



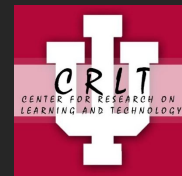
Understanding How Roles Mediate Young Children's Science Learning Within an Embodied Mixed-Reality Environment

Xintian Tu

Ph.D. Candidate in Learning Sciences

Indiana University

INDIANA UNIVERSITY



Background

- **Role-play** is a valuable tool in science education, allowing students to demonstrate their understanding, explore their views, and develop a deeper understanding of scientific phenomena (McSharry, 2000; Aubusson, 1997).
- In the prior studies, the findings have revealed that **allowing students to engage in different perspectives** including role play and discussion helps them to build an understanding of target science concepts.



Roles

Embodiment

**Understanding of
Mechanism**



Roles and Perspectives

The system: Honeybee system

Roles directly interact and may influence the system: Bee and Beekeeper



Roles and Perspectives

First-person perspective: Students take the roles assigned in the activity; they engage in the activity in a way that the target character would do.

Third-person perspective: Students take roles outside of the system.

- **But still, engage in the activity!**



Research Question

1. How do students perceive the learning activities within a Mixed Reality environment from different perspectives?
2. How did students demonstrate their understanding of the science model when they took different perspectives in the interview?



GEM-STEP:Bee (2022)

Bee Activities

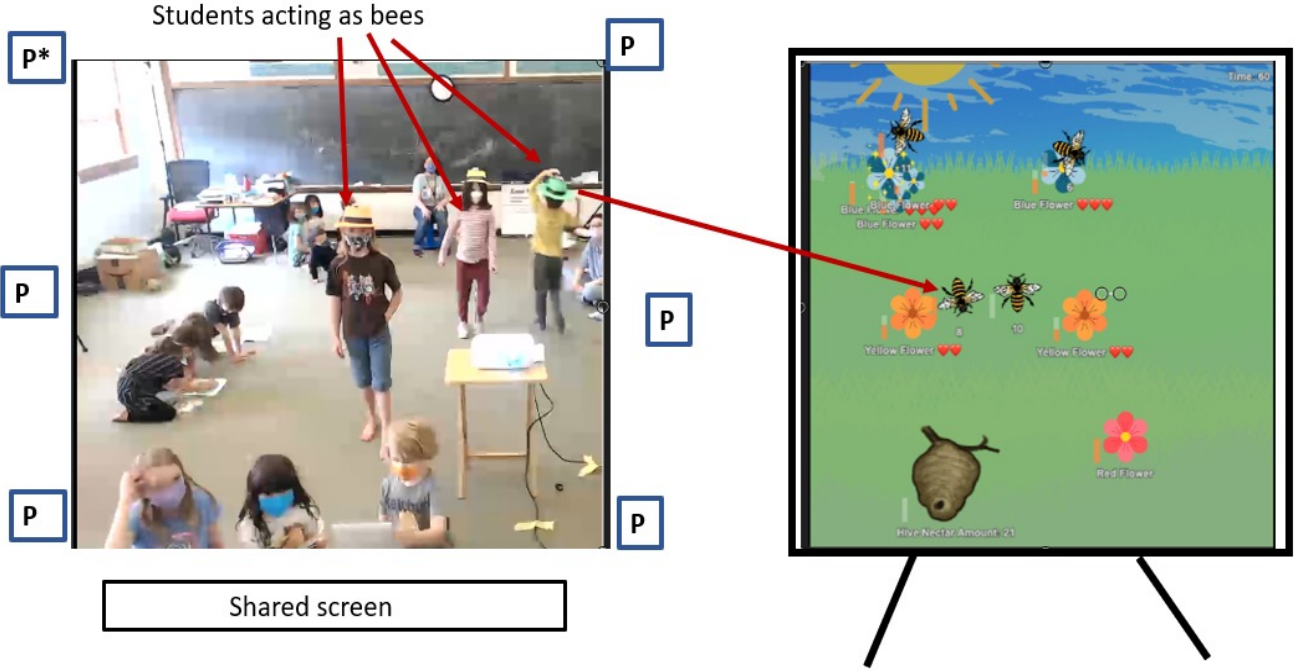
- Embody as bees.
- Track by GEM-STEP and transfer to bees on a shared screen.
- Collect nectar.
- Drop pollen when they move.

Farmer and AI bees

- Take the role of farmers
- Draw design as a group
- Research to put a design on a shared screen
- Send out “AI” bees.
- Observe which plant(s) get pollinated and reproduced



Design of GEM-STEP Bee



P* stands for Pozyx Antenna

Demo of GEM-STEP, students interacting within the classroom (left), GEM-STEP platform (right) Tu, X. & Danish, J.



Farmers and the AI bees



Checks representing pumpkins

Students' design of garden on a color-printed map.



Researchers move the plants as students designed in the simulation.



After the "bees" visit, plants got pollinated producing more plants.

Design of day 6 garden design activity within the MR environment.



Method

- 16 students from a 1st and 2nd grade mixed classroom participated in the study.
- 28-item multi-modal interview (Pre-test)
- 34 Item multi-modal interview (Post-test)
- Thematic analysis on interview data
- Interaction analysis on representative clips.



Interview Instrument

Perspective	Roles	GEM-STEP activities	Interview questions
First-person perspective	Bee	Non-tech activity GEM-STEP Activity 1 to activity 4, students pretended to be bees and explore how bees collect nectar and pollinate flowers.	Q11-Q12: How bees act Q15-Q16: How bees collect nectar Q25-Q26: How bees pollinate flowers
	Farmers	GEM-STEP Activity 5 to Activity 6, students the role of farmers, and design their garden.	Q23-26: Design a garden as a farmer and explain why they consider it a good garden. Then predict which plants may get pollinated.



Interview Instrument

Perspective	Roles	GEM-STEP activities	Interview questions
Third-person perspective	Scientist	All seven activities. Students were told that they were scientists and encouraged to take notes when other students engaged in embodied activities.	Q13-Q14: Show a model of how bees pollinate flowers. Q28: Show how the garden is designed as a scientist.
	N/A		Follow-up questions. E.g. Why do you think xx Why do you make that change?



Code in Atlas.ti	Description	Bee- specific Example
Behavior	Behavior of the students' roles	Students describe the bee movement, use their body to take the role of the bees/Sciences/farmers.
IE	Identify Entities	Entities: There's nectar/pollen/hive.
IPE	Identify Properties of Entities	Nectar quality, Nectar quantity The nectar has great nectar! It smells really good
OE	Organization of Entities.	The location of flowers, arrangement, but with no reasoning of HOW and WHY. E.g. arrange the flowers in the meadow without any reasoning
IA	Identify Activities	Bees collect nectar. Bees dance to communicate/call other bees to collect nectar.
C	Chaining: Backward and Forward reasoning	Flowers/Plants in the same species get pollinated. There should be more flowers to be pollinated. Bees pollinate plants/flowers to help reproduce.
AM	Animated Models	In our paper, there's lots of embodied activity. Therefore, we only code when there's animated model for a full round of bee pollinate flowers when they use their body. When they use their body flying, we won't assign AM



Findings RQ1: How students perceive GEM-STEP

	Students' favorite roles.	Play	Science	Both Play and Science
Farmer	2	1	1	
Bee	9	5	4	
Scientist	1			1
No idea/ preference	3			



How GEM-STEP help students Learning

Quote from students' interview

- Observe how bees do. (1)
- Understand what farmers do (2)
- Use movement to learn new things (3)
- Collaboration (1)
- Take the role of Bees (5)



Findings RQ2: Roles and Mechanism

- Bees: Identify Activities, Identify Entities
- Farmers: Organization of Entities
- Scientist: Chaining and Animated Models
- **Complementary each other: No comparison**



Findings RQ 2: Roles and Mechanism

	BEHAVIOR	IA	IE	IPE	OE	CHAINING	AM	ANALOGIES
Bee	11	16	6	4	1	1	14	0
Farmer	0	2	1	3	13	3	0	0
Scientist	2	7	2	3	4	4	6	1
N/A	0	25	6	18	1	24	2	0
Total	13	50	15	28	19	32	22	1



First Person Perspective

- Bee: Focus on the phenomena level
 - Mimicking bees' behavior and identifying activity.
- Beekeepers: Macro view of having a certain amount of plants at locations.
 - Rationale: Personal choice but not the mechanism.





Researcher: Can you act out what you would do if you are a bee

Tony: Um, I will pollinate flowers with my friends

Researcher: Pollinate flowers with your friends? Tony:

So.. How I would do is

[Put the bee headband on]

Tony: Finding nectars

[Touching the flowers on the floor]

Tony: I'll try to find nectars, oh there's no nectar on this one.

CM code: Identify Activity (IA)

[Wave his arms, pretending to fly to another flower]

CM code: Behavior

Tony: Bluh bluh bluh [singing while pretending fly]

[Tony collects the sticker underneath the flowers]

Tony: Dah dah

[Showing sticker to the camera]

(Tony visits several other flowers to show how bees pollinate flowers)

CM code: Animated Models (AM)



Third Person Perspective: Scientist

- Explain the mechanism from an “outside” perspective
- Focus on the organization of the entities
- Why question





Researcher: Why do you think these two flowers get pollinated [pointing to flowers]

Ian: Um, just this

Ian: [pointing to the flower, second from the right]

Researcher: Just this one? Okay

Ian: That's because, um has two of them

[Pointing to the two flowers to his right.]

CM code: Identify property of entities (IPE)



Ian: [pointing to the other two flowers to his left]

Ian: These two, only have one of each

Researcher: [point to the first flower that he visited]

Researcher: not this one?

Ian: Cause it's the first one.

CM code: Chaining



RQ2: Roles and Embodiment

	Full body movement	Gesture	Interact with props
Bee	53	1	3
Scientist	6	6	1
Farmer	0	4	10
N/a	1	0	



	Behavior	IA	IE	IPE	OE	Chaining	AM
Full body movement: mimic behavior	11	13	4	3	1	1	9
Full body movement: Bee dance	3	9	4	1	0	0	6
Full body movement: Nectar collection	11	16	7	4	1	0	11
Full body movement: Pollination	2	4	1	2	0	1	4
Gesture: Communication, pointing	0	3	2	2	5	1	2
Gesture: Bee system	0	3	1	0	0	1	2
Interact with prompt	0	3	2	2	10	2	2
Total	27	51	21	14	17	6	36



Researcher: what are you doing?

Andi: I'm collecting nectar (**IA**)

[**Full body movement:** use her hands to collect stickers (nectar) in the flower]



Researcher: why you made this change? And think it's a good design?

Andi: Because these two flowers are the same flowers (species), and they are close to each other. They may get more flowers (**Chaining**)

[pointing to the lilies on the floor – **Gesture**]



Discussion

- The multi-modal interview that allows students
 - 1) take different perspectives,
 - 2) use their body movement to demonstrate ideas
 - 3) interact with props.
- This modality allows students to demonstrate their understanding of the target science concept more deeply.



Conclusion

Role complementary each other

- Benefit young children's **understanding of the honeybee** system in the MR environment.
- **Multi-modal interview encourages** students to use their body movements and interact with props to demonstrate their understanding.
- Both body movement and **props served as tools to mediate mechanism reasoning.**



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