Creativity-Supporting AI: Empowering the Next Generation of AI Creators

There is a distinct sense of joy I felt after creating my first painting, writing my first hello world program, playing my favorite kalimba tunes, telling stories and creating imaginative spaces in my head. I recognize that joy in a little girl flaunting drawings that she just created with a drawing robot she built and programmed. The girl is a part of my Creative AI middle school cohort, where children partner with algorithms to create art and explore AI as a creative medium. Another student from the same cohort remarks,

> *"I am not much interested in STEM in school. But when we [made] art in the workshop, I am now wanting to learn more about AI and maybe it could be an area for me."*

As these students congregate every week to create art with AI tools, I pause to reflect on creativity lessons from our most creative citizens - children. These children are able to see technology as an imperfect collaborator, that they train, and collaborate to *create* with.

Human creativity, our ability to create novel artifacts and ideas, is the foundation of all innovation. Though we are separated by the visible and invisible lines of languages, borders, races, genders, classes and castes, we are united in our ability to create and share art. *Making* has always been fundamental to human communities, and has manifested in various forms - be it making art for storytelling or creative problem solving for survival. Children's creativity has been known to contribute to their learning outcomes and personal growth (Carterette et al., 1994). However, early childhood research tells us that children's creativity drops when students enter elementary school and curricula become more structured (Torrance, 1968). Their ability to think outside of the box, or divergent thinking, reduces. This is concerning, especially for children growing up in today's world, where mechanical repetitive jobs get automated and shifted to machines and the need for fostering human creativity is more vital than ever. As a child, I was continuously encouraged to keep making and this has played a huge positive role in my work and life. My dream is to be able to make that accessible to all children. In my research, I focus on building technology to foster creativity in young children. More specifically, I explore how children can partner with generative AI algorithms and co-located social AI agents to create art. Further, I work on making these tools of creation more accessible and equitable to those with less access to computational resources and technical backgrounds through low resource creative AI learning materials.

Why create with AI?

Contrary to popular belief, creativity *can* be inspired from extrinsic factors, such as, social interactions with others in our environment, playful settings, mediums of creation and the nature of a task (Kafai, 2012; Kaufman & Sternberg, 2012). Children learn creativity by emulating the creative behaviors of mentors and peers, and express heightened creativity when their play is scaffolded by ideas, questions and challenges from others. Collaboration with peers is one of the most significant extrinsic factors influencing creativity, as it facilitates an exchange of ideas and feedback, and social emulation of creativity.

With advancements in educational technology, we increasingly see digital pedagogical tools used in education. Many of these tools also leverage AI, such as Socially Assistive Robots used as adaptive tutors that personalize learning and measure affect and engagement (Belpaeme et al., 2018). However, these tools seldomly focus on creative learning. Advents in generative AI techniques such as Generative Adversarial Networks (GANs) have made it possible for AI to create novel media, including visual images, videos, music and stories (Cao, et al., 2019). Deep generative models such as Transformers have made it possible to train these models with large amounts of data that result in models that can generate very realistic media (Vaswani, et al., 2017; Parmar, et al., 2018). AI's ability to express creativity enables the use of AI agents as potential models of creativity for children to emulate. Coupled with human input, these models facilitate human-AI collaboration in media creation. Hence, partnering with AI agents that can express creatively to collaborate with children as well as socially interact with them is a very compelling use of AI to inspire children's creativity. The majority of research in Human-AI collaborations in the workplace focus on benefitting human *productivity*. I believe there is a unique opportunity to leverage these collaborations to benefit human *creativity*, especially in children, who are known to pick up learning behaviors from others, including social-robotic peers (Park, et al.,2017).

In my research, I explore ways to empower young creators by studying how children can partner with AI agents to create, for which I propose two approaches: (1) *Designing creativity-supporting collaborative AI agents,* and *(2) Developing creative AI education curricula and resources that make tools of creation accessible to all children.*

Creativity-Supporting Collaborative AI Agents

In my work, I research how AI can help stimulate children's creativity, and whether partnering with AI agents can enhance their creative expression. In my previous work, I studied whether we can leverage social-robotic peers as creativity support tools for children in collaborative interactions. Social robots have the unique ability to socially and emotionally interact with children through verbal and non-verbal behaviors, and can not only collaborate with children in creative tasks, but also offer creativity scaffolding such as demonstrating creativity, offering ideas, asking questions and posing challenges. I focused on two robot interactions: creativity demonstration, where the robot exhibits creative behaviors, and creativity scaffolding, where the robot poses challenges, suggests ideas, provides positive reinforcement, and asks questions to scaffold children's creativity. I situated my research in four playful and collaborative child-robot tasks with the social robot Jibo: (1) Droodle creativity game, where children and Jibo create humorous titles for abstract images, exhibiting verbal creativity, (2) MagicDraw game where they collaboratively make drawings on a digital interface, exhibiting figural creativity (3) the WeDo LEGO blocks construction task, where the robot collaborates with children in a LEGO blocks construction and block-based programming activity, exhibiting constructional creativity and divergent thinking, and (4) EscapeBot, where they play a cooperative strategy platform game exhibiting creative problem solving (Ali, et al., 2021). Jibo acts as a peer collaborator and expresses artificial creativity in each task. For exhibiting artificial creativity, I trained task specific generative models. Jibo used a recurrent neural network trained on children's drawings to complete children's doodle strokes in the MagicDraw game, and a language model trained on many examples of humorous titles for abstract images in the Droodle game. The robot's social interactions were modeled after data that I collected from human teachers while scaffolding children's creativity in LEGO construction and problem solving tasks. With the baseline human instructor data, I constructed generative models that used the sequence of students' actions in the activities to predict when and how to deliver creative support.

To evaluate the efficacy of the robot's behaviors in enhancing creative expression in children, I ran four randomized controlled trial experiments where children either interacted with the robot expressing creativity eliciting behavior or were in the control condition with the robot expressing low creative behaviors. I found that children who interacted with the robot exhibiting high verbal creativity in the Droodle game and high figural creativity in the MagicDraw game also exhibited significantly higher creativity than participants in the control group (Ali, et al., 2019; 2020). In the WeDo construction task and EscapeBot game, children who interacted with the robot that expressed creative scaffolding behaviors demonstrated significantly higher creativity than participants in the control group by expressing a greater number of ideas, more original ideas, and more varied use of available blocks (Ali et al., 2021). I found that both *creativity demonstration* and *creativity scaffolding* offered by a robot can be leveraged as social mechanisms for eliciting creativity in children (Ali et al., 2020). From these findings, I suggested creativity scaffolding design guidelines for game designers and Human-Computer Interaction (HCI) and Human-Robot Interaction

(HRI) practitioners, including, creativity demonstration, reflective question-asking, designing playful tasks, and positive reinforcement (Ali et al., 2021).

Through this research, I established that co-present robots' ability to create and socially interact with children makes them effective creativity support tools in collaborative game-based tasks. However, the experiments were constrained to narrow, controlled tasks. In my thesis, I aim to build AI partners that facilitate open-ended multi-modal creative expression during storytelling through visual, textual and audio modalities. I will make use of a combination of language generation and image generation algorithms for the AI companion to create parts of a story to assist children in creative storytelling. I envision a turn-taking interaction, where the agent utilizes a generative model that takes into account the human input at every turn during inference to generate novel AI-input. I will make use of a combination of Contrastive Language–Image Pre-training (CLIP) models and visual and audio GANs for collaborative visual and textual storytelling. The AI collaborator will use dynamic text from children's stories to produce generative visuals, text, music and social interactions for rich storytelling. I will also use the Common Sense Transformers for Automatic Knowledge Graph Construction (COMET) to train the AI companion to generate relational content relevant to children's story content, in order to personalize stories to children's interests. Since several existing generative language models replicate biases in large text datasets, I aim to take a child-aware focus in training language models using child-friendly datasets (Saldias & Ali, 2020).

Through human studies with children, I aim to study how this open-ended creativity-support social-robotic system influences children's creativity during the task, and how that transfers to their creativity in daily lives. In a smaller attempt to learn from human-human collaboration, I designed a collaborative web tool where two children can work together to create a narrative using drawings and text, and compiled a two-person collaborative drawing and chat dataset. To facilitate human-AI collaboration, I am currently training a part-based GAN that generates a new constituent part of the drawing or text after the human creates a part, using the intermediate creation as input during inference, taking turns until the narrative is complete.

AI is emerging as a new medium of creativity, with artists and technologists participating to create and sell AI-generated art. However, in my work on AI supporting human creativity, I quickly realized how these tools and spaces remain unreachable for many, since tools of AI creation are not accessible to all due to limitations of computation resources and prerequisite knowledge. In addition to developing creativity-supporting AI agents for children, I aim to make these tools of creation with AI more accessible, especially to youth from underrepresented groups in STEM fields. To this end, I developed several low-resource accessible Creative AI learning resources for k12 students.

Creative AI Education for Youth

I developed the Creative AI curriculum with educational materials and interactive activities for middle school students with a focus on GANs, creation of machine-generated media, and its benefits and harms. Students learned about the technical constitution of generative models (how they work), their benefits and harms (how they can be used), and their societal and ethical implications (how they affect us). We partnered with S.T.E.A.M. programs that engage students from underrepresented minority groups in the United States of America, including non-male students and BIPOC youth, and deployed the curriculum with over 200 students (Lee, Ali, et al. 2020). I developed interactive games that help students explore what generative models are, how they can train GANs, how they can partner with generative models to make art, who owns machine generated art, what Deepfakes are, and how generative models might exacerbate the spread of misinformation. I developed an interactive style transfer tool to create visual art, and used child-friendly datasets to create a text-generation tool. To explain how GANs work, I developed a pixel art generation game, where student teams played the role of a generator network that creates art and a discriminator network that provides feedback after being trained on examples to create synthetic data (Ali & DiPaola, 2020). I also worked on creating a generative models learning trajectory (LT) appropriate for middle schoolers and laid out a framework generalizable to create LT's for other complex socio-technical systems (Ali et al., 2021). Using learning assessment tools in our workshops, we found that these materials enabled children to gain a basic understanding of what generative models are and the roles of a generator and discriminator networks in a GAN. In a post-workshop survey, students reflected on potential benefits and harms of the generative models they interacted with. Students identified benefits such as "Helping me be more creative" and "Teaching me [art]", and harms such as "Impersonation" and "Spreading false news".

To make these materials accessible to more students, I am currently conducting teacher training workshops with 33 Title-I middle-school computer science teachers from five states across the country, where we collaborate to integrate these resources into middle school curricula. I am co-designing these materials with students and their teachers, while taking into account students' interest areas, prior knowledge and learning abilities. In order to scale these efforts, I propose to develop an evolving low-resource AI-creation studio where students can train generative algorithms using block-based programming environments with their unique datasets, and use human input to collaboratively create art with AI. As generative models are a rapidly evolving area of research, tools used in our existing curriculum start to get outdated. I propose to develop a k12 framework that is ready to adapt new advancements in the field into teachable lessons for students, together with their applications and ethical implications, making avant-garde algorithms accessible to young learners. This research empowers young children to leverage AI algorithms for creative applications, and prepares them to navigate their societal implications.

K12 AI literacy is critical for children growing up in the age of AI to be responsible consumers and creators of AI-enabled technologies (Williams, et al., 2019; Ali, et al., 2019). In my commitment to make AI learning accessible, I helped design the SureStart program as a head mentor, that aims to bring AI learning resources to high school and college students from underrepresented groups and matches them with AI opportunities in the industry. I co-organized the Women in ML workshop "Towards Child-Aware Machine Learning with a Focus on NLP Challenges and Applications." I am also a part of the MIT India Initiative and Clubes de Ciencia program in Mexico where, as a mentor, I help bring these resources to student communities across the world.

Potential Impact of Research

In a data-driven creative storytelling workshop that I mentored in Mumbai, students developed interactions to tell crucial narratives about local businesses, climate change and women safety, which are issues their communities are tackling. This kind of unique community perspective can only be developed by members of that community, and they must be empowered with emerging tools of creation to do so. AI literacy helps young children's voices to be a part of development of AI algorithms and awareness about their capabilities and societal implications better prepares children to interact with content online, and be responsible creators. Through my work on using social AI agents to foster children's creativity, I aim to leverage generative AI tools to empower the next generation of creators. Early childhood creativity plays a huge role in children's overall success and well being, and with the rise of AI-assisted pedagogical tools in classrooms, there is a unique opportunity in leveraging them to augment creativity. Through my work in creative AI education, I aim to make creative AI tools accessible to non-technical students, more specifically, K-12 learners from groups historically underrepresented in STEM. Making tools of creation accessible to diverse communities provides mediums to amplify their narratives. The creative AI curriculum not only provides students with novel platforms to create, but also enables them to think critically about the ethical implications of these technologies, and their societal impact. This learning framework would further equip them with the technical knowhow of pursuing careers at the intersection of AI and art, and make AI learning more approachable and fun through art-making. Finally, with this work I aim to contribute to the fields of AI literacy, creativity support tools and HRI.

Microsoft Research PhD Fellowship

My work draws on AI Education, Human-Robot Interaction, Ethics in AI and Creative Computing. At MSR, I find several research threads that strongly align with my research interests, including the development of creative technological tools such as Microsoft MakeCode, Expressive Pixels and Computational Creativity Support, and the FATE group's work on how AI impacts people. I am inspired by how empowering people has been the focal point of all these projects. This fellowship will give me access to collaborate with amazing researchers at Microsoft and will support my ability to bring learning toolkits to historically underrepresented groups in STEM. Finally, the support of the MSR PhD Fellowship will give me the freedom to devote my time to research, and invest my time and efforts in collaborations with community partners and educators.

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