The Effects of AR Learning Environment to Preschool Children's Numerical Cognition

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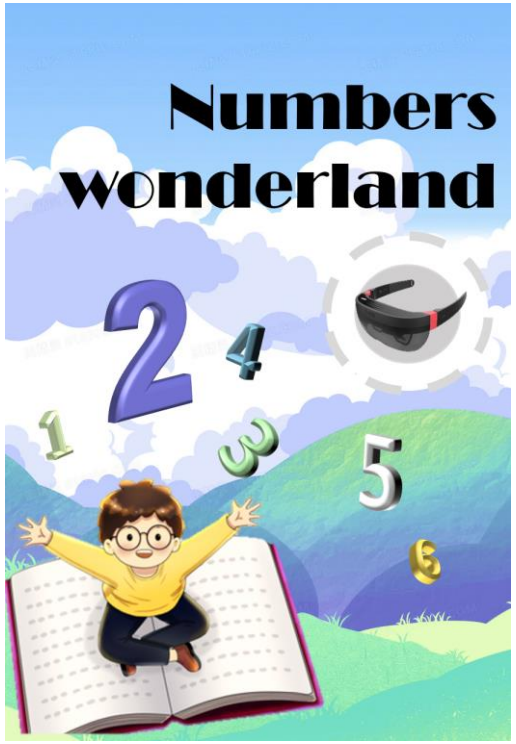
What Is Augmented Reality?

- An enhanced version of the real physical world

AR's potential in various fields:

- Public interest of AR
- Rapid development of mobile devices
- Powerful and easy-to-use development tools

Introduction



Numbers Wonderland

Our research:

- Developed an AR application to help preschool children
  - build their cognition of cardinal and ordinal numbers
  - comprehend logical relationships of numbers
  - master simple arithmetic
- Investigated the effectiveness of using AR in an kindergarten
- Interviewed the teachers of the kindergarten for their feedbacks

Questions

RQ1: Compared to traditional teaching methods, Whether AR application has a more positive impact on preschoolers' numerical cognition.

RQ2: Whether AR application could improve preschool children's learning interest.

RQ3: How do kindergarten teachers evaluate AR and what are their suggestions.

Literature Review

The Effects of AR Learning Environment to Preschool Children's Numerical Cognition

Literature Review

AR in Preschool Education

How's the application of AR in preschool education going on?

Numerical Cognition

What is numerical cognition? What does it consist of?

The Measurement of Children's cognition

How to measure the progress of children's Cognition?

Literature Review: AR in Preschool Education

In the preschool education field:

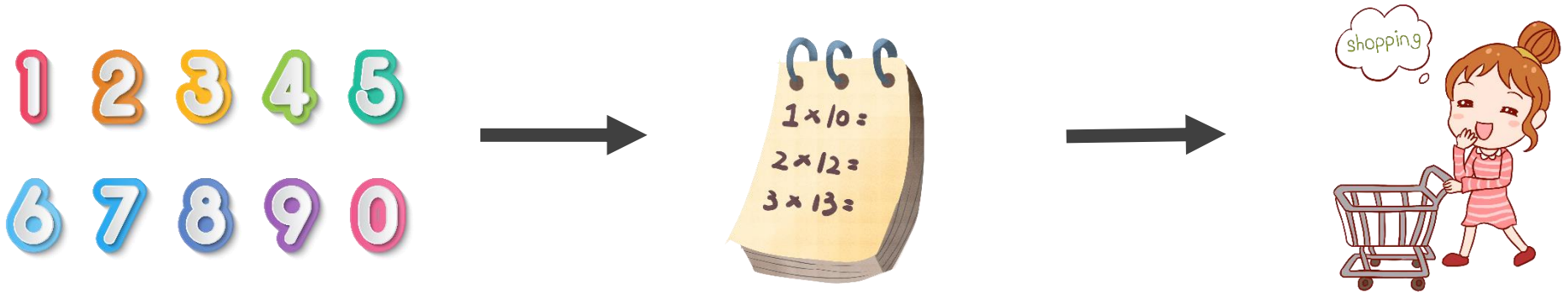
- A hot research topic
- Mainly used in language and science teaching
- Cards, books, hardware devices and mobile applications

AR's advantages in education:

- Improvements on motivations and engagement
- Sharing of learning experience, group works and inquiry-based learning
- Better learning experience, especially in difficult courses (Kose, Koc et al. 2013)

Literature Review: Numerical Cognition

- Cognition of preschool children(P.-H. Wu, G.-J. Hwang et al. 2018)
  - Based on unintentional memory and image memory, supplemented by the children's re-creation of imagination
- A disposition and ability to use numbers and quantitative methods as a means of **communicating**, **processing** and **interpreting information**.(P.-H. Wu, G.-J. Hwang et al. 2018)
- Three components: **the concept of numbers**, **arithmetic of numbers**, and the **applications of arithmetic** (D. Kuhn, R. Siegler, and W. Damon, Handbook of child psychology. J. Wiley, 2006.)



Literature Review: The Measurement of Children's cognition

- The ***Piaget Cognitive Development Scale (IPDT)*** compiled by Furth in 1970 based on Piaget's theory of children's cognitive development:
  - mainly measures children's **cognitive structures**
  - relationships, representations, classifications and laws
- The third edition of the ***Wechsler Intelligence Scale*** for Preschoolers(2002):
  - divides tests into **verbal** and **operational tests**
  - the **arithmetic tests** testing children's ability to **add and subtract numbers**.

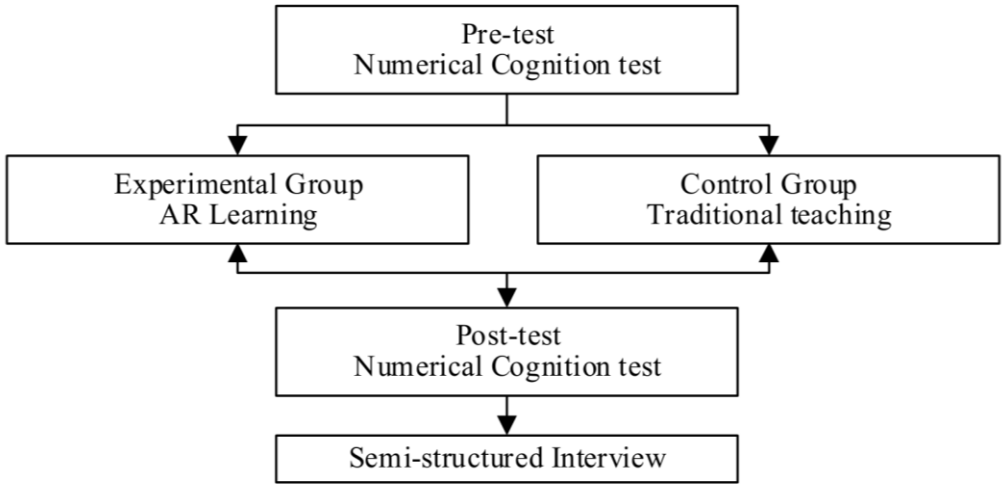
Procedure

The Effects of AR Learning Environment to Preschool Children's Numerical Cognition

Participants

- A total of **28 preschool students** participated in the experiment,16 boys and 12 girls, with an average age of 54 months
- Had **not had systematic mathematical knowledge**
- **an experimental group** (EG) (n = 14) and **a control group** (CG) (n = 14)
- Two experienced teachers (have rich experience in AR teaching)

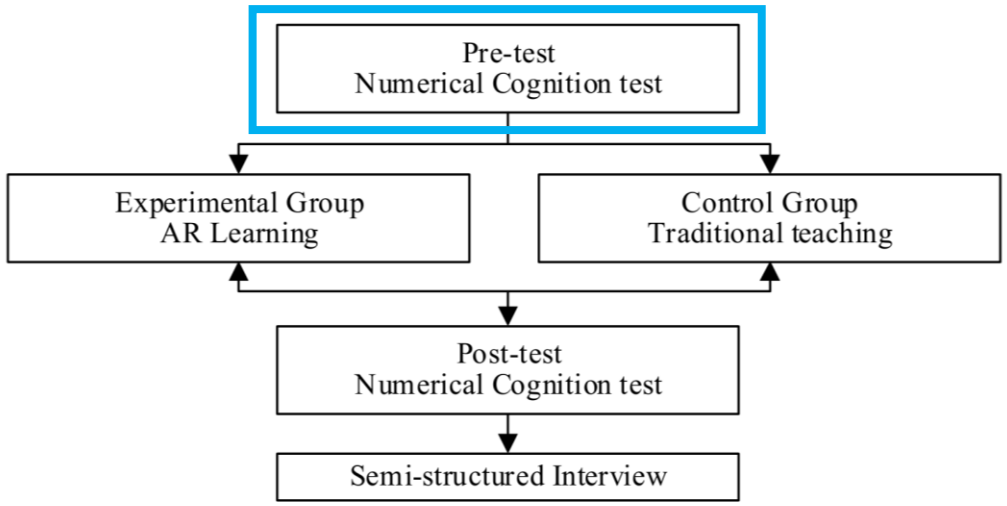
Procedure



- ***Hypothesis:*** AR can help children learn mathematics better and improve their numerical cognitive skills more significantly than traditional teaching
- ***Independent variable:*** whether the AR application was used to teach
- ***Dependent variable:*** the progress in numerical cognition ability of the children (scores of the post-test and the pre-test)
- ***Control variables:*** the teacher, the duration of the lesson, the questions used in the pre-test and the post-test, and the test method.

Procedure

Numerical Cognition Test : face to face & one by one



a) Step 1: Cognition of cardinal and ordinal numbers

- Test if children can fluently say 1~10 numbers in sequence and ask them some questions like "What is the number after 2?".
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b) Step 2: Quantity cognition and simple logical relationships comprehension (number comparison, class concept cognition)

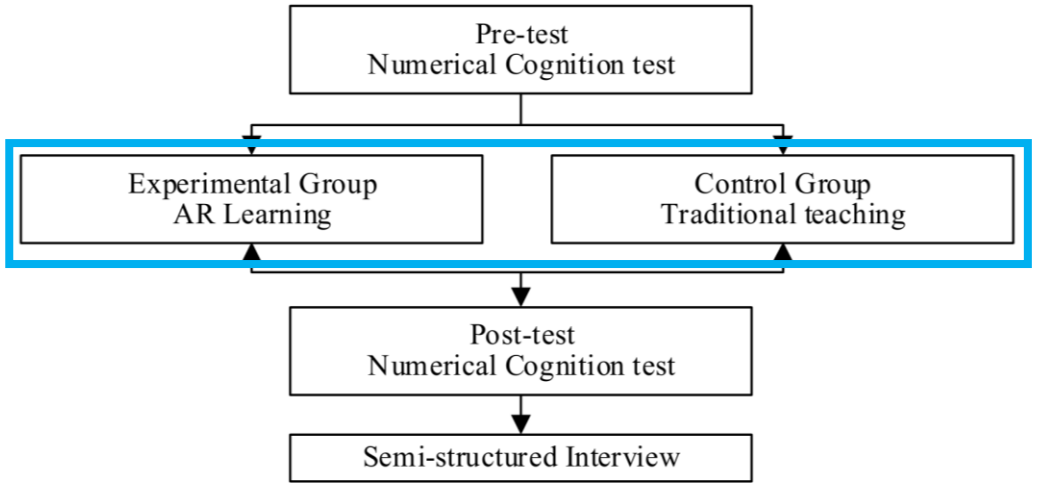
- Introducing part: Put two black beads and eight white beads into a transparent container and let the child see them. Ask: "Let's play a game! Look, there are black and white beads inside the box. Now could you told me that are there more black beads or white beads?"
- Number Comparison part: Present two different numbers to the child, ask the subject which number is bigger.

c) Step 3: Addition operation

- Dictate to the child: Yesterday morning, your mom gave you 4 pieces of candy and in the afternoon, she gave you 4 pieces of candy; this morning, your mother gave you 1 piece of candy, and in the afternoon, she gave you 7 pieces of candy. Then ask them: "Did you eat the same amount of candy on both days? Or which day had more?"
- Addition test: Present simple addition equations to the child.

Procedure

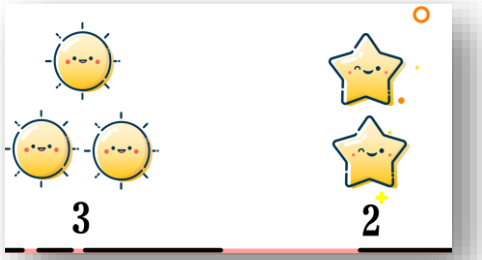
The experimental group and the control group were taught separately

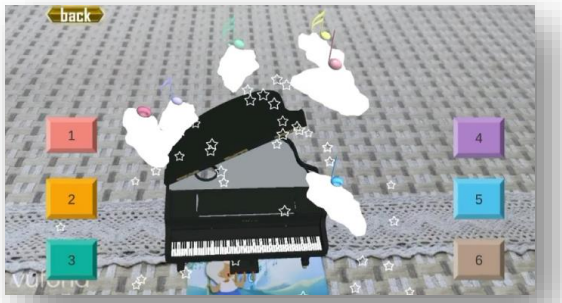


Procedure

Teaching design

Recognition of Numbers (0~9) → The comparison of numbers → Arithmetic of numbers → Numeric Music Box





Experimental Materials: AR application

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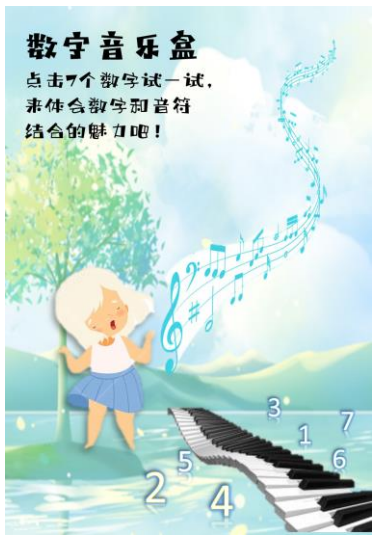


Experimental Materials: AR application

Recognition of Numbers(0~9):

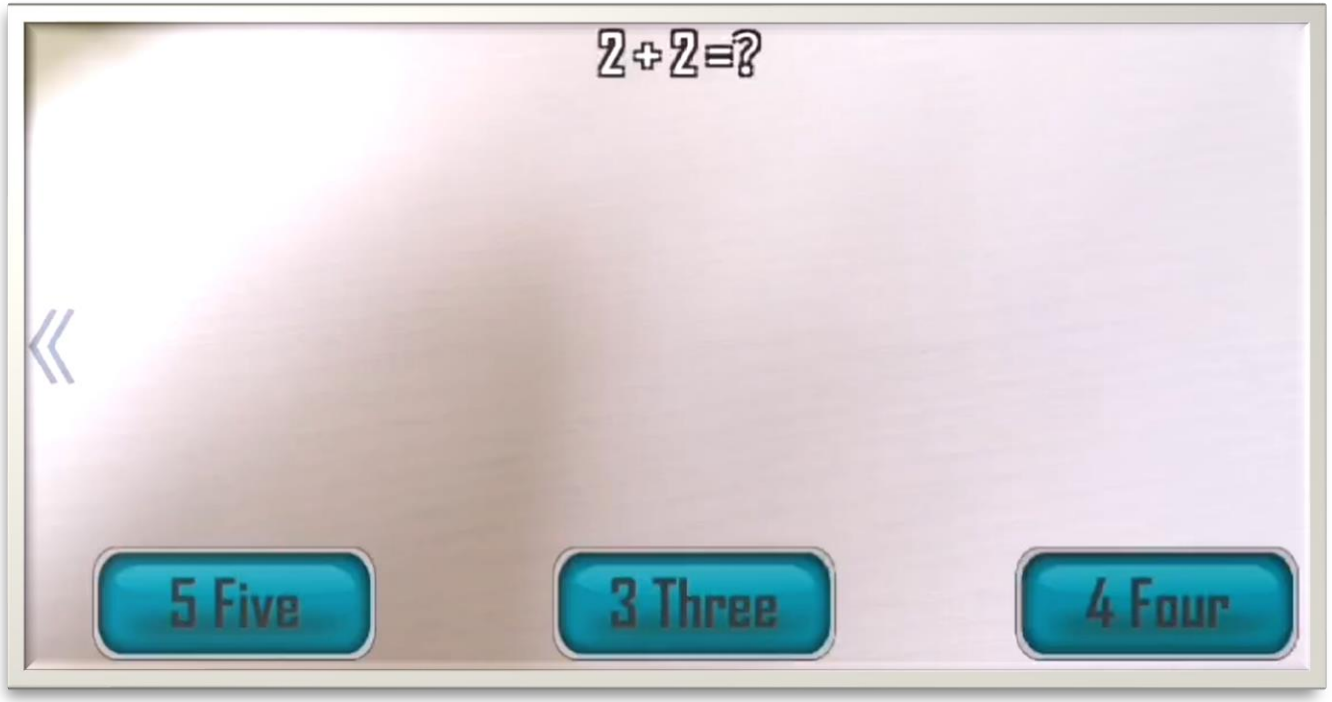
- An physical object (such as, a flag)
- A 3D model of the corresponding number
- Some cute animals (corresponding quantity)

Experimental Materials: AR application

The comparison of numbers (larger/equal to/smaller)

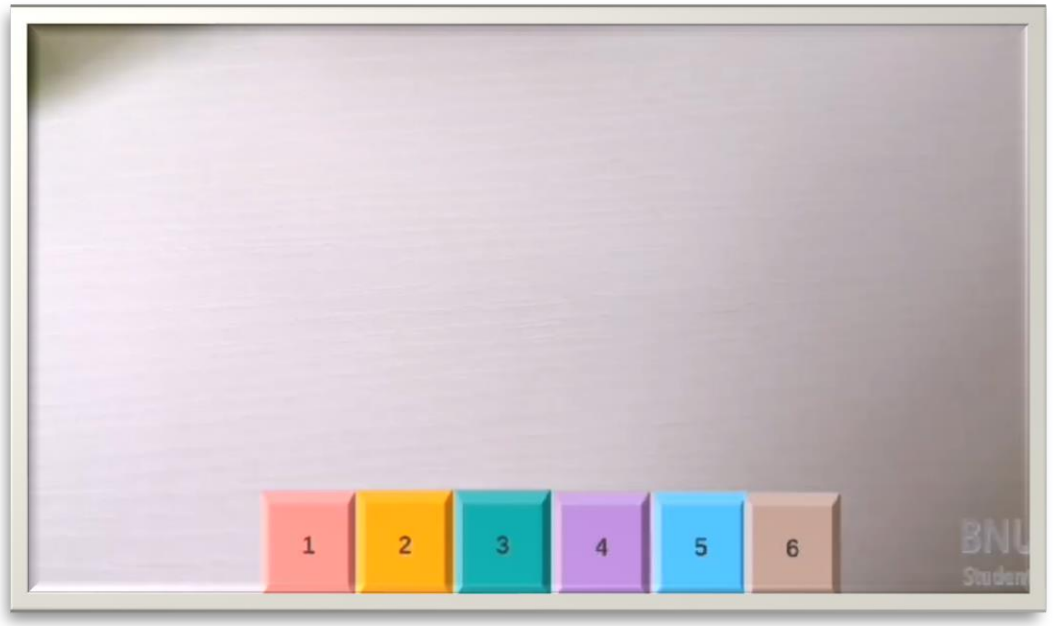
- **An interesting game: “Guard My Forest”**
- **The guard (player, which is number “6”) can only defeat the number which is smaller than it**

Experimental Materials: AR application



Arithmetic of numbers: in real life situation (3 situations)

Experimental Materials: AR application

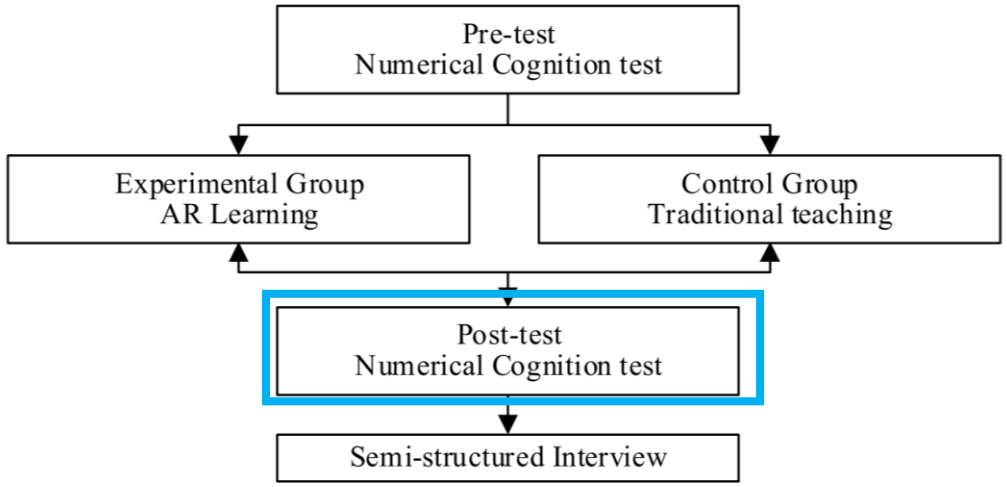


Numeric Music Box

- **Experience the charm of connecting numbers with tones**

Procedure

Numerical Cognition Test : face to face & one by one



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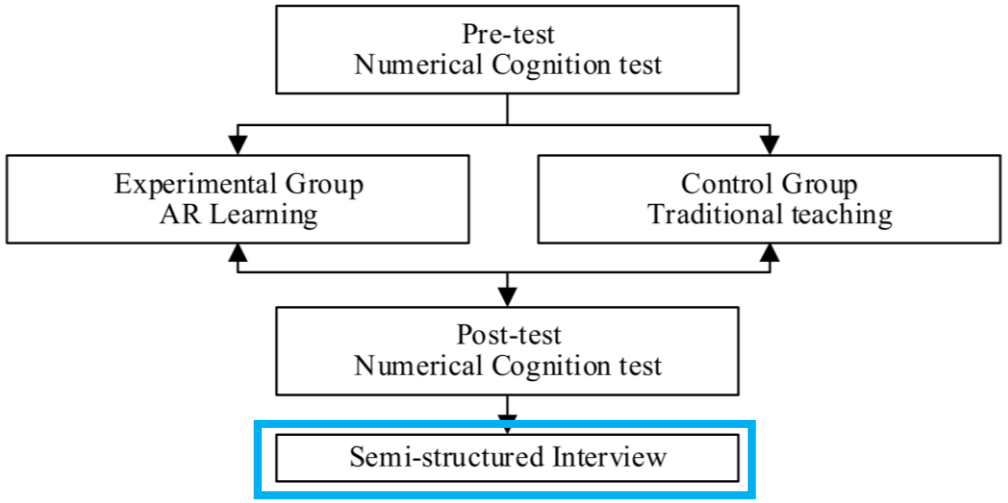
Procedure

Outline of the interview



a) What do you think of the effectiveness of using AR software on tablets for teaching? What are the benefits and drawbacks?

b) Do you think tablet teaching can really make its way into kindergartens?

c) What do you think could be improved about the AR software used in this experiment?

d) What do you think could be improved about the identification cards used in this experiment?

Results

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Results

Numerical Cognition Test Results: a paired-sample t-test

	N	Pre-test	Post-test	t	df
Experimental group (Mean, S.D.)	14	10.79/3.620	14.86/2.797	5.647***	13
Control group (Mean, S.D.)	14	9.93/3.668	12.43/3.390	5.827***	13

The two group students' cognition of numbers and skills of arithmetic have improved after this course.

Results

Numerical Cognitive Ability Test Results: ANCOVA

- Covariate: pre-test scores (to exclude the interference of the pre-test results.)
- Result: F = 6.360, P =0.018
- The experimental group (M = 14.86, SD =16.69)
- The control group (M = 12.43, SD = 18.10)

✓ The experimental group's development in numerical cognition is significantly better than the control group

✓ The use of AR contributed more to the improvement of preschoolers' numerical cognition than traditional methods

Results

Interview Content

"*In fact, this kind of software is really more interesting to children, but it is also necessary to take into account the convenience of software interaction.*"

"The cards are a bit difficult for children to use"

"This software can contribute to the physical, cognitive, emotional, and language development of young children, but it needs to be considered appropriate for how young children use it."

"Before students use the application, they should be given some requirements to ensure proper class order."

Discussion and Conclusion

The Effects of AR Learning Environment to Preschool Children's Numerical Cognition

Discussion and Conclusion

- AR has a positive impact on preschool children's numerical cognitive development
- Preschool children usually held positive attitudes toward AR and showed extremely high interest in learning
- Proficiency in manipulation had a greater impact on children's learning performance

Discussion and Conclusion

- The use of augmented reality technology has been shown to be helpful in improving preschoolers' numerical cognitive skills
- The number of experimental participants is small

- The ways and details of interaction design for augmented reality educational applications adapted to preschoolers
- Increase the number of participants

futurework

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Thanks.

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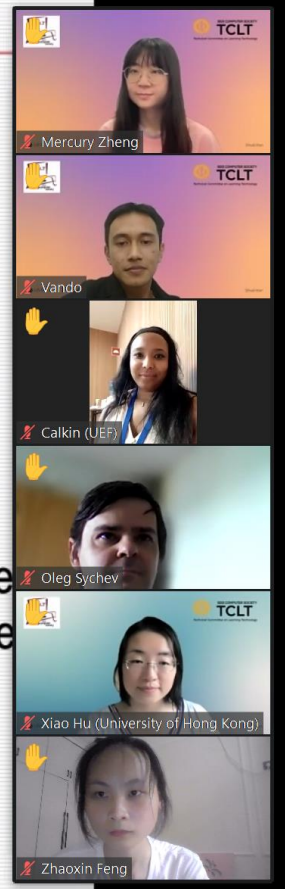
Nominations for Best Full Paper Awards

(listed in alphabetic order)

- Advances in Readability Research: A New Readability Web App for English
- Exploring the Affordances of Drones from an Educational Perspective
- FEAIS: Facial Emotion Recognition Enabled Education Aids IoT System for Online Learning
- Generating Expression Evaluation Learning Problems from Existing Program Code
- Learning-Relevant Concept Extraction By Utilizing Automatically Generated Textbook Corpora
- Mobile Eye Tracking Research in Inclusive Classrooms: Children's Experience
- Predicting Reading Performance based on Eye Movement Analysis with Hidde Markov Models
- Robot as a Ventriloquist Doll in a Virtual Situational Learning Environment to Facilitate Learning Through Self-Dialogue
- Towards A Vocalization Feedback Pipeline for Language Learners
- The Effects of AR Learning Environment to Preschool Children's Numerical Cognition



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