

# Hainachuan Huang

## Research Portfolio

AI-Supported Learning · AR Learning Environments · Learning Assessment

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Research training: VR/AR+Education Lab, Beijing Normal University · Supervisor: Prof. Su Cai

### RESEARCH PROFILE

I design and study AI-supported learning environments that help students use AI productively while retaining responsibility for thinking, evidence checking, and learning decisions. My work connects learning-science questions with system development and school-based research: I translate educational needs into functional AI/AR prototypes, implement them in authentic K–12 settings, analyse quantitative and qualitative evidence, and turn findings into scholarly and design outputs.

### RESEARCH FOCUS

| Human-AI Collaborative Learning                                                        | Assessment in the AI Era                                                        | Digital Well-Being                                                                      |
|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Supporting effective and independent learning with AI while preserving learner agency. | Making learning processes visible and evaluating evidence beyond final answers. | Developing responsible, purposeful, and equitable approaches to educational technology. |

### RESEARCH PROCESS

|             |              |                 |                 |               |                   |
|-------------|--------------|-----------------|-----------------|---------------|-------------------|
| 01<br>Frame | 02<br>Design | 03<br>Prototype | 04<br>Implement | 05<br>Analyse | 06<br>Communicate |
|-------------|--------------|-----------------|-----------------|---------------|-------------------|

### PORTFOLIO CONTENTS

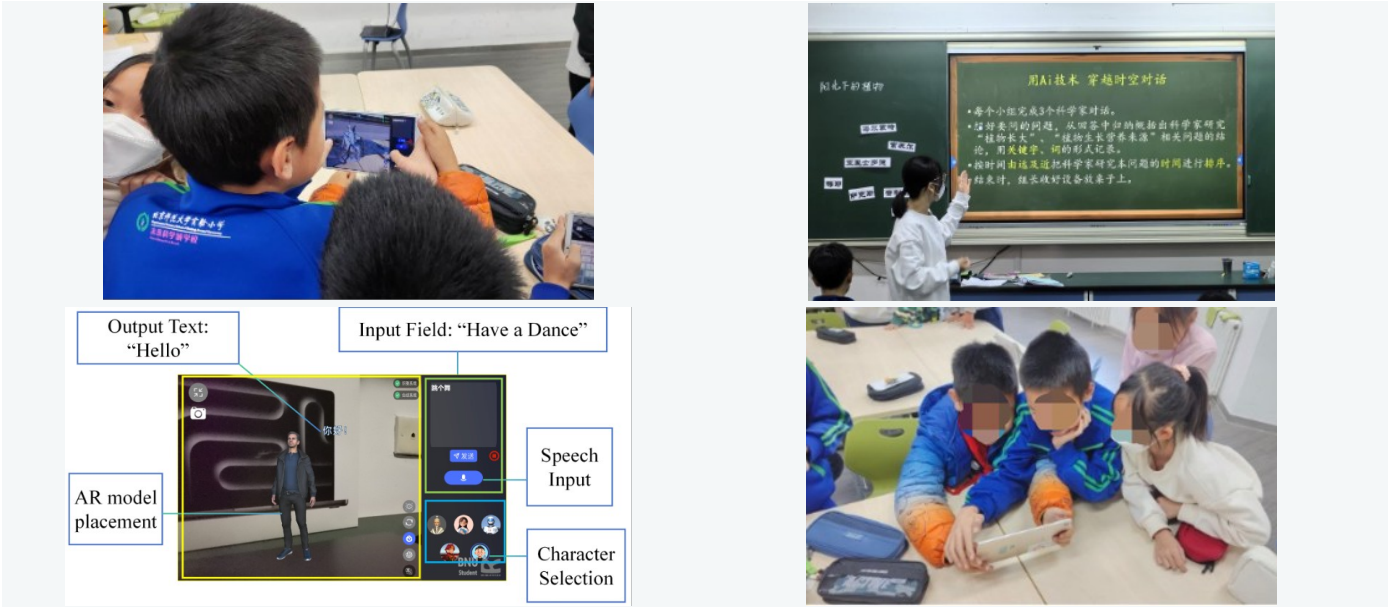
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|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| 01 Generative AI + AR: A novel embodied conversational agent in an interactive learning environment | 02 Beyond the Screen: Enhancing Augmented Reality Collaborative Inquiry with Social Scripts |
| 03 Effects of AR Educational Games on Spatial Ability of Primary School Students                    | 04 Study on the Influence of Different Spatial Ability Students in AR Geography Teaching    |
| 05 Design Everything for Smart Education (DESE): A Diverse Learning Space Initiative                |                                                                                             |

### RESEARCH CONTEXTS

Beijing Normal University · Graduate Researcher, VR/AR+Education Lab | HKUST (Guangzhou) · Research Assistant, Jan-Jun 2025 | K–12 field research in primary and secondary school settings

# Generative AI + AR: A novel embodied conversational agent in an interactive learning environment

Cai, S., Huang, H., Jiao, X., & Zhang, Y. (2026). Generative AI + AR: A novel embodied conversational agent in an interactive learning environment. *Interactive Learning Environments*, 34(6), 4141–4155. DOI ↗



System interface and four-week classroom implementation. Student faces are obscured in the original research materials.

|                               |                               |                                             |                         |
|-------------------------------|-------------------------------|---------------------------------------------|-------------------------|
| 62<br>primary-school students | 4 weeks<br>school-based study | Mixed methods<br>quantitative + qualitative | SSCI<br>journal article |
|-------------------------------|-------------------------------|---------------------------------------------|-------------------------|

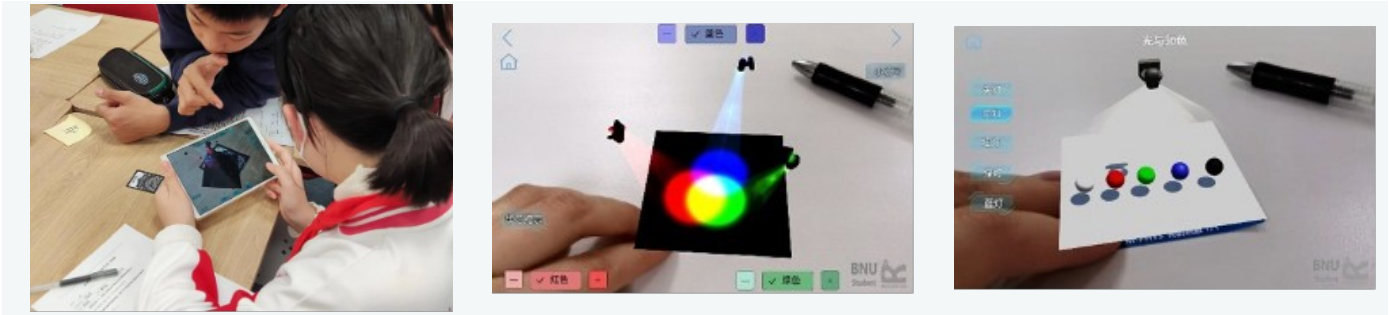
## RESEARCH FRAMEWORK

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| <b>01 NEED</b><br>Inquiry support without replacing student thinking                                                                                                                                                                                                                                                                                                                                       | <b>02 SYSTEM</b><br>Embodied conversational agent integrated with AR | <b>03 STUDY</b><br>Four-week implementation with 62 pupils                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>04 EVIDENCE</b><br>ANCOVA, interviews, and thematic analysis |
| <b>ABSTRACT</b><br>This study developed an embodied Generative AI–AR learning environment and evaluated it with 62 primary-school students over four weeks. Mixed-methods evidence examined learning outcomes and students’ classroom experience.                                                                                                                                                          |                                                                      | <b>MY CONTRIBUTION</b><br><b>Led the end-to-end research-and-development cycle, from study design and system development to school implementation, data analysis, and manuscript preparation.</b> <ul style="list-style-type: none"><li>Framed the research question and led the experimental design.</li><li>Designed, developed, and iterated the embodied GenAI–AR learning system.</li><li>Coordinated the school deployment; cleaned and analysed quantitative and qualitative data.</li><li>Drafted the manuscript and led substantive revisions with senior-lab support.</li></ul> |                                                                 |
| <b>RESEARCH DESIGN &amp; FINDINGS</b><br>A school-based evaluation connected system design with evidence about learning and student experience. <ul style="list-style-type: none"><li>The study reported significant gains in critical thinking, inquisitiveness, and learning motivation.</li><li>Student feedback indicated broadly positive perceptions of the embodied GenAI–AR environment.</li></ul> |                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                 |

**KEYWORDS** human–AI learning · embodied agent · augmented reality · mixed methods · ANCOVA · thematic analysis

# Beyond the Screen: Enhancing Augmented Reality Collaborative Inquiry with Social Scripts

Jiao, X., Huang, H., Liu, Z., Fan, Z., Huang, Q., & Cai, S. (2025). Beyond the Screen: Enhancing augmented reality collaborative inquiry with social scripts. *2025 IEEE International Conference on Advanced Learning Technologies (ICALT)*, 290–294. DOI ↗



Collaborative classroom use and two complete views of the Light and Color AR system.

|                               |                                |                                                         |                                             |
|-------------------------------|--------------------------------|---------------------------------------------------------|---------------------------------------------|
| Best Full Paper<br>ICALT 2025 | 78 / 70<br>enrolled / analysed | 4 script types<br>roles, exchange, process, interaction | p=.007 · .030<br>knowledge · cognitive load |
|-------------------------------|--------------------------------|---------------------------------------------------------|---------------------------------------------|

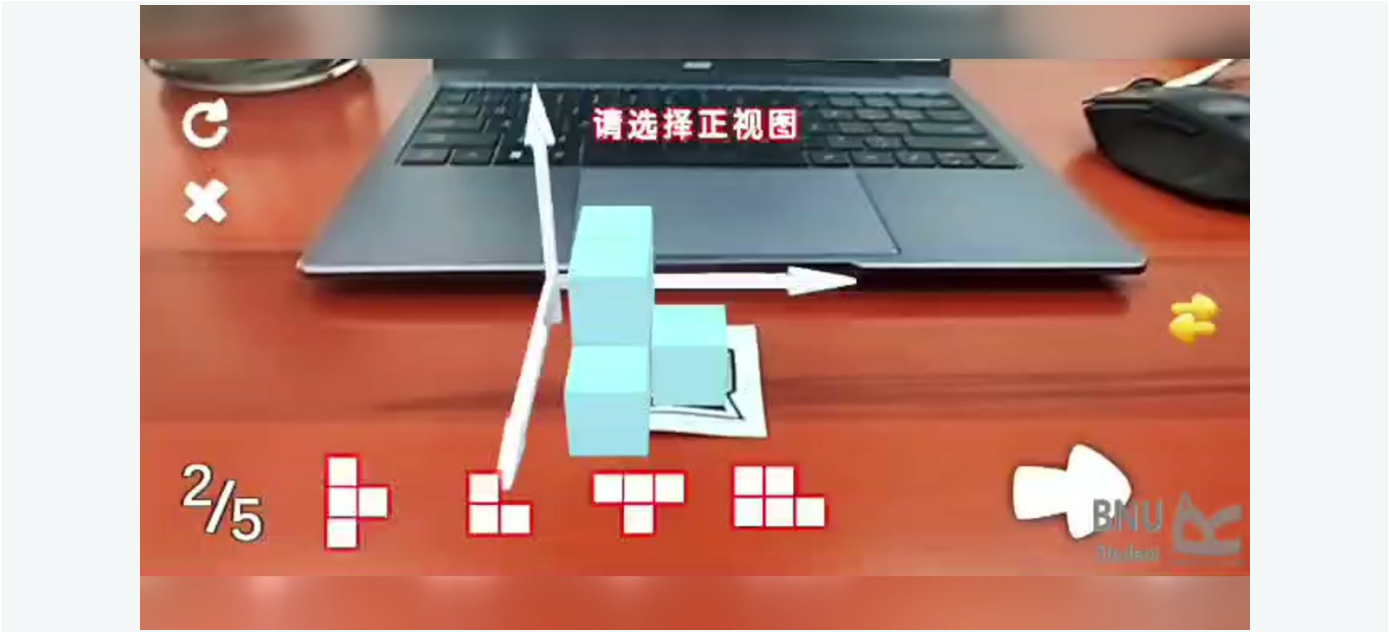
## RESEARCH FRAMEWORK

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| <b>01 PROBLEM</b><br>Communication barriers and unequal participation                                                                                                                                                                                                                                                                                                                                         | <b>02 SUPPORT</b><br>Structured collaboration scripts in AR inquiry | <b>03 COMPARISON</b><br>Scripted group versus unscripted group                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>04 OUTCOMES</b><br>Knowledge, cognitive load, group efficacy |
| <b>ABSTRACT</b><br>This study examined whether social scripts could improve AR-supported collaborative inquiry among sixth-grade students. A quasi-experimental comparison assessed knowledge acquisition, cognitive load, group efficacy, and collaborative experience.                                                                                                                                      |                                                                     | <b>MY CONTRIBUTION</b><br><b>My contribution focused on manuscript development and the integration of quantitative and qualitative evidence.</b> <ul style="list-style-type: none"><li>Drafted and revised paper sections presenting the research rationale, design, findings, and interpretation.</li><li>Structured the conference-paper narrative around the study design, quantitative findings, and qualitative explanation.</li><li>Supported final manuscript development for the ICALT Best Full Paper Award–winning publication.</li></ul> |                                                                 |
| <b>STUDY EVIDENCE</b><br>The quasi-experiment paired quantitative outcomes with classroom observation and interviews. <ul style="list-style-type: none"><li>Scripts significantly improved knowledge acquisition (p=.007) and reduced cognitive load (p=.030).</li><li>No significant difference was found in group efficacy; qualitative evidence clarified how structure supported collaboration.</li></ul> |                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                 |

**KEYWORDS** collaboration scripts · AR inquiry · cognitive load · group efficacy · mixed-methods reporting

# Effects of AR Educational Games on Spatial Ability of Primary School Students

Huang, H., Yin, P., Zhang, Y., & Cai, S. (2023). Effects of AR educational games on spatial ability of primary school students. *2023 15th International Congress on Advanced Applied Informatics Winter (IIAI-AAI-Winter)*, 111–116. DOI ↗



The complete Spatial Memory King AR interface used for three-view and spatial-reasoning tasks.

|                             |                               |                                      |                                     |
|-----------------------------|-------------------------------|--------------------------------------|-------------------------------------|
| 66<br>primary-school pupils | Grades 3–4<br>target learners | Unity + Vuforia<br>development stack | Pre / post<br>AR versus traditional |
|-----------------------------|-------------------------------|--------------------------------------|-------------------------------------|

## RESEARCH FRAMEWORK

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| <b>01 NEED</b><br>Practice with three-view perspective taking                                                                                                                                                                                                                                                                                                                                    | <b>02 DESIGN</b><br>Game mechanics translated into AR spatial tasks | <b>03 STUDY</b><br>Experimental and control conditions with 66 pupils                                                                                                                                                                                                                                                                                                                                                                                                     | <b>04 EVIDENCE</b><br>Mental rotation, orientation, and attitudes |
| <b>ABSTRACT</b><br>This study developed an AR educational game for three-view and spatial-reasoning practice and evaluated it with 66 primary-school pupils. Pre- and post-test evidence compared the AR intervention with traditional learning activities.                                                                                                                                      |                                                                     | <b>MY CONTRIBUTION</b><br><b>Led the full project cycle as first author and principal developer.</b> <ul style="list-style-type: none"><li>Designed the educational game concept, interaction mechanics, and research plan.</li><li>Built and iterated the software in Unity with Vuforia.</li><li>Conducted the school experiment and completed data processing and analysis.</li><li>Prepared the manuscript and presented the study at IIAI-AAI Winter 2023.</li></ul> |                                                                   |
| <b>RESEARCH DESIGN &amp; FINDINGS</b><br>The project links an independently developed learning game to a comparative classroom evaluation. <ul style="list-style-type: none"><li>The conference study reported improved spatial ability following the AR-game intervention.</li><li>Students also expressed positive willingness to learn through this form of game-based AR activity.</li></ul> |                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                   |

**KEYWORDS** spatial cognition · AR game · three-view reasoning · Unity · Vuforia · quasi-experiment

# Study on the Influence of Different Spatial Ability Students in AR Geography Teaching

Huang, H., Huang, A., Feng, J., Xu, X., Li, H., & Cai, S. (2024). Study on the influence of different spatial ability students in AR geography teaching. *Methodologies and Intelligent Systems for Technology Enhanced Learning, 14th International Conference*, 302–312. DOI ↗



Authentic classroom implementation and verified interfaces from the Explore Contour Lines AR intervention.

|                                |                              |                       |                                |
|--------------------------------|------------------------------|-----------------------|--------------------------------|
| 69 / 65<br>enrolled / analysed | Grades 7–8<br>school context | p=.003<br>achievement | p=.008<br>lower cognitive load |
|--------------------------------|------------------------------|-----------------------|--------------------------------|

## RESEARCH FRAMEWORK

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| <b>01 NEED</b><br>Make contour lines and terrain relationships visible                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>02 SYSTEM</b><br>Explore Contour Lines AR learning environment | <b>03 STUDY</b><br>AR group versus traditional instruction                                                                                                                                                                                                                                                                                                                                                                  | <b>04 EVIDENCE</b><br>Achievement, cognitive load, and spatial ability |
| <b>ABSTRACT</b><br>This study investigated how AR-supported geography instruction affected achievement and cognitive load, and whether outcomes differed by spatial ability. The school-based study compared AR and traditional instruction among Grade 7–8 students.                                                                                                                                                                                                                                            |                                                                   | <b>MY CONTRIBUTION</b><br><b>Principal contribution: on-site field implementation.</b> <ul style="list-style-type: none"><li>Coordinated and conducted the classroom experimental sessions in the school setting.</li><li>Supported administration of the intervention, pre/post measures, and study-data collection.</li><li>As first author, contributed to reporting and communicating the completed research.</li></ul> |                                                                        |
| <b>RESEARCH DESIGN &amp; FINDINGS</b><br>The field study examined whether spatial-ability differences shaped learning in an AR-supported geography lesson. <ul style="list-style-type: none"><li>The AR group achieved higher post-test scores (<math>p=.003</math>, partial <math>\eta^2=.131</math>) and lower cognitive load (<math>p=.008</math>).</li><li>Within the AR group, higher-spatial-ability students outperformed lower-spatial-ability students (73.92 vs 56.50; <math>p=.006</math>).</li></ul> |                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                        |

**KEYWORDS** AR geography · contour lines · spatial ability · field experiment · learner differences

# Design Everything for Smart Education (DESE): A Diverse Learning Space Initiative

Huang, H., Zhao, D., Yin, P., Cao, S., & Peng, Y. (2026). Design Everything for Smart Education (DESE): A diverse learning space initiative. *Empowering Educational Innovation Through Design: Volume Two*, 205–217. DOI ↗



DESE contextual-learning prototype and 2023 Silver Award.

|                                 |                                           |                                 |                               |
|---------------------------------|-------------------------------------------|---------------------------------|-------------------------------|
| Team lead<br>project leadership | Silver Award<br>global design competition | 2023<br>competition recognition | 2026<br>Springer book chapter |
|---------------------------------|-------------------------------------------|---------------------------------|-------------------------------|

## RESEARCH FRAMEWORK

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| <b>01 OPPORTUNITY</b><br>Everyday objects and spaces as learning resources                                                                                                                                                                                                                                                                                                                                                                                                  | <b>02 CONCEPT</b><br>Context-aware overlays connect objects to knowledge | <b>03 DEVELOPMENT</b><br>Team-based design and prototype iteration                                                                                                                                                                                                                                                                                                                           | <b>04 EVIDENCE</b><br>Competition recognition and scholarly chapter |
| <b>ABSTRACT</b><br>This design project explored how everyday objects and spaces could become contextual learning resources through interactive overlays. The resulting prototype received international competition recognition and was documented in a Springer book chapter.                                                                                                                                                                                              |                                                                          | <b>MY CONTRIBUTION</b><br><b>Led the initiative from concept to publication.</b> <ul style="list-style-type: none"><li>Directed concept development, educational design, and prototype iteration.</li><li>Coordinated team roles, project delivery, and competition presentation.</li><li>Led the conversion of the design initiative into a first-authored Springer book chapter.</li></ul> |                                                                     |
| <b>DESIGN CONTRIBUTION &amp; EVIDENCE</b><br>Evidence from the project includes a functional prototype, international competition recognition, and a first-authored Springer book chapter. <ul style="list-style-type: none"><li>The prototype demonstrated how ordinary environments could become contextualised, interactive learning spaces.</li><li>The project received a Silver Award at the 6th Global Competition on Design for Future Education in 2023.</li></ul> |                                                                          |                                                                                                                                                                                                                                                                                                                                                                                              |                                                                     |

**KEYWORDS** educational design · contextual learning · ubiquitous learning · team leadership · design research