ARtist - Educational Experience in Art through Augmented and Virtual Reality

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ABSTRACT

ARtist is a mobile application that integrates Augmented Reality (AR) and Virtual Reality (VR) to support drawing practice and art education. The AR component overlays drawing guides on physical paper, while the VR component presents a virtual museum containing forty famous paintings and contextual information. The system, implemented in Unity for Android, comprises eight modules, including step-by-step drawing tutorials, daily reference images, an AI-based art tutor using OpenAI API, a personal gallery, the possibility to place art on your real walls using AR, and a knowledge quiz. An on-device CNN estimates the difficulty of any reference image and allows users to adapt accordingly. A formative usability study with sixteen participants (aged 13–55) awarded the application the maximum overall score, while recommending minor refinements that were subsequently incorporated. The paper details the system architecture, the integration of AR and VR workflows into a coherent learning path, and the main findings of the user study, illustrating the potential of computer science to widen access to cultural education and the fact that innovation should not replace art, but enrich it and bring it closer to people.

Author Keywords

Augmented Reality; Virtual Reality; Artificial Intelligence

ACM Classification Keywords

H.5.1 Multimedia Information Systems - Artificial, augmented, and virtual realities. K.3.1 Computer Uses in Education - Computer-assisted instruction (CAI).

General Terms

Augmented Reality; Image Tracking; Design;

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INTRODUCTION

Art is often perceived as a discipline accessible only to those with innate talent, which may discourage many individuals from pursuing it. Additionally, access to artistic education is frequently constrained by financial and geographic factors, such as the high cost of materials, limited availability of drawing courses, or the absence of nearby museums and galleries. At the same time, traditional educational methods are increasingly insufficient to capture the attention of younger generations, who are accustomed to visual, interactive, and personalized learning experiences. The present work proposes an interdisciplinary approach that brings together visual arts and computer science, two domains traditionally seen as distinct. The mobile application ARtist aims to bridge this gap by combining AR, VR, Artificial Intelligence (AI), and Machine Learning (ML) to support both practical drawing exercises and the exploration of art history. The goal is not to replace art with technology, but to use technology to enhance artistic expression and make it more accessible. In ARtist this is achieved by enabling users to practice drawing directly on paper with AR guidance, to explore knowledge through the VR museum, and to receive instant answers and advice through the AI tutor. The AR component of the application enables users to draw on physical paper by following projected guides in real time, while the VR component allows them to navigate a 3D virtual museum containing forty classical artworks accompanied by contextual information. An additional AR placement mode anchors artworks, either the built-in collection or the user's own creations, onto detected vertical planes, allowing realistic visualization of how a painting would integrate into a physical space. Further features include daily references for inspiration, guided tutorials, an AI art tutor chatbot using OpenAI API, a difficulty estimator based on a lightweight convolutional neural network (CNN), and a personal gallery for managing and displaying completed artworks. All components are integrated within a unified application developed in Unity for Android.

THEORETICAL FOUNDATIONS AND EXISTING WORK

Recent studies show that the simultaneous integration of AR, VR and generative AI models boosts motivation, critical thinking and collaboration in art workshops [1-8], while workshop-style deployments confirm the scalability of these technologies within university curricula [9-17]. Research also highlights the positive impact of AR on students learning technical or artistic drawing [8, 14], on museum visitors seeking personalized immersive experiences [2], and on patients in art therapy, where AR / VR facilitates digitally assisted emotional expression [13].

Similar Applications

While developing ARtist, we analyzed several existing solutions that use AR and VR in art education. No single

application combines all the functions proposed for ARtist, but many offered useful reference points. **ShadowDraw**[1] guides users through step-by-step drawing exercises based on contours created by professional artists. Lines appear progressively, making the method intuitive for beginners. However, its use of AR is limited; the app focuses on showing contours on-screen rather than providing a richer spatial experience. Advantages include active feedback after every stroke, small well-defined steps and hints that mimic an art teacher. Disadvantages are the small number of free tutorials, tablet-only availability and a lack of theoretical content or alternative learning modes. **SketchAR**[2] overlays drawing guides directly onto real paper with AR, offering interactive lessons for various skill levels plus editing and personalization tools. Its surface detection is stable, and onboarding generates a personalized plan. Users can draw both in AR and in a normal mode, but the augmented-reality workflow always presents the sketch step by step. SketchAR accelerates contour practice for beginners, yet the free tier is limited and feedback is not adaptive. **Google Arts & Culture**[3] is a comprehensive platform for exploring art and culture. Users can place paintings or sculptures in real space with AR or enjoy immersive VR tours, interactive games and thematic stories. Although the content is vast and well curated, the platform does not provide hands-on drawing practice. Instead, it emphasizes passive exploration through games like a virtual gallery-decorating activity. **Art Placer**[4] lets artists and collectors preview artworks on real walls with AR. It supports precise scaling and placement, making it useful for exhibitions and private collections. Its anchoring mechanism is robust and works under most conditions, but the focus is purely commercial, with no educational features comparable to those in ARtist. **Da Vinci Eye**[5] projects drawing guides onto real surfaces, helping users copy images accurately. It offers two modes: Classic (on-screen overlay) and AR Mode, which anchors the guide to paper. Step-by-step tutorials are available in both modes. The app is excellent for copying but lacks a VR gallery and theoretical instruction, capabilities integrated into ARtist. Because each app covers a narrow function, the learning path is fragmented. ARtist addresses these gaps with an integrated, accessible platform that combines AR tracing, VR exhibition and AI-driven feedback in one application.

Extended Uses of AR in the Arts

Beyond these apps, AR is used to display paintings in heritage sites [18], support collaborative sketching on physical surfaces [16], create interactive scenography in museums [2, 7] and merge AI with AR in interdisciplinary studio practice. These broader deployments reinforce AR's relevance to art education and public engagement [19-24].

IMPLEMENTATION OF FUNCTIONAL MODULES

My Artworks

The first module is MyArtworks, a digital album where users can save their drawings created with the app, view them at any time, and even project them onto their own room's walls using ARpe (see Figure 1).

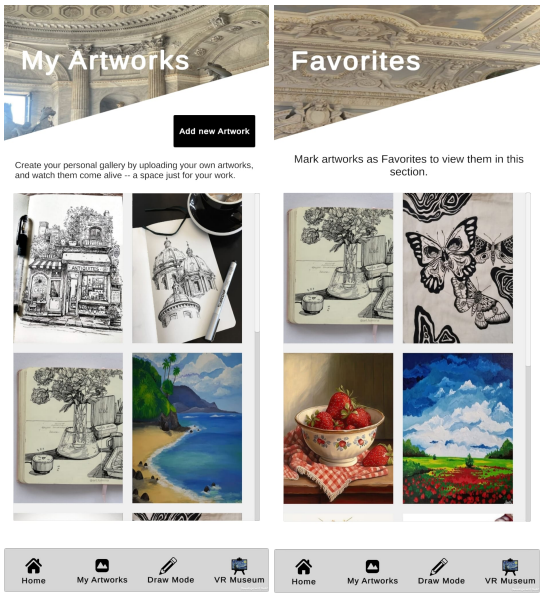

Figure 1. My Artworks and Favorites modules.

Users can add artworks either by selecting a photo from the gallery or by taking a new photo. Metadata such as title, artist and dimensions can be stored for each artwork. After saving, the artwork immediately appears in the personal gallery. Saved artworks can later be viewed, edited or marked as favorites. The View AR button exports the image texture and opens the ARScene to project it onto a real wall. Data persistence is handled locally, with artwork details stored in a JSON file on the user's device. This approach provides users with their own digital gallery for keeping, organizing, viewing, and projecting artworks in AR or marking them as favorites for easy access.

Favorites

The Favorites module collects all the artworks users liked most, whether from their own gallery or from "Today's Inspiration." Artworks can be marked as favorites for quick access later. Favorites are stored locally, allowing quick access to preferred artworks.

ARScene - Placing Artworks on Walls

In ARScene, the app detects vertical surfaces (walls) using AR Foundation. Once a suitable wall is recognized, a transparent plane appears, indicating the user can place

[1] https://www.shadowdrawapp.com/
[2] https://sketchar.io/
[3] https://artsandculture.google.com/
[4] https://www.artplacer.com/
[5] https://davincieyeapp.com/

artworks there by tapping the screen. The app automatically selects a portrait or landscape frame to match the image's orientation, preventing distortion (see Figure 2). After placement, artworks can be resized, replaced or deleted.

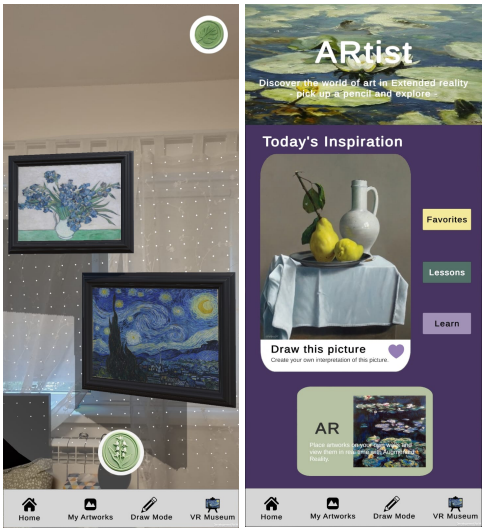

Figure 2. AR (place on walls) and Today's Inspiration Components.

Drawing Mode

The Drawing Mode module (see Figure 3) is central to the app, allowing users to choose between two drawing methods:

- **Classic Mode**: overlays a semi-transparent image over the live camera feed.
- **AR Mode**: anchors the reference image to a printed marker using AR tracking.

Users select their reference images from their phone gallery or directly from "Today's Inspiration." Each image is analyzed by a small CNN to estimate its difficulty level (easy/hard). The result is displayed in a popup, helping users choose suitable images.

1. Classic Mode

In Classic Mode, the reference image is displayed semi-transparently over the camera feed. Users can adjust the image's position, size, rotation, and transparency through intuitive touch gestures, helping them easily trace outlines onto their paper.

2. AR Mode

In AR Mode, the reference image aligns perfectly with a printed marker placed on the drawing paper. This mode offers greater stability, users can freely move the paper without losing alignment, as the reference image continuously tracks the marker in real-time. In both modes, users place real paper on their desk and position the phone on a stable support above it. By looking through the phone's camera, they see the semi-transparent reference image aligned with the sheet and trace its contours step by step, gradually reproducing the artwork.

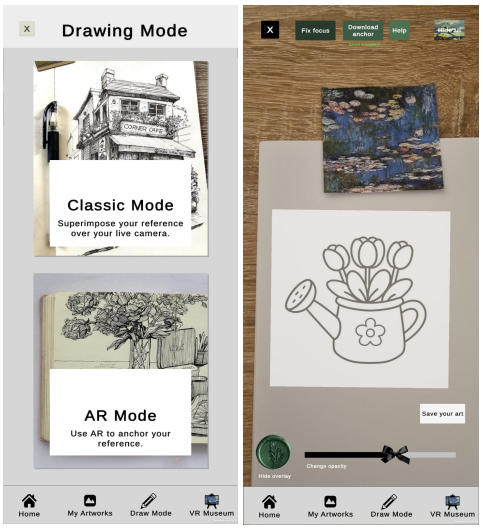

Figure 3. Drawing Mode module.

Today's Inspiration

The main menu displays Today's Inspiration, offering a daily randomly selected drawing suggestion from a predefined image library (see Figure 2). Users can immediately start drawing by tapping on the suggestion, quickly jumping into either drawing mode. Each inspiration can also be saved instantly as a favorite, providing rapid access later.

Lessons - Drawing Tutorials

The Lessons module provides five beginner-friendly tutorials with hand-drawn, step-by-step illustrations created specifically for this app (see Figure 4).

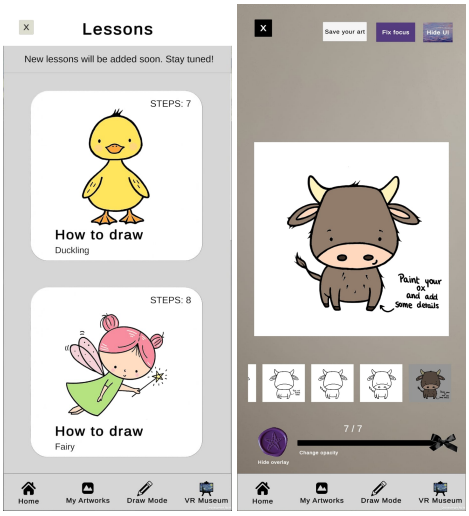

Figure 4. Lessons – step-by-step tutorials.

Users select tutorials displayed as cards, each containing the final artwork, title, and the number of steps. After selecting a lesson, users navigate through steps via a horizontal scrollbar, seeing each drawing stage progressively.

Learn - OpenAI

The Learn module integrates an AI-powered virtual tutor using OpenAI Chat (see Figure 5). It provides:

- **Quick art tips** (under 20 words) via Tips & Tricks.
- **Detailed answers** to any art-related question (up to 120 words) via Q&A.
- **A quick knowledge check** via the Test your Knowledge button, linking users to the Quiz module.

This integration offers users real-time interactive guidance and valuable artistic insights.

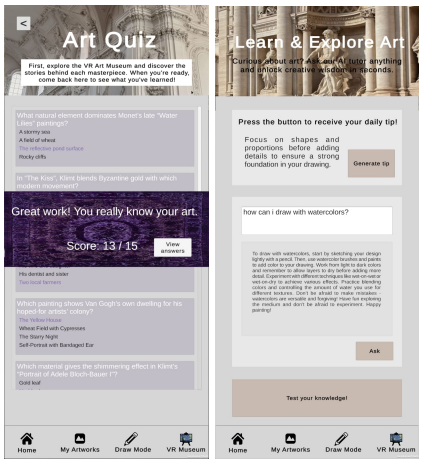

Figure 5. Quiz and Learn (OpenAI API) modules.

VR Museum

The VR Museum is a virtual 3D art gallery containing 40 famous paintings and some decorative sculptures (see Figure 6). Users move around the gallery using two on-screen joysticks, reading informational panels about each artwork's details, enhancing the learning experience. The virtual gallery was modeled in Blender to ensure an immersive experience. All artworks included are either public domain or used strictly for educational purposes according to copyright laws.

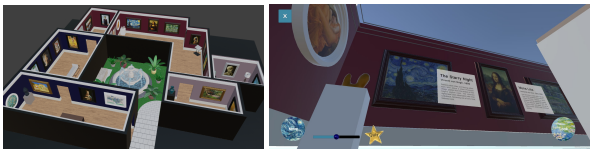

Figure 6. VR Museum.

Quiz - Knowledge Testing

The Quiz module provides a set of 15 multiple-choice questions based on the artworks' details from the VR Museum (see Figure 5). Users select answers, receiving immediate feedback: correct answers turn green, and incorrect selections highlight the correct response. At the end, users receive their overall score along with a motivational message, reinforcing their learning process. This quiz effectively ties the museum visit and active learning together, allowing users to assess and consolidate their newly acquired knowledge. Together, these modules provide users with a comprehensive learning and drawing experience: from exploring famous artworks and receiving personalized tips to actively practicing and showcasing their creations, all integrated within a single, intuitive application.

MACHINE LEARNING MODULE

One of the key features of the ARtist app is the ability to automatically evaluate the difficulty of a drawing. This feature uses a small CNN trained in PyTorch, integrated into Unity through Sentis, to provide automatic feedback about the artistic complexity of an image.

Problem Definition

In the workflow of the ARtist app, it's important for the user to know from the beginning if the selected image will be easy or hard to draw. Although experienced artists can often estimate the difficulty of an image, beginner users frequently misjudge their own abilities. Some may underestimate the complexity of a drawing and become discouraged when they cannot complete it, while others may avoid challenging images even if they have the required skills. By providing an automatic and objective difficulty score, the classifier reduces this subjectivity and helps users select images that better match their current level. We formalized this as a binary classification problem with two classes:

- **easy (y = 0):** images with simple geometric shapes and few visual details.
- **hard (y = 1):** abstract or realistic images with complex shapes, many details, overlapping elements, colors, and textures.

The neural model outputs a probability value *phard* $\in$ [0,1], representing the chance that an image belongs to the “hard” class. The final decision uses a simple threshold of 0.5:

- If the probability is ≤ 0.5, the image is labeled as easy.
- If the probability is > 0.5, the image is labeled as hard.

This simple decision ensures stable behavior and makes it easy to explain to users without technical training.

The raw probability isn't shown directly to users. Instead, it's turned into a user-friendly score from 1 to 10:

- **Scores ≤ 5** are shown as “Easy”, indicating the drawing is suitable even for beginners.
- **Scores > 5** are shown as “Difficult”, indicating a higher effort is required.

A popup with this score appears immediately after selecting an image and drawing mode, so users can adjust expectations or choose a different image. We chose binary classification for simplicity, faster inference on mobile devices, and because our training set clearly divides into two categories (geometric vs. abstract images).

Dataset

To train the model, we selected two very different public image collections:

- **Geometric Shapes** (Mathematics): 20,000 synthetic images of basic shapes (circles, triangles, squares, etc.), clearly contrasting with the background.
- **Abstract Art Gallery**: 2,782 complex abstract paintings from the internet with irregular shapes and rich details, making them hard to draw.

While the dataset contains more synthetic than real images, the abstract artworks are highly diverse, covering a wide range of shapes, textures, and styles. This variability ensures that the "hard" class is well represented, despite its smaller size. In addition, the model was validated on a balanced test set (2000 easy, 2000 hard), which confirms that the imbalance did not negatively affect performance.

Preprocessing and Training

We developed the classification module in Python because of available efficient libraries. The trained model is saved and manually integrated into Unity. Images undergo simple preprocessing before training:

- **Converted to grayscale** (focusing the network on shapes, textures, and contrast rather than color).
- **Resized to 128×128 pixels** (small enough to ensure fast processing while keeping relevant details).
- **Converted into PyTorch tensors** and normalized to the range [−1,1].

We did not use any additional augmentations (rotations, flips, etc.) because the visual difference between simple and complex images is clear enough for the model to learn directly, keeping training quick and straightforward.

CNN Overview and Training Details

The neural network we chose is a small CNN with just three convolutional blocks and pooling layers, reducing the number of parameters and speeding up inference. After the convolutional blocks, two dense layers predict the final binary class. The output layer uses a sigmoid function to convert the result into an interpretable probability. The model was trained for five epochs using the Adam optimizer, known for its stable performance in visual tasks, and Binary Cross-Entropy loss, suitable for binary classification. Data was split into 80% training and 20% validation to objectively evaluate performance on unseen images.

Integration in Unity with Sentis

The trained ONNX model file was imported into Unity using the Sentis package, which supports running ML models directly in Unity. At runtime, Unity converts this model into a GPU-compatible object to perform inference quickly, even on mobile devices. The probability result is transformed into the 1-10 intuitive difficulty score displayed in the user interface. The entire inference runs locally without network calls, and the memory footprint remains small (under 3MB), ensuring good performance on mobile hardware.

Difficulty Popup and User Experience

Immediately after image classification, the difficulty popup shows the user a clear, intuitive score (see Figure 9). Users see the complexity before starting the drawing and can choose images suited to their skill level without interrupting the workflow.

Testing and Metrics

To evaluate the model, we tested it on 4,000 images (2,000 easy and 2,000 hard) that were not used during training. These images were randomly rotated and slightly blurred to simulate real-world conditions. The results were good:

- **Total accuracy**: 86% (see Table 1),
- **ROC curve area** (AUC): 0.988, indicating strong performance in separating easy and hard images (see Figure 7).

The confusion matrix showed that the model tends to label easy images as hard rather than the opposite, which is acceptable in practice because it encourages users to start with more caution and avoid underestimating the complexity (see Figure 8). In conclusion, the model successfully achieved its goal of providing automatic difficulty feedback, allowing users to select drawings according to their skill level. Although the classifier is intentionally lightweight and focused on geometric complexity, it demonstrates the feasibility of integrating real-time ML into mobile art education tools. Future research will explore more complex models of artistic difficulty, trained on larger and more diverse datasets, and incorporating pedagogical insights from art teachers.

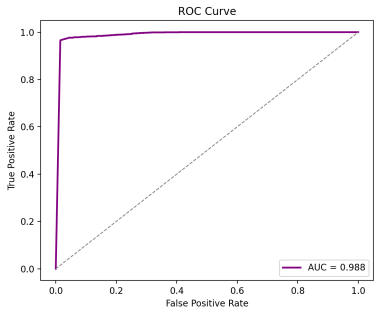

Figure 7. ROC curve and its area (AUC = 0.988).

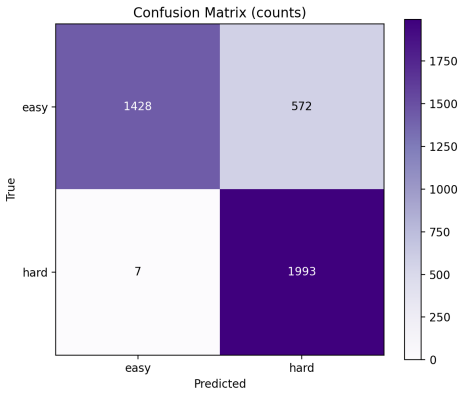

Figure 8. Confusion matrix - absolute counts (4,000 images).

Class	Precision	Recall	F1	Sample
Easy	1.00	0.71	0.83	2000
Hard	0.78	1.00	0.87	2000
Macro avg	0.89	0.86	0.85	4000
Overall accuracy		0.86		
AUC (ROC)		0.988		

Table 1. Classifier performance on the test dataset.

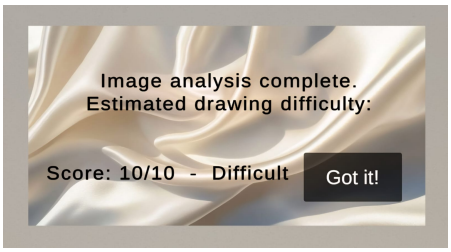

Figure 9. Easy/Hard difficulty classification (instant feedback).

USABILITY TESTING AND VALIDATION

The testing approach for the ARtist app was designed practically, considering that the application combines several different types of functionalities. The main purpose was to check whether these key features work correctly on real devices, without aiming for full coverage through automated testing. Therefore, the testing focused mainly on two methods: internal functional validation by the developers and a user study conducted through a structured questionnaire.

The first method was internal validation, carried out throughout development by installing the .apk on Android devices, checking the main workflow, and fixing any issues to ensure everything behaved as expected and to maintain a stable application.

The second method consisted of a user study using a Google Forms questionnaire. The role of this questionnaire was to collect direct feedback from real users who actually installed and tested the app. It provided insights into how participants interacted with the application, how intuitive they found the interface, and whether they perceived the app as educationally useful. The questionnaire included five sections with 24 questions: demographic information, technical familiarity, artistic background, evaluation of individual modules (AR Draw, Classic Draw, VR Museum, AR placement), and final opinions/suggestions. Most questions used 5-point Likert scales, complemented by multiple-choice and open-ended answers. Participants were first instructed to follow a usage scenario (installing the app, completing at least one drawing, and exploring the VR Museum) before filling in the form, ensuring that responses reflected real experience with the system. Combining these two testing approaches allowed us to validate both the technical reliability of the application and the overall user experience.

For user evaluation, we designed a detailed questionnaire using Google Forms, selected because it provides automatic summary graphs and integrates easily with Google Sheets for statistical analysis. The questionnaire was intentionally sent to a small, targeted group of people who were willing to complete the entire process of installing the app, using the drawing modules, and exporting at least one artwork. Although the testing setup was relatively complex for quick usability testing, the chosen participants provided valuable feedback and clear suggestions, significantly helping us improve the app and its documentation. Throughout the entire development period, especially while designing the drawing features, we consistently asked for opinions from beginner-level users. This ensured that the interface and instructions were intuitive and clear even for people without any previous drawing experience.

The questionnaire itself had five sections with 24 questions in total. The sections collected demographic information, technical familiarity, artistic experience, evaluations of specific app functionalities (like usefulness, clarity, and AR tracking precision), and finally general opinions and suggestions for improvements. We had 16 valid responses from participants ranging in age from 13 to 55 years, with a balanced gender distribution (approximately half women and half men). Participants had diverse technical backgrounds, from beginners with no previous knowledge of AR to experienced IT students and artists. This diversity helped us realistically understand how different people perceive the app. Most participants regularly use Android applications and rated their general tech skills as above average. However, familiarity with VR and AR technologies was lower, indicating that clearer explanations of these features might be beneficial. Regarding artistic background, about 38% draw weekly or daily, 43% draw occasionally, while approximately 19% rarely or never draw. Despite this, 81% of participants successfully

completed a satisfying drawing (see Figure 10) after their first session with ARtist, suggesting the guided workflow effectively helps beginners. Users indicated that the AR Draw Mode was the most useful feature, closely followed by the Classic Draw mode, VR Museum, and the Place on walls option. Participants found the interface intuitive, and the concept of combining AR with drawing lessons was highly appreciated.

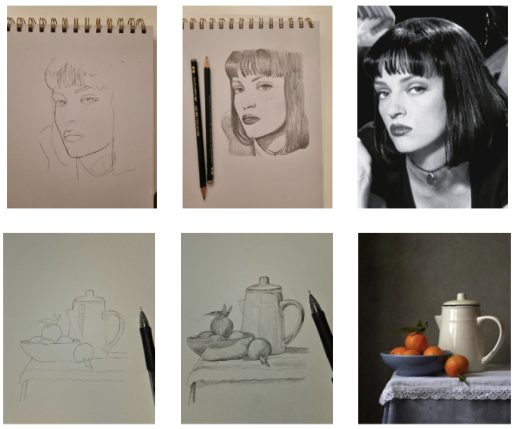

Figure 10. Drawings made by real users.

Both drawing modes were found helpful, indicating that they complement each other and address different user needs. The AI assistant also received positive reviews for providing relevant and useful advice. In general, feedback from the participants was extremely helpful, and throughout the development we continuously asked for as many opinions as possible. This allowed us to constantly adjust features, significantly improving the app's overall quality. All participants rated the app at the top of the evaluation scale (5/5).

Overall, the survey analysis showed that ARtist was positively received by all user categories. Both beginners and those familiar with XR technologies rated the application very highly. The results confirm that the app successfully facilitated learning and encouraged users to attempt drawings they might otherwise have avoided, thereby helping them build confidence in their skills. The application also performed smoothly across different devices, including those used by participants who were familiar with XR technologies.

Limitations

This evaluation was exploratory in nature and should be considered a formative usability study. The number of participants was limited, there was no control group, and no direct comparison with alternative tools was made. In future work, we aim to extend the evaluation with a larger and more diverse sample, statistical analysis of results, and objective learning outcome measurements.

CONCLUSION

This paper and the ARtist application have demonstrated that AR, VR, and AI can be integrated into a single educational tool capable of supporting the entire creative process of an aspiring artist. The application aims to develop both practical drawing skills and theoretical knowledge in the field of visual arts. Usability testing and analysis of user feedback through an evaluation questionnaire confirmed that the application is a valuable educational resource, and that learning art can be not only accessible but also interactive and tailored to each individual. For many people, access to art education remains limited due to high costs, geographic constraints, and the perception that talent is a prerequisite. ARtist aims to challenge this perception by showing that AR and VR technologies, combined with modern tools based on AI and ML, can improve the process of learning and exploring art.

Overall, the project highlights the potential of bridging art and computer science: a mobile platform that does not replace traditional drawing methods, but enriches them and makes them available to anyone who wants to draw, explore, or learn about art. The main contribution of this work lies in the integration of AR, VR and AI components into a single coherent application, designed to be intuitive and accessible. Beyond the technical contributions, ARtist also raises socio-technical considerations, as it demonstrates how digital tools can complement traditional artistic practices and expand access to cultural education across diverse social contexts.

Future research directions will focus on extending ARtist towards supporting collaborative and adaptive learning in art education. One line of work will explore the design of digital communities for art learners, investigating how social interaction and peer feedback can enhance artistic skill development. Another direction concerns improving the AI module by refining the classification task (e.g., expanding from binary to multi-level difficulty) and validating it on larger and more diverse datasets. In addition, we plan to study methods for improving the accuracy of AR spatial placement (e.g., real-world size estimation) and to adapt the VR component for immersive headsets such as Meta Quest, where we will evaluate the pedagogical value of mini-games and interactive experiences. Finally, we aim to examine cloud-based data management strategies that ensure accessibility across devices, while assessing implications for user privacy and data security.

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