Designing AI Tools to Support Art Learning

A Case Study of Four AI Tools to Support Creative Inquiry

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Abstract
The ability of Artificial Intelligence (AI) tools to provide personalized feedback to creators, co-create media with artists, and enable artists to reflect on their creative style, makes them effective facilitators of art learning. Principles of constructionism highlight the importance of open-ended creative environments for enabling creative expression in young learners, yet there exist few accessible creative playgrounds that are safe for young learners to create with AI. Guided by design principles of constructionism, creativity support and accessibility, we designed four web-based AI-enabled creative tools that support art learning for middle and high school art learners and educators. These tools were administered to 94 middle and high school students and ten educators as part of an Art and AI learning summer program. We outline the design principles guiding the development of these tools, their system design features and learnings from deploying these tools with middle and high school learners. These designing insights serve as guiding principles for Creative AI tool designers and K-12 art educators.

Keywords and Phrases: Creativity Support Tools, Artificial Intelligence, K-12, Art Learning

1. Introduction

Constructionism researchers and practitioners have long been proponents of utilizing technology that affords learners to make using digital and tangible objects, such as in LEGO Mindstorms (Papert, 1991) Interactive digital tools that allow hands-on exploration of technical concepts, such as Scratch, have found success in K-12 CS learning (Resnick, et al., 2009). Technological tools have shown to be effective in learning by providing students with access to complex concepts, increasing teacher-student interactions, and providing creative exploration playgrounds for students (Shahid et al., 2019). Artificial Intelligence (AI) tools have significant impact on other fields of work, such as art, and AI learning must adapt to art classrooms. To effectively include art students and educators into the realm of AI literacy, it is essential to adopt pedagogical approaches that align with the methodologies traditionally used in art education. This entails presenting AI concepts in a manner that mirrors the experiential, iterative, and practice-based learning styles prevalent in art instruction, which in turn entrails developing AI tools that support art making. AI tools are especially well suited to support art learning due to their capability of facilitating (1)

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co-creation of media using generative algorithms (such as co-drawing, or co-writing), (2) contextual understanding of human artwork, and (3) personalized feedback and scaffolding during art creation, promoting reflection on one's art practice.

However, within the field of K-12 AI learning, barring a few exceptions (Carney et al., 2020.), there still exists a lack of accessible, interactive tools that are child-friendly, and allow hands-on exploration of creative AI technologies. The tools that do support art-making using AI often require either complex technical setup and knowledge (such as access to a Graphical Processing Unity (GPU), or pre-requisite technical experience) (Podell et al., 2023), or are behind paywalls (Ramesh et al., 2021). For accessible K-12 AI learning, and utilizing AI tools for creative learning, there is a need for low-cost, child-safe, and school district-permitted interactive tools for their classrooms.

To address this need, with the goal of supporting children's art learning using AI, I designed interactive learning tools to supplement an art program for middle and high school students. These tools incorporate principles of constructionism, where students gain art skills, knowledge, and attitudes via making personally meaningful projects (Harel & Papert, 1991). I also learn from design principles from Creativity Support Tools (CSTs) (Resnick et al., 2005) and principles of inclusive design to develop accessible and safe art environments that foster creative expression in young learners. I developed and implemented in an art learning program – "*Art and AI*", four hands-on web-based learning tools, where students can create art and reflect on their artistic practice:

1. *Write with Authors:* A co-writing tool where students can collaborate with famous authors
2. *GANPlay:* An art generator, where students can convert their doodles to different visual styles
3. *AI Art Explorer:* A tool that provides art feedback and art history from an art image
4. *Character Design:* A code notebook and web tool to design and program virtual characters

In the following section, I outline the design principles guiding the development of these AI tools that support art making learning for youth, the design of the four AI-enabled art learning web tools, and learnings from designing AI tools to support art learning.

2. Design Principles: Constructionism and Creativity

The following design principles primarily guided the design of these tools:

1. *Afford children's creative exploration:* All tools afford space for learners to create artifacts or ideas, and be drivers of the creative process. In *Write with Authors*, learners create prose in collaboration with AI, and in *Character Design*, they create and program digital characters. Taking from design principles of CSTs, the tools all have a low-floor, high-ceiling, wide-walls approach to creative learning (Rensnick et al., 2009), as they are easy to use, allow for different types of creative exploration, and can be expanded to create complex projects. For instance, one student used the *AI Art Explorer* to create an entire comic book. Tools also make space for open-ended creative exploration with no right answer, and a safe space to fail, iterate, and create again.

2. *Accessibility:* School districts that I worked with had a wide range of resource availability. I designed these tools as web-tools in an attempt to make them accessible to a wide range of students, and compatible across multiple devices. Furthermore, *Write with Authors* and *AI Art Explorer* supported multiple languages.
3. *Child safety:* All tools were designed with keeping child safety in mind. For instance, in *Write with Authors*, if children attempt to create a text category that is deemed child inappropriate, the tool will disallow it. Similarly, in the *Character Design* tool, I used feedback examples from art teachers as part of the fine-tuning data to provide child-safe feedback. Generative tools are trained on child-friendly datasets (Saldias and Ali, 2020), and incorporate educators' inputs for offering creativity scaffolding.
4. *Data privacy:* None of the tools actively collect or store any data from student usage. Using the tool will only store participants' inputs in their local browser cache memory, with no external access to the data.
5. *Adaptable:* I aimed for these tools to be usable by diverse student groups, with different interests, objectives, and cultural references. Hence, these tools build in some amount of adaptability by educators to personalize the context to different learner groups. In *Write with authors*, educators can create their own author categories that may be relevant to storybooks that they are aware of. Similarly, the *Character Design* tool is flexible to adapt to different styles of character drawings, and art educators can specify new styles for students to explore.

In the following section, I outline the design of four accessible plugged and unplugged tools that I created for children's creative learning with AI. I also discuss preliminary findings from 94 students' and ten art educators' experiences with these tools as part of an Art and AI summer program.

2.1 Write with Authors

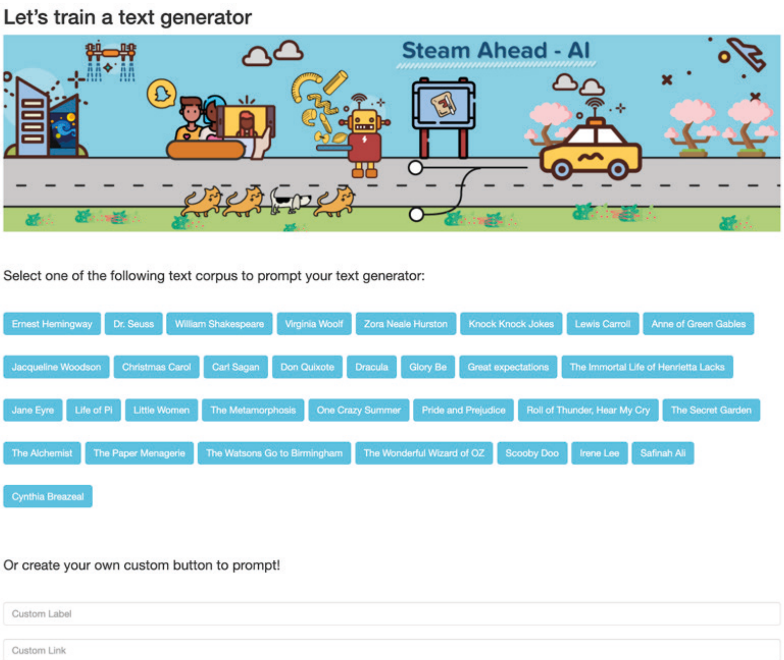

Figure 1: Write as an author text generation tool for teachers and students to create using their favorite author styles and train their own author styles. Versions of the tool use Long short-term memory (LSTM) networks or Large Language Models (LLMs).

To tackle a lack of hands-on AI-powered creative writing tools that are designed for children, I designed *"Writing with Authors"* - a Long Short Term Memory (LSTM) co-writing tool that outputs a string of text given human-inputted seed text and a selected training corpus with storytelling styles that are relevant for young readers (Figure 1) . Students could choose from a variety of styles such as Dr. Seuss, Harry Potter, and Zora Neale Hurston. Upon selecting a style for the corpus, students could choose the seed text that started the generation of text, the length of the output text, and its temperature (randomness). Outputted sentences and phrases were used as machine-generated text for the story.

In the student implementation, we found that students often used an iterative process in writing with the tool, were able to grasp the concepts of datasets, and story length. Some students struggled to understand the concept of temperature in GANs. Initial usage revealed that teachers often requested new categories of text styles to be added (e.g. an educator asked Native American texts to be added to make the tool relevant for their students), or they requested categories to be removed. Students and teachers also reported several limitations with the generated text such as incomplete sentences, or occasional gibberish words. Furthermore, two years from the development of the tool, text completion algorithms vastly improved, and we could now use LLMs for text generation. I redesigned the *Write with Authors* tool to allow teachers and students to create their own text categories by finding sample datasets from their chosen category, for teachers to monitor student created categories, and I replaced LSTMs with LLMs to make the AI response more accurate. This provided educators with greater ability to personalize *Writing with Authors* for their students.

2.2 GANPlay

To enable students to create visual art using a simple web interface, I created GANPlay (Figure 2). This tool uses the Pix2Pix algorithm (Isola et al., 2017.) to convert children's sketches or doodles into stylized images from chosen style categories. Students can make digital doodles, select style categories and create stylized images from their sketches. Students can explore the small datasets (in this case, pairs of outlines and stylized images) used for training each style category, to map elements of their stylized image to the training dataset. This also gave students insights into how different formats of datasets (such as image pairs) are used to train generative algorithms.

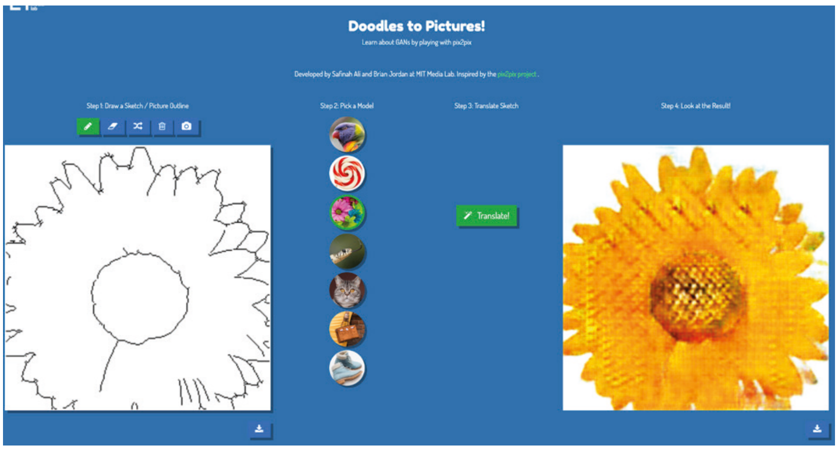

Figure 2: Interface of the GANPlay tool used to create stylized images

In the learning program, teachers decided to use *GANPlay* and *Write with Authors* in tandem for creative storytelling. Here, students would create stylized images using *GANPlay*, write a short story about it, and then use *Write with Authors* to complete their story. This way, they ended with picture stories co-created with AI, that they shared with their peers. Widely popular among educators we worked with, GANPlay is a mobile-compatible, lightweight, creative playground that affords finger drawing.

The first iteration of *Write with Authors,* that used LSTMs, and *GANPlay* that used Pix2Pix, were imperfect models that often led to erroneous media. For instance, *Write with Authors* would often make grammatical errors. In *GANPlay*, when students would select cat styles, it would insert eyes in abrupt spots, and create scary visuals. While these were technical limitations of generative models at that time, these errors were met with joy, where students could realize the imperfection of AI, but found humor in their errors. Early advances in generative AI also gave AI a unique style with its imperfections, which students often found delightful to create with, even though the art was less 'polished'. Students also had to typically carry out several iterations with the AI tools to get their desired results. This iterative creation process facilitated learning through trial and error in artistic production in an emerging creative medium - AI.

2.3 AI Art Explorer

Art Explorer is an AI-powered web-based art reflection tool that helped students reflect on their own art practice, iterate on their artwork, gain personalized feedback, perform creative storytelling through their art and deepen their art technique (Figure 3). While most creative AI tools focus on learners being able to use AI to generate novel artwork, AI's ability as an art instructor that can provide personalized feedback on visual art is often overlooked. The Art Explorer tool serves as a learning resource to help middle and high school students learn about creative applications of AI in art-making as a creativity scaffolding agent, and gain knowledge about vision capabilities of AI. Students can upload an image of their artwork, use the canvas to create digital artwork, or draw on top of their uploaded artwork to highlight a certain part of the image, and use the textbox to input specific queries to the AI tool. The tool was inspired from Chen's (2024) work on developing web-UIs for interacting with Gemini's Vision model. Borrowing UI elements of the drawing canvas, I used the vision models of both Gemini (Gemini Vision) and OpenAI (GPT-4o) in this tool, and prompted the tool with art feedback categories of responses relevant to art scaffolding practices. This tool was fine-tuned with art scaffolding examples that I designed with art educators. For learners under 18, we did not make use of the Gemini API.

I developed guided art exploration and storytelling activities that scaffold youth's use of the *Art Explorer Tool*. Students uploaded their visual artwork to the Art Explorer tool to get personalized feedback, iteratively develop their art with feedback from AI, and reflect on the painting "*Nighthawks*" by Edward Hopper to learn about the art history and techniques used in the historic artwork. Following this guided exploration, students use the Art Explorer in their own art-making activities, such as the character design or self-portrait activity.

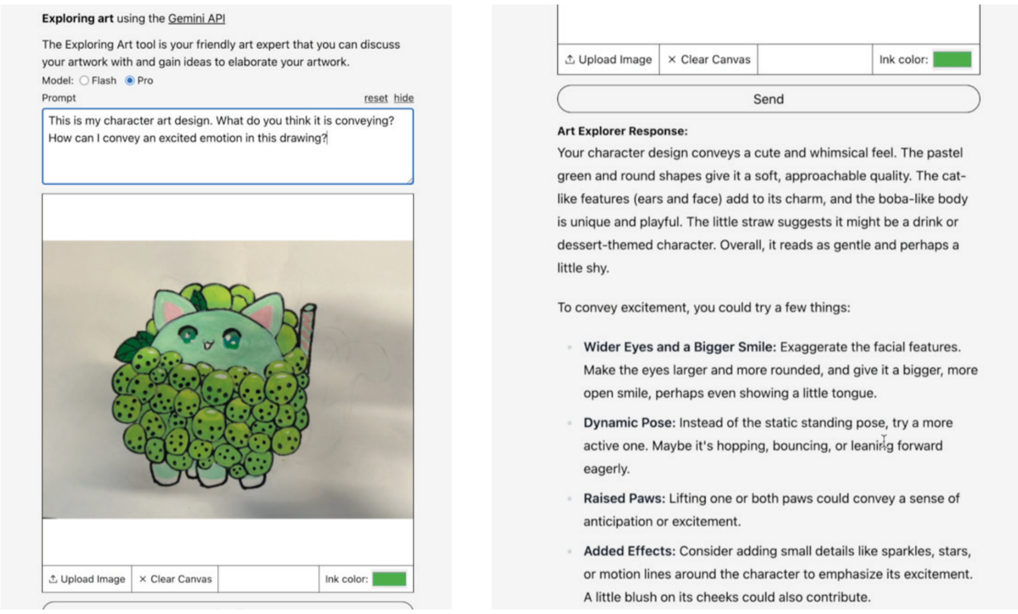

Figure 3: A student's interaction with the AI Art Explorer tool.

Sherry, a high school student in the Art and AI program, uploaded the image of her character design, explained to the AI that this is her character design, and asked the *AI Art Explorer*, *"What do you think it is conveying? How can I convey an excited emotion in this drawing?"*. The *AI Art Explorer* provided Sherry with its perception on the character conveying a *"cute and whimsical feel"* and relating its features to a *"boba drink or dessert themed character."* The Art Explorer goes on to provide her suggestions on the character's facial expressions, poses, and visual effects to make the character seem more excited. Then, Sherry draws a circle in the top-right of the canvas and specifically asks suggestions about adding elements in that segment, and the Art Explorer makes suggestions specific to the design of the straw. In this way, Sherry and the Art Explorer go back and forth to evolve the character art to her desired state. Sherry reflected that,

> "At first I could tell that it would tell me about colors and stuff. It felt more generic. But when I asked more specific questions, I got good detailed feedback. [..] It was definitely useful. I added the straw and bubbles getting ideas from the tool." Middle school student Reif said, "It is like having your art tutor in your computer."

2.4 Character Design with AI

Inspired by the traditional character design methodologies followed by creative professionals such as character artists, I developed the AI-assisted character design guided learning activity. The learning activity consisted of four design steps that typically constitute character design: (1) *Briefing*, or describing key defending features and purposes of the character, (2) *Referencing*, or gathering images, inspirations, related characters, and setting that form as inspiration for the character, (3) *Sketching*, or drawing or illustrating the character, and (4) *Production*, or developing high fidelity character designs along with multiple poses or color schemes, and readies the character for sharing. Two additional stems may sometimes be performed – (5) developing the character's *personality*, where the artist develops the character's traits, likes, dislikes, experiences, and dialogues, and (6) *animate* the character, or exploring how the character would move and emote. In this tool, students practice the essential steps of character creation and gain the skills to apply them across various aspects of the design process - developing briefs, gathering references, receiving feedback, designing character personalities, animating the character, and interacting with the character, in their preferred order.

In the AI-assisted character design process, students follow the following steps through adaptable code blocks:

- *Briefing*: Students begin by describing core attributes of their character, including personality, background and visual elements of the characters. Students declare several character variables, and the *Character Design* tool utilizes OpenAI's GPT-3.5 model[1] to further develop these attributes into a character brief.
- *Referencing*: In this step, students create and organize references for their characters. The tool utilizes OpenAI's DallE model to generate references, and organize the desirable references.
- *Sketching*: Students use their character briefs and references to begin sketching their characters. The tool utilizes GPT-4o's vision capabilities to get personalized feedback and art suggestions on their sketches. Based on feedback from AI they iterate on their sketches. They may also compare and combine multiple sketches. We use the term sketching, but this step includes different media, such as pencils, markers, clay modeling, digital drawings, paints, etc.
- *Production*: Students develop their final characters using the medium of their choosing, and develop character assets for sharing it with their peers.
- *Animation*: Students use Meta's Sketch Animate tool[2] to animate their characters.
- *Personality design*: Students design their character's personality by defining their character's key traits, such as their likes and dislikes, and develop sample dialogues to explain how their character interacts with humans. They then use OpenAI's GPT-3.5 model to bring their character to life into an interactive chatbot, where the character can have digital conversations with humans.
- *Character conversations:* Students can interact with their own character by having a chat conversation with the character. Students use the chatbot code block to create a chatbot for their character. They feed in their character's personality traits and some sample dialogue data. They then interact with their character by inputting their own dialogues and questions into the chatbot and witness how their character responds.
- *Sharing*: Students then invite their peers to interact with their characters. Students then share out to the class their final characters and how they used AI.

While these are the steps outlined in the guided code notebook, students may choose to use the code blocks in any order. Students are also encouraged to return to different parts of the process that suits their creative needs. The character design notebook provides students with multimodal opportunities for: AI interaction including drawing on paper, modeling with clay, creating character descriptions, AI-made visual design references, AI feedback on character designs, and character animation.

In order to accomplish the AI-assisted character design process, students work with OpenAI's Application Programming Interface (API) in Python code. Since students had little to no programming experience, we made use of Google Colab's rich text and interactive GUI options to help students configure variables and adapt the code to suit their character design process. Students had to write a few lines of code, but the sample code blocks made that action relatively easy. Though the activity

1 https://platform.openai.com/docs/models
2 https://sketch.metademolab.com/

sheet was set up in a certain order: *character descriptions -> AI references -> physical art ->AI feedback on physical art -> physical art modifications -> personality generation ->character chats,* students were told that they could create their own workflow, which was then reflected in their character design activity sheets.

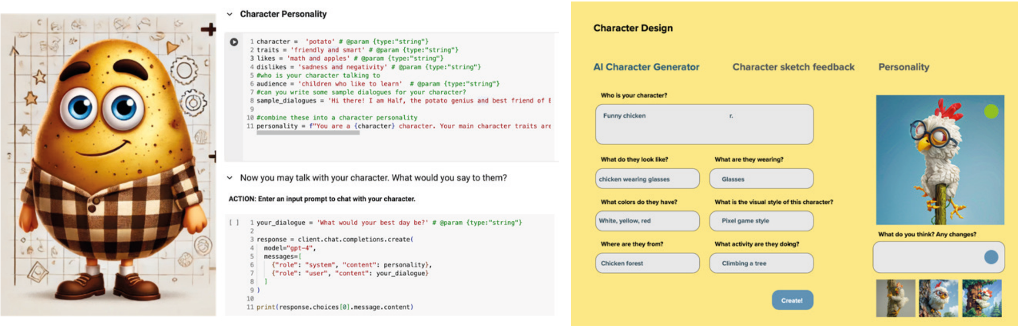

Figure 4: (Left) Character design code notebook that uses AI to guide students through the character design process (Right) Character creation tool GUI where students draw, design, animate and program imaginary characters.

In the Art and AI program, I observed that all students designed and programmed their character using visual and personality traits. Students were able to create references, seek feedback on their art, and program the character's personality. The character design tool increased participants' trust in AI, agreement with the AI's feedback, knowledge about AI concepts, and confidence in making with AI.

I also designed a web tool for character design, where learners can create characters using a GUI without using code. In this web-based tool, students could describe their character, create character reference images, get feedback on their character sketches, modify existing character art, add personality features, and interact with the virtual character using dialogue. While the tool was created for students who are novices in programming, in the *Art and AI* program, educators preferred using the code notebook, since students could see more of the 'under the hood' and it gave them greater flexibility to adapt the character, and modify model parameters. In this case, greater usability of the tool for a creative purpose did not directly correlate with greater efficacy in learning.

3. Discussion: Learnings from Designing Accessible AI Tools for Creative Learning

Student experiences with tools, and educator reported feedback from Art and AI program led to the following overarching learnings about designing effective accessible AI tools for promoting creative learning:

1. *Provide accompanying learning guides:* Educators found that learning guides that outline target age group, prerequisite knowledge, materials, lesson time, learning objectives, instructional guide, supplemental learning materials, troubleshooting instructions, and discussion prompts were valuable for them to integrate these tools in their own classrooms. I found that standalone tools, while compelling creative playgrounds, lacked the context that teachers needed to integrate tools into their curricula. Learning guides also enabled educators to share these tools with other educators.
2. *Accessibility challenges in schools:* Even though I designed these tools guided by accessible design principles, educators reported accessibility challenges of using them in actual schools. The most common one would be the school's policies around the use of technology in classrooms. Design of tools must take into account

technology policies and resource limitations for different school districts, and it is pertinent to design alternatives in these cases, such as, teacher-guided activity, local computer software, or unplugged versions of the same activity.

3. *Make tools adaptable by instructors:* I found success in adding functionality where instructors could adapt the tools and their content to suit their classrooms. Especially in the *Write with Authors* tool, the ability for educators to create their own author categories was found to be valuable by both educators and students. Educators used culturally relevant texts, and different languages such as Hindi, Japanese and Spanish to create new categories.
4. *Make tools flexible to incorporate new technology:* Since I began this work, the technologies used in the tools have rapidly gotten obsolete. For instance, GANs cease to remain the state-of-the-art in generative algorithms today, and learning tools such as How GANs Work are less relevant to AI learning. However, tools such as AI Art Explorer, or Write with Authors, where I was able to switch out the underlying algorithm, but offer the same creative interactions (albeit more accurate), were flexible to incorporate new technology. In the future, these tools can be modified further with emerging technology. Furthermore, these tools also allowed teachers to compare an old and a new version to witness how AI algorithms have advanced. Hence, there is value in building flexibility in tools that allow us to incorporate different underlying algorithms over time.
5. *Prioritize transparency:* Teachers and some learners valued the under-the-hood information that some tools provide. For instance, in the *GANPlay* tool, learners can explore the datasets used to train the models they used. In the *Write with Authors* tool, learners can not only view the underlying dataset, but also modify it to update the model category. Educators valued this transparency to (1) be better informed to support their students' learning, and (2) guide students to self-discover the underlying mechanisms of the tool. Tools such as *AI Art Explorer* and *Write with Authors* clearly indicate that AI tools can be erroneous, and responses must always be verified. Tools must make transparent known limitations of the AI used, especially when used with minors who have known to harbor misconceptions about AI's abilities (Druga et al., 2017).
6. *Encourage integrating multiple tools:* A practice we observed in the Art and AI program was that the educators encourage participants to jump across several tools, particularly in art making. Art educators encouraged students to use sketching materials, music generation tools, image generation tools, and video editing tools in tandem to create their final projects. The design of the tools must incorporate seamless integration across multiple tools, such as the ability to import and export assets from one tool to another.
7. *Develop educator communities for sustainable tool use:* I also observed that students and teachers may often run into challenges that may not be immediately addressed by the makers of the tools. These could be a result of an extension no longer being supported, changes in age restrictions, or new feature addition to the tool. I found several instances of educators exchanging tool usage strategies, new learner guides, and tips and tricks in communication channels that I set up, such as Discord. There is a need for wider community building of educators that utilize AI tools in classrooms, for which we can take inspiration from large learning community platforms accompanying tools such as Scratch (Resnick et al., 2009).

4. Conclusion

This work is an attempt to develop AI tools to support art learning for middle and high school students. Based on principles of constructionism, creativity-support tools, and inclusive design, I designed four web-based AI-enabled creativity support art production and learning tools. These tools provide open-ended creative environments that allow learners to engage in art production, and reflection on their art practice. In this paper, we reflect on findings from administering these tools for 94 middle and high school students as part of the Art and AI summer program. These design guidelines can be utilized by K-12 art educators, as well as the designers of AI tools to support art learning for youth.

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