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EXPLORING THE IMPACT OF KNOWLEDGE ACQUISITION IN A COMPUTER AUTOMATIC VIRTUAL ENVIRONMENT (CAVE) ON ENGINEERING STUDENTS COMPUTATIONAL THINKING (CT) SKILL LEVELS

AUTHORS

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SCAN FOR PRESENTER'S CONTACT DETAILS

AFFILIATIONS

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BACKGROUND AND MOTIVATION

- Recent advances have made Virtual Reality (VR) (Figure 1& 2) more accessible and effective in education.
- VR addresses key challenges in engineering education, such as spatial understanding and experiential learning. (Papert, 1980;Wing, 2006).
- CT is a problem-solving framework emphasizing computational solutions.
- Korkmaz et al. (2017) created a validated five-point Likert scale with 29 items across five CT factors as illustrated in Figure 3.
- Ojajuni et al. (2024) adapted the CT scale for engineering students in CAVE environments.
- Despite VR positive results, more evidence is needed to fully understand VR's effectiveness in developing CT skills.
- Currently in its fourth year, the project investigates the effectiveness of VR interventions, specifically within CAVE systems, in enhancing CT skills among engineering students in cybersecurity-additive manufacturing training, aligning with the NSF's mission to enhance the STEM workforce.

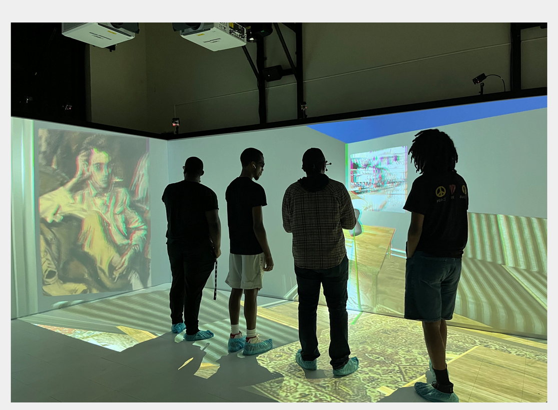


Figure 1. CAVE system.

Figure 2. Head Mounted Devices.

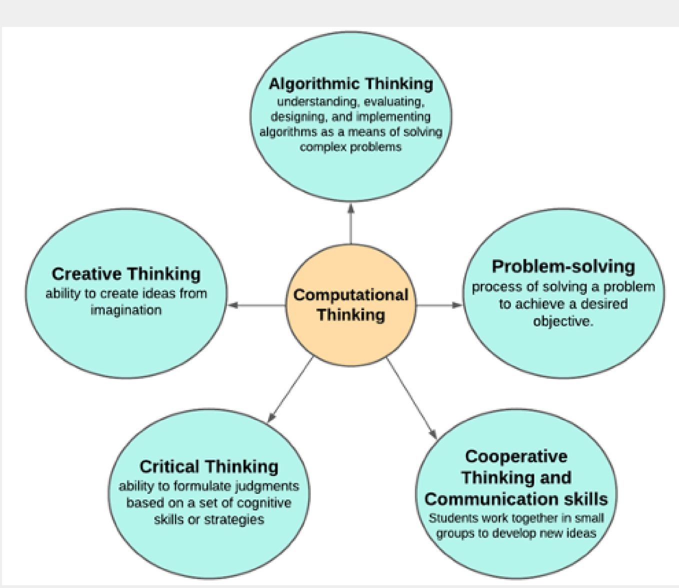


Figure 3. Factors of the CT Scale.

RESEARCH QUESTIONS

The research was guided by the following key research questions:

- Does the VR intervention lead to a statistically significant increase in students' CT skills compared to their pre-test scores?
- Is there a significant difference in the post-test scores of CT between the experimental group (VR intervention) and the control group (no VR intervention)?
- Does the VR intervention have a greater impact on CT skills compared to traditional methods?

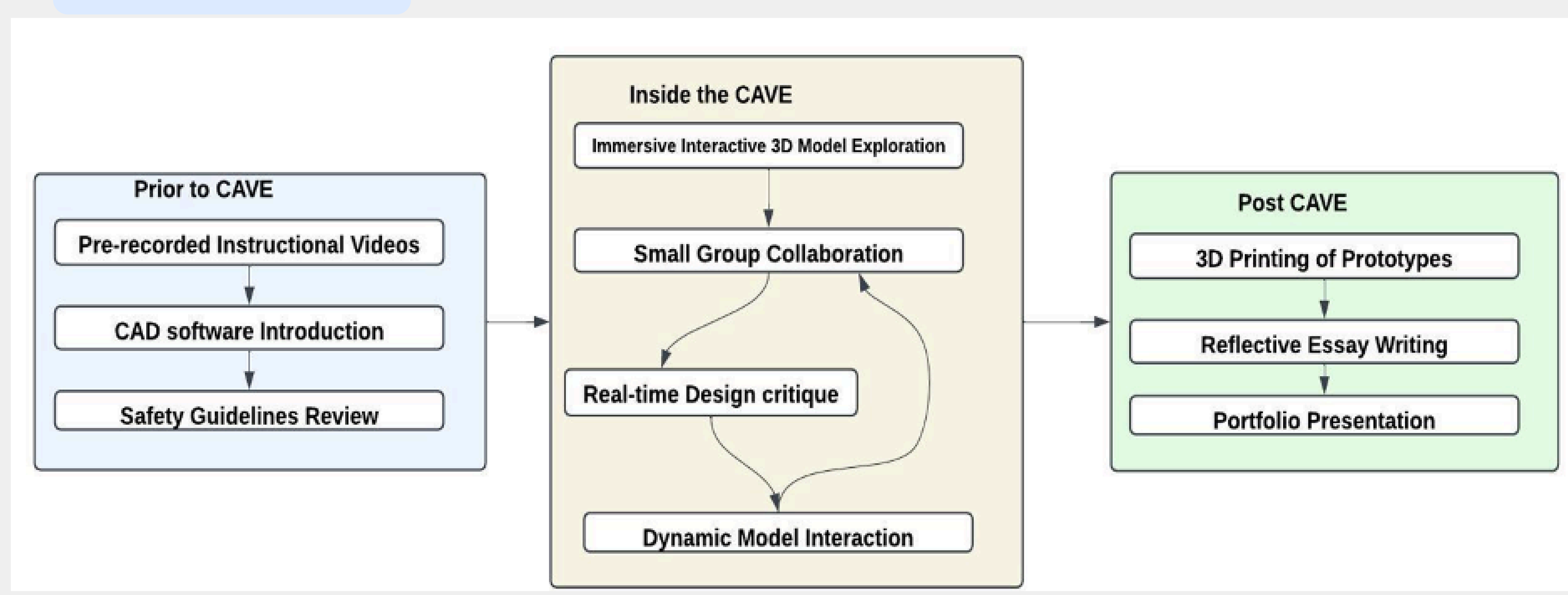
RESEARCH METHODS AND DESIGNS

Research Design	Quasi-experimental, pre-test/post-test design with control (n=17) and experimental (n=20) groups to assess VR impact on CT skills.
Participants	37 freshman engineering students; the experimental group used VR in a CAVE, control group used traditional methods.
Survey Instrument	Used adapted Computational Thinking Scales (Korkmaz et al., 2017; Ojajuni et al., 2024), covering 5 factors with 29 items: Creativity, Algorithmic Thinking, Cooperativity, Critical Thinking, Problem-Solving.

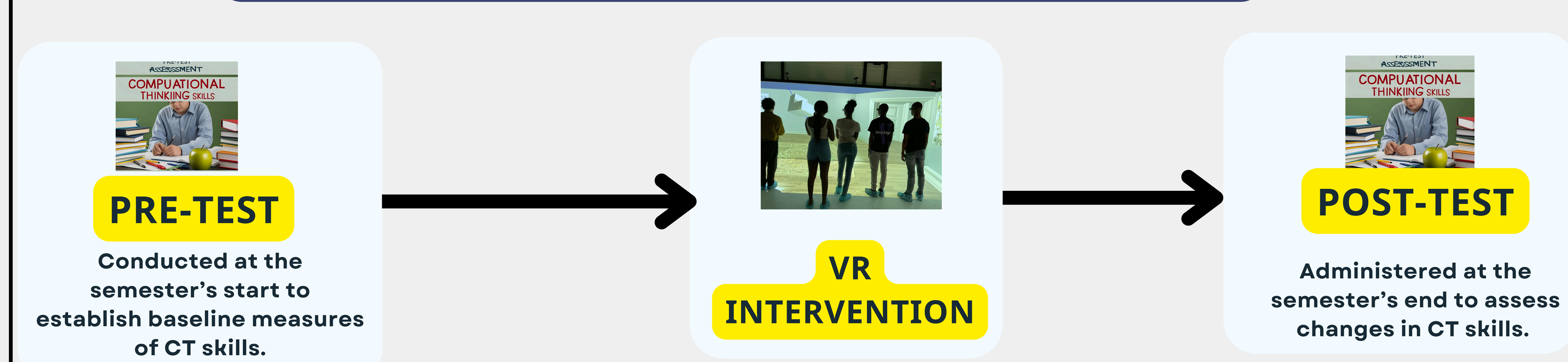
RESEARCH HYPOTHESIS

- The VR intervention does not lead to a statistically significant increase in students' CT skills.
- There is no significant difference in the post-test scores between the experimental group (students using VR) and the control group (students without VR).
- The VR intervention does not have a greater impact on CT skills compared to traditional.

VR INTERVENTION



DATA COLLECTION PROCEDURE



DATA ANALYSIS PROCEDURE

RESULTS

COMPARSION RESULT SUMMARY.

CT Skill factors	Baseline Comparison	Within-Group (Experimental)	Within-Group (Control)	Between-Group Comparison
Creative Thinking	No significant difference	Improved	No change	VR > Control
Algorithmic Thinking	No significant difference	Improved	Slight improvement	VR > Control
Cooperative Thinking	No significant difference	Improved	No change	VR > Control
Critical Thinking	No significant difference	Improved	No change	VR > Control

BETWEEN-GROUP COMPARISON EFFECT SIZE ANALYSIS SUMMARY

Factor	Effect Size	Effect Type	Interpretation
Creative Thinking	0.214	Small (Cohen's d)	Small positive effect; modest improvement in the experimental group.
Algorithmic Thinking	0.461	Small-Medium (Cohen's d)	Strongest effect; notable gain in Algorithmic Thinking in the experimental group.
Cooperative Thinking	0.268	Small (Cohen's d)	Small gain; slight improvement in Cooperative Thinking in the experimental group.
Critical Thinking	-0.148	Negligible (Cohen's d)	Negligible negative effect; control group slightly better.
Problem Solving	6.833	Large (r)*	Extremely large effect; needs review.

CONCLUSION

- The study found positive trends in Algorithmic Thinking and Problem-Solving, showing VR's potential to enhance CT.
- The research contributes empirical evidence to the field of educational technology, supporting VR's effectiveness in engineering education.
- It emphasizes the need for balanced instructional design to improve all CT components, including those less impacted by VR.
- These findings support the advancement of immersive learning in engineering education and help equip students for future technological challenges.
- The future direction:
  - Conduct Longer-term studies with larger groups.
  - Conduct VR impact on retention.
  - Exploration of AI-driven adaptive VR systems for personlized learning.

REFERENCES

- Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. Basic Books.
- Wing, J. M. (2006). Computational thinking. Communications of the ACM, 49(3), 33–35. https://doi.org/10.1145/1118178.1118215
- Ö. Korkmaz, R. Çakir, and M. Y. Özden, "A validity and reliability study of the computational thinking scales (CTS)," Computers in Human Behavior, vol. 72, pp. 558–569, Jul. 2017, doi: 10.1016/j.chb.2017.01.005.
- O. P. Ojajuni, B. Warren, F. Dawan, Y. Ismail, and A. H. Lawson, "Board 296: Immersive Engineering Learning and Workforce Development: Pushing the Boundaries of Knowledge Acquisition in a CAVE," presented at the 2024 ASEE Annual Conference & Exposition, Jun. 2024. Accessed: Sep. 29, 2024. [Online]. Available: https://peer.asee.org/board-296-immersive-engineering-learning-and-workforce-development-pushing-the-boundaries-of-knowledge-acquisition-in-a-cave