

# Ziyi Liu

HCI RESEARCHER | XR/AI AGENT DEVELOPER

Purdue University, West Lafayette, IN

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## Research Goal

My research goal is to reshape STEM education in extended reality with AI-driven agents, wearables, tangible toolkits, and spatial user interfaces. I aim to create immersive, intelligent, adaptive, and natural experiences that empower educators and learners in the aspects of learning content creation, delivery, and consumption.

## Education

### Purdue University

PH.D. STUDENT

West Lafayette, IN

Aug. 2021 - Present

- Lead HCI research in developing **XR systems of Pedagogical Agent, Tutorial Authoring, Teleconsulting, Tangible Toolkit, and Spatial Programming**. Advisor: Dr. Karthik Ramani.
- Published **4** lead-author research papers in CHI and UIST. Co-authored **10** papers in top-tier HCI venues. **3** papers are conditionally **accepted by CHI 2026**. Got **3** Patent Applications.

### Purdue University

MASTER'S DEGREE OF MECHANICAL ENGINEERING

West Lafayette, IN

Jan. 2019 - Aug. 2021

### Purdue University

BACHELOR'S DEGREE OF MECHANICAL ENGINEERING

West Lafayette, IN

Aug. 2014 - May. 2018

## Highlighted Publications

### AgentHands: Generating Interactive Hand Gestures for Spatially Grounded Agent

#### Conversations in XR

San Jose, CA

LEAD AUTHOR

Accepted in CHI 2026

- Proposed AgentHands, an LLM-powered XR system that augments conversational agents with expressive, spatially anchored co-speech hand gestures, bridging the mental mapping gap of text/speech-only responses.
- Conducted a formative study (N=10) to derive a multidimensional gesture taxonomy (handedness, gesture, spatiality, temporal dynamics, interactivity, visual effects) and key design attributes for embodied hand agents in XR.
- Built an end-to-end pipeline integrating Gemini-powered response generation with inline GestureEvents, gaze-based object registration, word-level speech alignment, and a parametric animation engine on Android XR.
- Ran a within-subjects user study (N=12) demonstrating significantly improved spatial understanding, engagement, and response comprehension compared to a speech-only baseline.

### AmIWrite: Exploring Scalable One-on-One Handwriting-Based Tutoring for Mathematical

#### Problem-Solving with an LLM-Powered AI Tutor

West Lafayette, IN

LEAD AUTHOR

Accepted in CHI 2026

- Proposed AmIWrite, an LLM-powered AI tutoring system that delivers real-time co-speech handwriting interactions on tablet devices, enabling scalable one-on-one mathematical problem-solving tutoring with synchronized verbal and visual feedback.
- Defined a design space of tutor-student handwriting interactions comprising text writing (declarative, procedural, selective) and annotations (underline, circle, arrow, check/cross), deployed across lecture, guidance, and practice scenarios following the Gradual Release of Responsibility model.
- Built an end-to-end pipeline integrating Gemini 2.5 Pro reasoning with handwriting function tags, grid-based spatial referencing, word-level speech alignment, and animated canvas annotations for temporally synchronized multimodal instruction.
- Conducted a within-subjects user study (N=40) in linear algebra showing significantly improved user experience, reduced NASA-TLX cognitive workload, and higher system usability compared to a text-based AI tutor baseline.

## **JustShape: Exploring Co-Speech Gestures for Multimodal LLM-Powered 3D Parametric Modeling**

*West Lafayette, IN*

CO-AUTHOR

*Accepted in CHI 2026*

- Co-designed *JustShape*, an AR-based multimodal parametric modeling system that combines speech with co-speech gestures to reduce language ambiguity and support intent-driven 3D creation.
- Contributed to interaction design and system architecture, including a multimodal fusion pipeline (gesture parameterization + multimodal LLM reasoning) and LLM-based OpenSCAD code generation/rendering in an AR workflow.
- Co-designed a formative elicitation study (N=16) to characterize speech–gesture synergy and derive a gesture design space mapping free-form gestures to core shape attributes (e.g., profile, scale, position, direction, trajectory, angle).
- Co-designed and ran a two-session user study with novice designers (N=16), showing co-speech gestures produced models 40.1% closer than speech-only and reduced interaction time by 47.3% compared to sketch+speech baselines.

## **ClassMeta: Designing Interactive Virtual Classmate to Promote VR Classroom Participation [C.4, P.1] [Honorable Mention Award (Top 5%)]**

*West Lafayette, IN*

CO-LEAD AUTHOR

*Published in CHI 2024*

- Designed an LLM-powered virtual agent to promote classroom participation in VR by simulating peer influence through adaptive voice and body gesture behaviors.
- Developed a systematic interaction framework (instructor–agent, student–agent, self-behavior) enabling context-aware responses based on real-time conversational understanding.
- Conducted a between-subjects user study (N=24) combining eye-tracking, pre-post learning assessments, Likert-scale surveys, and semi-structured interviews—demonstrating significant improvements in engagement, note-taking quality, and learning outcomes.
- Created a reusable prompt template enabling educators to customize agent behaviors for different subjects and pedagogical needs.

## **InstruMentAR: Auto-Generation of Augmented Reality Tutorials for Operating Digital Instruments Through Recording Embodied Demonstration [C.5, P.2]**

*West Lafayette, IN*

CO-LEAD AUTHOR

*Published in CHI 2023*

- Designed an AR tutorial authoring system that reduces cognitive load during complex instrument operations by automatically generating guidance from embodied demonstrations.
- Developed a multimodal sensing approach fusing gesture tracking and wearable pressure sensors to detect user manipulations on physical UI elements (buttons, knobs, sliders).
- Conducted an elicitation survey (N=50) to establish a gesture taxonomy for five common UI element types, informing the system’s interaction design.
- Evaluated the system through comparative user studies (N=20) measuring task completion time, context switches, and SUS scores—demonstrating significant improvements in authoring efficiency and user confidence.
- Designed preemptive haptic-visual feedback that warns users before errors occur, reducing operational mistakes during procedural tasks.

## **LearnIoTVR: An End-to-End Virtual Reality Environment Providing Authentic Learning Experiences for Internet of Things [C.6] [Honorable Mention Award (Top 5%)]**

*West Lafayette, IN*

CO-LEAD AUTHOR

*Published in CHI 2023*

- Designed an end-to-end VR environment enabling novice users to install, program, and explore spatially distributed IoT systems through an immersive 3D block-based interface grounded in cognitive load and multimedia learning theory.
- Developed a custom 3D programming language with dynamic block nesting and a “container” feature for multi-device interaction, reducing spatial complexity when configuring interconnected smart-home components.
- Conducted a pre/post-test user study demonstrating statistically significant learning gains across all measured competencies, with strong system usability scores.
- Ran a qualitative comparison study against a desktop-based baseline, revealing user preference for embodied exploration and in-situ feedback—transferable insights for onboarding users to complex, spatially distributed systems.

## **MechARspace: An Authoring System Enabling Bidirectional Binding of Augmented Reality with Toys in Real-time [C.7, P.3]**

*West Lafayette, IN*

CO-LEAD AUTHOR

*Published in UIST 2022*

- Proposed a bidirectional interaction framework mapping physical inputs to AR outputs and vice versa, derived from an elicitation study analyzing 78 user-designed artifacts across four toy categories.
- Designed a plug-and-play modular IoT toolkit (8 sensor/actuator modules) and an in-situ AR authoring interface on HoloLens 2, enabling novice users to prototype interactive physical-digital experiences through demonstration and trigger-action visual programming.
- Conducted a two-session user study evaluating system usability across structured tasks and a freestyle design session, achieving strong usability scores and validating that non-technical users could independently create diverse interactive prototypes.

## **agentAR: Creating Augmented Reality Applications with Tool-Augmented LLM-based Autonomous Agents [C.1]**

*West Lafayette, IN*

Co-AUTHOR

*Published in UIST 2025*

- Introduced agentAR, an authoring system that enables end-to-end AR application creation through natural-language dialogue with a tool-augmented LLM agent.
- Derived a common AR application structure and built a tool library from state-of-the-art research to inform the agent's planning and execution mechanisms.
- Developed an interactive workflow where users can describe, refine, and deploy AR experiences entirely in situ through iterative conversation.
- Validated the system via a case study of six re-implemented AR applications and a user study with 12 participants, demonstrating significant usability gains for non-experts.

## **GesPrompt: Leveraging Co-Speech Gestures to Augment LLM Understanding in Mixed Reality [C.2]**

*West Lafayette, IN*

Co-AUTHOR

*Published in DIS 2025*

- Introduced GesPrompt, a copilot system that integrates speech with co-speech gestures for seamless interaction in XR environments.
- Utilized LLM capabilities to process multimodal inputs, enabling users to manipulate virtual objects with gestures and natural voice commands seamlessly.
- Designed a prototype implementing the workflow, showcasing applications in virtual content creation and real-time interaction.
- Conducted a user study to evaluate the system, showing enhanced usability and communication efficiency in spatial tasks.

## **ColabAR: A Toolkit for Remote Collaboration in Tangible Augmented Reality Laboratories [C.8]**

*West Lafayette, IN*

Co-AUTHOR

*Published in CSCW 2022*

- Developed a tangible AR laboratory toolkit that attaches haptic-enabled modules to everyday objects for realistic remote manipulation of virtual lab equipment.
- Created a Unity package that enables rapid configuration of AR behaviors and customizable haptic patterns for designing new TAR laboratory experiences.
- Engineered a multi-tier collaboration architecture integrating BLE device control with cloud-based synchronization for real-time shared AR and haptic interactions.
- Conducted two controlled user studies (N=40) demonstrating improved collaboration, partner awareness, and 25% faster task completion while maintaining comparable learning performance.

## **RobotAR: An Augmented Reality Compatible Teleconsulting Robotics Toolkit for Augmented Makerspace Experiences [C.9]**

*West Lafayette, IN*

Co-AUTHOR

*Published in CHI 2021*

- Designed and built a teleconsulting robotics toolkit that provides instructors with fine-grained spatial accessibility to remote makerspaces of students.
- Developed an AR-compatible robot that functions as both a tutoring agent with integrated voice assistance and a teleconsultation tool connected to the human instructor.
- Implemented real-time AR instruction delivery, including spatial annotations, demos, and visual cues superimposed on students' physical workspaces.
- Conducted a comparative user study demonstrating improved key competencies, higher-quality teleconsulting, and enhanced instructor presence over Zoom-based distance learning.

## **Meta-AR-App: An Authoring Platform for Collaborative Augmented Reality in STEM Classrooms [C.10]**

*West Lafayette, IN*

Co-AUTHOR

*Published in CHI 2020*

- Developed Meta-AR-App, a collaborative AR authoring platform that enables rapid creation of augmented STEM learning content without coding.
- Introduced a novel pull-based collaboration model with both local (student-to-student) and global (student-to-instructor) contribution workflows to support an iterative improvement workflow of the learning content.
- Designed a four-category classroom framework (Work, Design, Collaboration, Technology) grounded in real classroom observations and AR-supported learning processes.
- Conducted controlled and open-ended user studies demonstrating reduced task errors, enhanced debugging efficiency, and improved collaborative learning in authentic STEM activities.

## **avaTTAR: Table Tennis Stroke Training with On-body and Detached Visualization in Augmented Reality [C.3]**

*West Lafayette, IN*

CO-AUTHOR

*Published in UIST 2024*

- Introduced an AR system for table tennis stroke training using both on-body and detached visual cues to enhance motor skill learning.
- Developed a motion capture system that uses pose estimation and IMU sensors for real-time feedback and comparison with expert avatars.
- Conducted user studies demonstrating the system's effectiveness in improving stroke accuracy and high user satisfaction.

## Technical Skills

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<b>AR/VR/XR Development</b>	Unity3D; Galaxy XR, HoloLens 2, Oculus Quest; AndroidXR, OpenXR, ARCore, ARKit, Vuforia
<b>Programming Languages</b>	C#, C++, Python, R
<b>Design and Prototyping</b>	PTC Creo, Arduino, AutoCAD, 3D Printing, Laser Cutting, CNC Machining, Matlab, Blender
<b>Vision and Graphics</b>	OpenCV
<b>Deep Learning</b>	Tensorflow, PyTorch; Object Detection(YOLO)
<b>Large Language Model</b>	LLM-Embedded Application Development in Unity, Prompt Engineering with GPT-4, Gemini

## Professional Experience

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### Google LLC

*Mountain View, CA*

STUDENT RESEARCHER INTERN, ANDROID XR

*May 2025 – Dec 2025*

- Implemented AgentHands — an Android XR conversational agent that converts LLM responses into time-aligned, space-anchored hand gestures, improving clarity and followability vs. text-based assistants.
- Established design space via a formative study; defined gesture taxonomy (deictic/iconic/expressive), composition rules (spatiality, timing, interactivity), and the appearance of the XR agent.
- Built end-to-end stack in Unity/OpenXR for Android XR headsets: Gemini-powered reasoning & TTS, Android STT, word-level alignment, and a gaze/scene-mesh registration pipeline for low-latency, semantic, and object-anchored gestures.
- Ran a within-subjects user study on realistic tasks; demonstrated higher engagement and spatial followability vs. speech-only; co-led experimental design, analysis, and paper writing.

### Purdue University

*West Lafayette, IN*

GRADUATE RESEARCH ASSISTANT

*Aug. 2023 – Present*

- Conduct research on Human-Computer Interaction (HCI) with a focus on pedagogical robotics, AI agents, and AR/VR applications in STEM education.
- Investigate the design and implementation of interactive learning systems, developing novel methodologies to enhance user engagement and learning outcomes.
- Design and conduct user studies, develop mixed-reality toolkits, and analyze human-agent interactions in virtual environments.
- Utilize tools including VR/AR headsets, robotics platforms, C#, Unity, and data analysis tools for qualitative and quantitative research.

## Teaching Experience

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### Toy Design (Computer-Aided Design and Prototyping)

*West Lafayette, IN*

GRADUATE TEACHING ASSISTANT

*Spring 2019 - Spring 2020, Fall 2021 -*

*Spring 2023, Spring 2024*

- Delivered lectures about prototyping methods, including CAD with PTC Creo, 3D printing, laser cutting, and Arduino to over 300 students.
- Evaluated assignments and provided detailed feedback to help students identify and correct design errors.
- Discussed project ideas with students and provided conceptual guidance and technical suggestions throughout the design process.
- Tutored struggling students individually and in small groups to reinforce conceptual and hands-on learning.
- Designed mid-term competition projects aiming to reinforce students' innovative thinking and the capability of prototyping.
- Organized the final toy fair event for the students to present their projects to the public.

### Introduction To Mechanical Engineering Design, Innovation And Entrepreneurship

*West Lafayette, IN*

LAB COORDINATOR

*Fall 2023*

- Actively interacted with student teams during lab sessions to guide them through each stage of the product development process.
- Answered technical and conceptual questions related to submodules such as problem definition, concept generation, prototyping, and testing.
- Discussed project ideas with teams and provided feedback and possible solutions to refine design feasibility and innovation.
- Evaluated design reports and presentations for each phase and provided detailed written feedback to support iteration and improvement.

## Academic Service

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**Program Committee** TEI WiP 2026, DIS WiP 2026

**Reviewer** CHI, IEEE VR, UIST, CSCW, ISMAR, VRST, TEI, DIS, CHI LBW, MobileHCI LBW

**Session Chair** CHI 2024: Learning and Teaching Technologies

## Honors and Awards

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May. 2024 **Honorable Mention**, ACM Conference on Human Factors in Computing Systems [CHI 2024] *Honolulu, Hawaii*

Apr. 2023 **Honorable Mention**, ACM Conference on Human Factors in Computing Systems [CHI 2023] *Hamburg, Germany*

May. 2025 **Special Recognitions for Outstanding Review (2 paper reviews, 1 late-breaking work review)**, ACM Conference on Human Factors in Computing Systems [CHI 2025] *Yokohama, Japan*

## Publications

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- [C.1] Chenfei Zhu, Shao-Kang Hsia, Xiyun Hu, Ziyi Liu, Jingyu Shi, and Karthik Ramani. 2025. AgentAR: Creating Augmented Reality Applications with Tool-Augmented LLM-based Autonomous Agents. In Proceedings of the 38th Annual ACM Symposium on User Interface Software and Technology (**UIST '25**). Association for Computing Machinery, New York, NY, USA, Article 54, 1–23. DOI: <https://doi.org/10.1145/3746059.3747676>
- [C.2] Xiyun Hu, Dizhi Ma, Fengming He, Zhengzhe Zhu, Shao-Kang Hsia, Chenfei Zhu, **Ziyi Liu**, and Karthik Ramani. 2025. GesPrompt: Leveraging Co-Speech Gestures to Augment LLM-Based Interaction in Virtual Reality. In Proceedings of the 2025 ACM Designing Interactive Systems Conference (**DIS '25**). Association for Computing Machinery, New York, NY, USA, 59–80. DOI: <https://doi.org/10.1145/3715336.3735769>
- [C.3] Dizhi Ma, Xiyun Hu, Jingyu Shi, Mayank Patel, Rahul Jain, **Ziyi Liu**, Zhengzhe Zhu, and Karthik Ramani. 2024. AvaTTAR: Table Tennis Stroke Training with Embodied and Detached Visualization in Augmented Reality. In Proceedings of the 37th Annual ACM Symposium on User Interface Software and Technology (**UIST 2024**). DOI: <https://doi.org/10.1145/3654777.3676400>
- [C.4] **Ziyi Liu\***, Zhengzhe Zhu\*, Lijun Zhu, Enze Jiang, Xiyun Hu, Kylie A Pepler, and Karthik Ramani. 2024. ClassMeta: Designing Interactive Virtual Classmate to Promote VR Classroom Participation. In Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (**CHI 2024**). DOI: <https://doi.org/10.1145/3613904.3642947>
- [C.5] **Ziyi Liu\***, Zhengzhe Zhu\*, Enze Jiang, Feichi Huang, Ana M Villanueva, Xun Qian, Tianyi Wang, and Karthik Ramani. 2023. InstruMentAR: Auto-Generation of Augmented Reality Tutorials for Operating Digital Instruments Through Recording Embodied Demonstration. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (**CHI 2023**). DOI: <https://doi.org/10.1145/3544548.3581442>
- [C.6] Zhengzhe Zhu\*, **Ziyi Liu\***, Youyou Zhang, Lijun Zhu, Joey Huang, Ana M Villanueva, Xun Qian, Kylie Pepler, and Karthik Ramani. 2023. LearnIoTVR: An End-to-End Virtual Reality Environment Providing Authentic Learning Experiences for Internet of Things. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (**CHI 2023**). DOI: <https://doi.org/10.1145/3544548.3581396>
- [C.7] Zhengzhe Zhu\*, **Ziyi Liu\***, Tianyi Wang, Youyou Zhang, Xun Qian, Pashin Farsak Raja, Ana M Villanueva, and Karthik Ramani. 2022. MechARspace: An Authoring System Enabling Bidirectional Binding of AR with Toys in Real-time. In Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology (**UIST 2022**). DOI: <https://doi.org/10.1145/3526113.3545668>
- [C.8] Ana M Villanueva\*, Zhengzhe Zhu\*, **Ziyi Liu**, Feiyang Wang, Subramanian Chidambaram, and Karthik Ramani. 2022. ColabAR: A Toolkit for Remote Collaboration in Tangible Augmented Reality Laboratories. In Proceedings of the ACM on Human-Computer Interaction (**CSCW 2022**). DOI: <https://doi.org/10.1145/3512928>
- [C.9] Ana M Villanueva, **Ziyi Liu**, Zhengzhe Zhu, Xin Du, Joey Huang, Kylie Pepler, and Karthik Ramani. 2021. RobotAR: An Augmented Reality Compatible Teleconsulting Robotics Toolkit for Augmented Makerspace Experiences. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (**CHI 2021**). DOI: <https://doi.org/10.1145/3411764.3445726>
- [C.10] Ana M Villanueva, Zhengzhe Zhu, **Ziyi Liu**, Kylie Pepler, Thomas Redick, and Karthik Ramani. 2020. Meta-AR-App: An Authoring Platform for Collaborative Augmented Reality in STEM Classrooms. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (**CHI 2020**). DOI: <https://doi.org/10.1145/3313831.3376146>
- [C.11] Ana Villanueva, Hritik Kotak, **Ziyi Liu**, Rutvik Mehta, Kaiwen Li, Zhengzhe Zhu, Yeliana Torres, Karthik Ramani. 2020. ARbits: Towards a DIY, AR-compatible electrical circuitry toolkit for children. In Proceedings of the 2020 ACM Interaction Design and Children Conference: Extended Abstracts (**IDC EA 2020**). DOI: <https://doi.org/10.1145/3397617.3397849>
- [C.12] Ana Villanueva, **Ziyi Liu**, Yoshimasa Kitaguchi, Zhengzhe Zhu, Kylie Pepler, Thomas Redick, and Karthik Ramani. 2021. Towards modeling of human skilling for electrical circuitry using augmented reality applications. In International Journal of Educational Technology in Higher Education 2021 (**ETHE 2021**). DOI: <https://doi.org/10.1186/s41239-021-00268-9>

- [C.13] Claudia Krogmeier, Justin Heffron; Justin Legare, Michael Nelson, **Ziyi Liu**, Christos Mousas. 2020. Blindness Visualizer: A Simulated Navigation Experience. In 2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (**2020 IEEE VRW**). DOI: <https://doi.org/10.1109/VRW50115.2020.00107>
- [C.14] Joey Huang, Ariel Han, Ana Villanueva, **Ziyi Liu**, Zhengzhe Zhu, Karthik Ramani, Kylie Pepler. 2024. Deepening children's STEM learning through making and creative writing. In International Journal of Child-Computer Interaction, Volume 40, 2024 (**2024 IJCCI**). DOI: <https://doi.org/10.1016/j.ijcci.2024.100651>
- [C.15] Xiyun Hu, Runlin Duan, **Ziyi Liu**, Vincent G. Duffy. 2023. Wearables and Mixed Reality in Applied Ergonomics: A Literature Review. In: Duffy, V.G. (eds) Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management. (**HCI 2023**). Lecture Notes in Computer Science, vol 14028. DOI: [https://doi.org/10.1007/978-3-031-35741-1\\_7](https://doi.org/10.1007/978-3-031-35741-1_7)

## Patents

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- [P.1] Karthik Ramani, Zhengzhe Zhu, **Ziyi Liu**. 2025. System and method for providing an interactive virtual classmate to promote student participation in a virtual reality classroom. U.S. Patent Application No. 19183412.
- [P.2] Karthik Ramani, Zhengzhe Zhu, **Ziyi Liu**. 2024. Auto-generation of augmented reality tutorials for operating digital instruments through recording embodied demonstration. U.S. Patent Application No. 18615083.
- [P.3] Karthik Ramani, Zhengzhe Zhu, **Ziyi Liu**, Tianyi Wang. 2024. Authoring systems and methods for enabling bidirectional binding of augmented reality with toys in real-time. U.S. Patent Application No. 18480158.