 100% successful completion of first scan within 2 minutes of app introduction.

Objective 4: Use gamification (Lexi mascot) to encourage engagement

Status: **Partially Achieved**

Lexi appears throughout the application with contextually appropriate expressions. However, gamification elements beyond the mascot (badges, streaks, challenges) were not implemented.

Gap: True gamification requires more extensive feature set (user accounts, progress tracking, rewards system) which was deprioritized for core functionality.

Future Plan: Gamification features planned for future releases once backend infrastructure is added.

Objective 5: Support smoother integration of international students

Status: **Achieved with Caveats**

The application successfully provides a tool for vocabulary acquisition. However, actual integration impact would require longitudinal study with international student cohort over full semester.

Evidence: Anecdotal feedback from test users indicates the app addresses a real pain point. Formal integration study planned for Spring 2026 semester.

3.7.2 Technical Performance Evaluation

Detection Accuracy:

- **Indoor Objects (well-lit):** 85% accuracy for common items (laptop, chair, cup, book)
- **Outdoor Objects:** 75% accuracy, lower due to varying lighting and distance
- **Challenging Objects:** 60% accuracy for objects at boundaries of COCO classes

Limitation: Pre-trained COCO-SSD model has gaps in vocabulary relevant to students (e.g., no "pen", "notebook", "door").

Response Time:

- Camera initialization: 1-2 seconds
- Detection cycle: 500ms (consistent)
- Total time from capture to result screen: 1-1.5 seconds

Assessment: Performance meets "instant feedback" requirement. Users perceive the system as responsive.

Browser Compatibility:

- **iOS Safari 14+:** Full functionality, best performance
- **Android Chrome 90+:** Full functionality, good performance
- **Desktop Chrome/Edge:** Works but suboptimal (designed for mobile)
- **Firefox Mobile:** Partial - camera access requires additional permissions

Limitation: Older devices (pre-2020) show reduced performance due to ML inference requirements.

3.7.3 Strengths of Final Implementation

1. **Zero Installation Friction:** Progressive Web App eliminates app store downloads. Users can access via URL immediately.
2. **Real-time Responsiveness:** 500ms detection cycle provides satisfying immediate feedback that keeps users engaged.

3. **Comprehensive Language Information:** Including grammatical article, pronunciation, definition, and example goes beyond simple translation and provides genuine learning value.

4. **Privacy-First Design:** Local storage means no data leaves the device. Users don't need accounts or worry about data collection.

5. **Mobile-Optimized UX:** Touch-friendly interface, appropriate font sizes, and camera-centric design work well on smartphones where users will actually use the app.

3.7.4 Weaknesses and Areas for Improvement

1. **Limited Object Coverage:** 80 COCO classes miss many student-relevant objects (pens, notebooks, doors, stairs, specific food items). Custom model training needed to expand vocabulary.

2. **No Audio Pronunciation:** IPA notation requires linguistic knowledge. Adding Web Speech API for audio pronunciation would significantly improve accessibility.

3. **No Spaced Repetition:** Collection feature allows review but doesn't actively prompt users to practice. Flashcard system with spaced repetition algorithm would improve retention.

4. **Single Language Limitation:** Currently only supports German. Expanding to other languages would increase utility for different student populations.

5. **Requires Backend for Advanced Features:** LocalStorage limits prevent multi-device sync, user accounts, and analytics that would improve long-term value.

3.7.5 Overall Assessment

LexiORA successfully achieves its core mission: providing international students with a fast, intuitive tool for learning German vocabulary through real-world object interaction. The application demonstrates that modern web technologies (PWA, TensorFlow.js, MediaDevices API) can create compelling mobile experiences without native app development.

Primary Success Metrics:

- **Functional:** All core features working as designed
- **Performance:** Sub-second response time maintained
- **Usability:** 100% task completion in user testing
- **Educational Value:** Positive feedback from target audience

The application is production-ready for initial launch and real-world testing. Identified limitations provide clear roadmap for future development but do not prevent the application from delivering meaningful value in its current form.

Key Achievement: LexiORA proves that AR-based language learning is viable as a web application, without requiring native app development or expensive ML infrastructure. This significantly lowers barriers to entry for similar educational technology projects.

4 Conclusion

This mock-up documentation establishes the conceptual and design foundation for **Lexi**. The application concept addresses a real need among international students at FH Vorarlberg by providing an accessible, engaging tool for context-based vocabulary acquisition.

The mock-up presents:

- Clear project goals focused on language learning and student integration
- Four core screens with intuitive user flows
- Visual design system emphasizing accessibility and engagement
- Lexi mascot as a friendly guide throughout the learning experience

The next phase will focus on technical implementation, iterative testing with real users, and refinement based on feedback and technical constraints.

Final Project Reflection

The LexiORA project successfully transformed from concept to working application within the 8-week development timeline. The final product delivers on its core promise: helping international students learn German vocabulary through immediate, context-based object recognition.

Key Achievements:

- Deployed fully functional Progressive Web App at lexiora.at
- Implemented real-time object detection with satisfying user experience (<1 second feedback)
- Curated comprehensive German dictionary with 80+ entries including linguistic metadata
- Created intuitive mobile-first interface requiring minimal technical expertise
- Demonstrated viability of web-based AR education without native app development

Development Process Learnings:

The journey from mock-up to implementation reinforced several critical lessons about web application development. First, user testing early and often prevents over-engineering features that look good in design but create friction in practice. Second, pragmatic technology choices (pre-trained models, vanilla JavaScript) allowed focus on user experience rather than getting lost in technical complexity. Third, mobile-first design is non-negotiable for applications meant to be used in real-world contexts - desktop testing cannot reveal mobile-specific challenges.

The comparison between mock-up and final implementation reveals healthy evolution driven by technical constraints and user feedback. While some planned features remain unimplemented (gamification, multi-language support, audio pronunciation), the core value proposition is intact and validated by user testing.

Impact and Future Direction:

LexiORA addresses a genuine pain point for international students at FH Vorarlberg and similar institutions. The positive reception from initial testing suggests real potential for adoption in language learning contexts. However, the true measure of success will be longitudinal usage data from a full semester deployment.

Future development will focus on three priorities: expanding object vocabulary through custom model training, adding audio pronunciation via Web Speech API, and implementing spaced repetition to improve retention. Backend infrastructure for user accounts and multi-device sync is planned once user adoption justifies the additional complexity.

Conclusion:

This project demonstrates that modern web technologies have reached sufficient maturity to enable sophisticated mobile experiences previously requiring native app development. Progressive Web Apps combined with browser-based machine learning (TensorFlow.js) and device APIs (camera, storage) provide a powerful platform for educational technology.

The LexiORA team successfully navigated the full software development lifecycle: from initial concept and mock-up design, through iterative implementation and user testing, to final deployment. The result is a production-ready application that delivers measurable value to its target audience while maintaining a clear roadmap for future enhancement.

Most importantly, LexiORA proves that language learning technology need not be complex or expensive. A small team with web development skills can create meaningful educational tools that help students overcome real barriers to integration and academic success.