Immersive Engineering Learning and Workforce Development: Pushing the Boundaries of Knowledge Acquisition in a CAVE

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Computer Automatic Virtual Environment (CAVE) system offers an immersive and interactive platform for learners to explore complex concepts, simulate real-world scenarios, and collaborate with peers in a shared virtual space.

AFFILIATIONS

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01. Introduction

Immersive technology **encompasses virtual reality (VR), augmented reality, and mixed reality. VR Immerses users in a computer-generated three-dimensional environment and provides immersive and interactive training experiences.**

Computational thinking (CT) **set of thinking and problem-solving skills derived from computer science.**

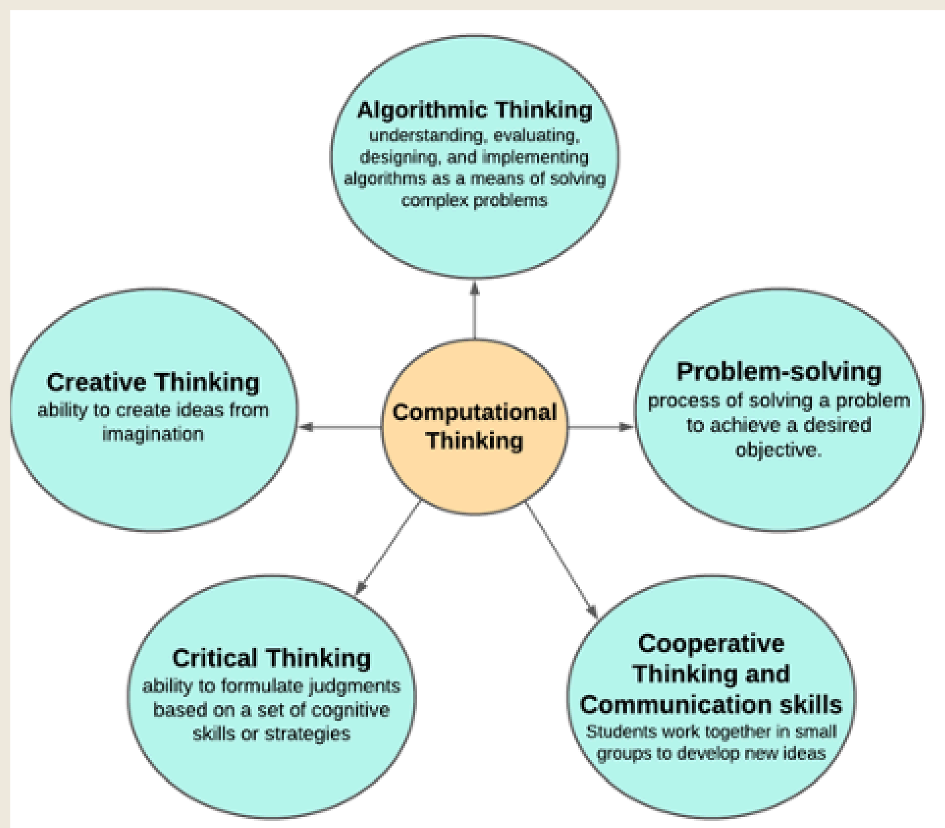


Figure 1. Factors of the Computational Thinking Scale

VR technologies, such as the CAVE and Head-Mounted Display (HMD) devices like Oculus Quest®, Apple Vision Pro®, and HTC Vive®, offer unique interactive and immersive experiences in engineering education.

CAVE, developed in 1992, is a room-sized, fully immersive VR experience distinguished by its stereoscopic displays, computer graphics, and motion tracking technology.

Figure 2. CAVE system

This innovative technology utilizes projectors or LED panels to illuminate virtual images within the CAVE, providing users with an immersive platform for analysis, collaboration, exploration, and decision-making.

03. Purpose of study

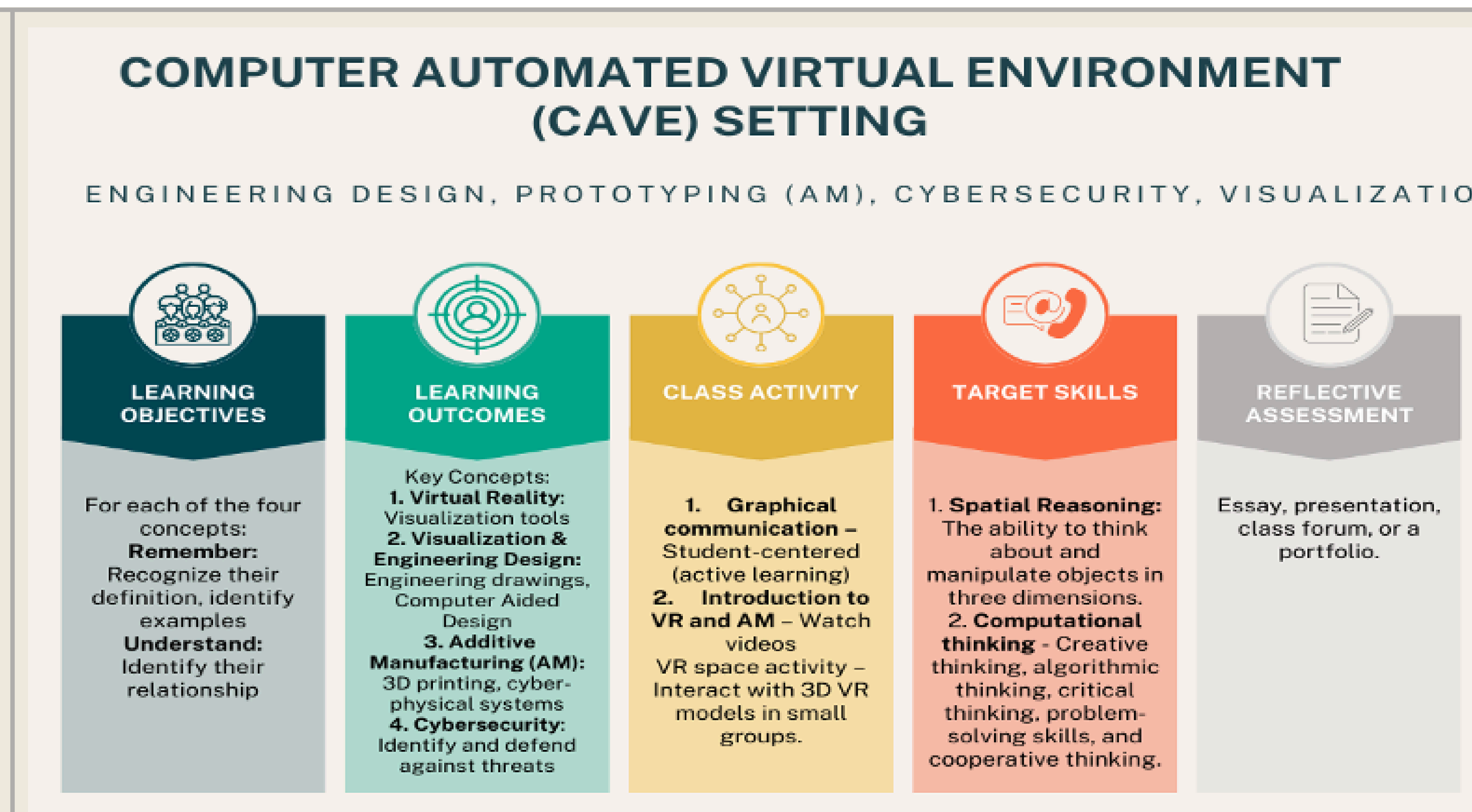
This study's purpose was to explore the integration of CAVE technology into engineering education at a Historically Black College or University (HBCU), addressing the research gap surrounding CAVE utilization for enhancing computational thinking (CT) skills.

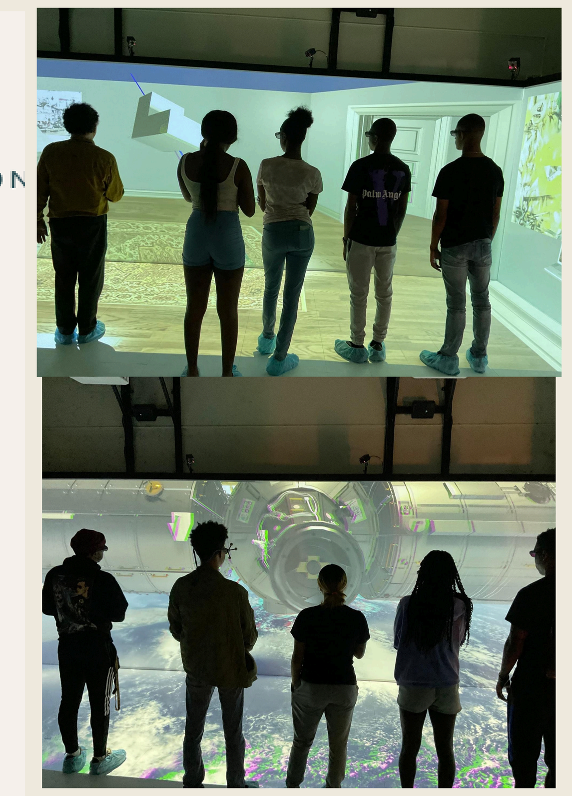
04. Research Questions

1. **Does Korkmaz et al.'s (2017) CT scale effectively measure the underlying construct of CT in HBCU engineering students?**
2. **To what extent do HBCU engineering students believe that integrating the CAVE into the curriculum enhances their CT skills relevant to engineering?**

05. Research hypothesis

- **The study formulated a null hypothesis positing no relationship between the 29 observed variables and the five underlying factor constructs of the CT scale, which represent various facets of computational thinking.**
- **The alternative hypothesis proposed a relationship between the observed variables and the underlying factor constructs.**





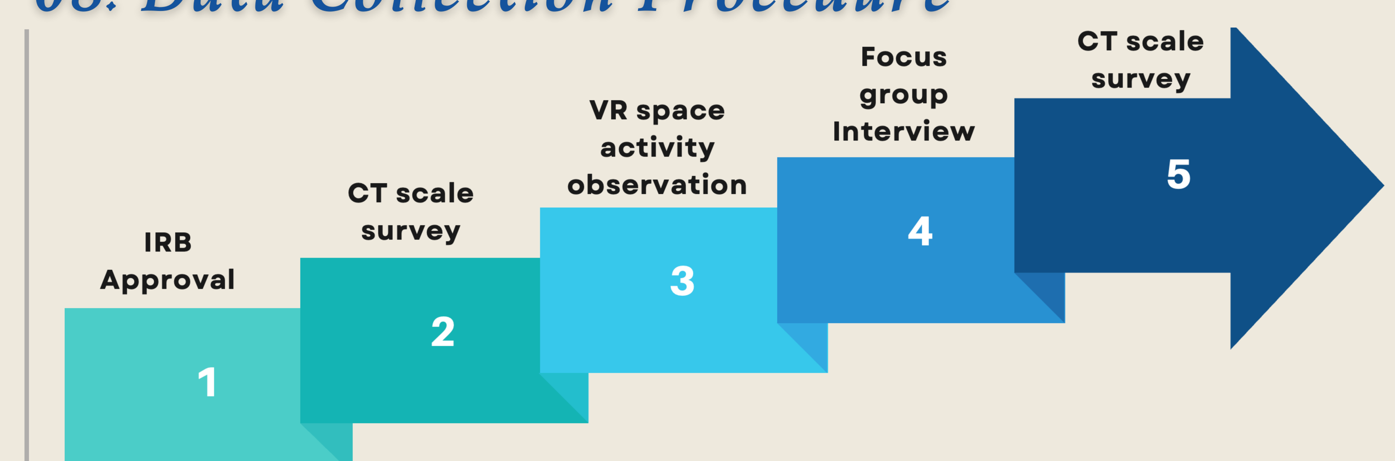
06. Research Design and Methodology

Research Design	Quantitative	Qualitative
Research Method	Survey	Cohort observational study
Participants	301 participants from an HBCU	44 students enrolled in first year engineering class in an HBCU
Sampling	Purposeful Sampling (based on enrollment in a freshman engineering class)	
Data Collection	Survey (CT scale)	Non-participant direct classroom Observations and Focus-group interviews
Data analysis	Factor analysis, Reliability Test	Thematic coding

07. Survey Instrument

- **Computational Thinking (CT) Scales, published by Computers in Human Behavior (2017) by Korkmaz et al, 2017**
- **Five-point Likert scale: scaled as never (1), rarely (2), sometimes (3), generally (4), and always (5).**
- **29 observable variables grouped into 5 Factor/ (Unobserved/ latent).**

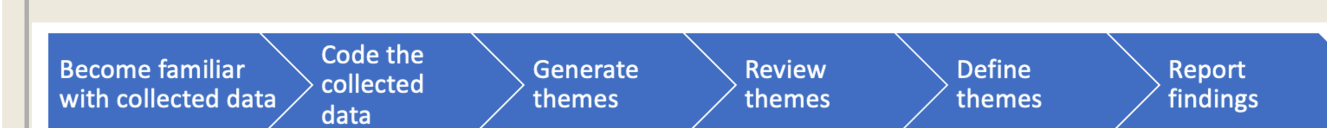
08. Data Collection Procedure



09. Data analysis Procedure

Quantitative data analysis Procedure

Qualitative data analysis procedure



10. Findings

Factors	Korkmaz et al.'s (2017) [4] study finding	Study Findings
Creativity (CR):	CR1, CR2, CR3, CR4, CR5, CR6, CR7, CR8	CR3, CR4, CR5, CR6, AT9
Algorithmic Thinking (AT):	AT9, AT10, AT11, AT12, AT13, AT14	AT10, AT11, AT12, AT13, AT14, CRT19, CRT20, CRT23
Cooperativity (CO)	CO15, CO16, CO17, CO18	CO15, CO16, CO17, CO18
Critical Thinking (CRT)	CRT19, CRT20, CRT21, CRT22, CRT23	CR1, CR2, CR7, CR8, CRT21, CRT22
Problem Solving (PS)	PS24, PS25, PS26, PS27, PS28, PS29	PS24, PS25, PS26, PS27, PS28, PS29

Research Question	Data collection	Data analysis	Findings
Does Korkmaz et al.'s (2017) CT scale effectively measure the underlying construct of CT in HBCU engineering students?	Survey – CT scale	Factor analysis and reliability test.	• Reject the null hypothesis. • CT scale is a valid and reliable scale.
To what extent do HBCU engineering students believe that the integration of the CAVE into the curriculum enhances their CT skills relevant to engineering?	• Non-participant direct classroom observation. • Focus-group interview.	Thematic coding	• High level of engagement • Motivation and interest. • Improve learning experience. • Enhance spatial reasoning. • Valuable tool in developing CT skills. • Health and sensitivity concerns.

11. Implication of Findings

- **The findings have implications beyond the immediate context, offering opportunities to enrich learning experiences, refine curriculum design, and foster inclusivity in STEM disciplines.**
- **Identifying specific CT dimensions influenced by immersive technology (problem-solving, algorithmic thinking, creativity, cooperativity, and critical thinking) guides STEM curriculum development.**
- **Students recognize immersive technology's potential to enhance CT skills by providing a safe virtual environment for gaining practical experience and learning by doing.**
- **Immersive technology bridges the gap between theoretical knowledge and practical application, preparing students for success in STEM fields.**
- **In addressing the potential challenges and limitations associated with integrating immersive technology into engineering education, several key points deserve attention - access barriers, technological dependencies, pedagogical integration, inclusive design**

12. Conclusion

- **Immersive technology bridges geographical gaps, providing a collaborative platform for engineers and students, accelerating learning and promoting a holistic approach to engineering education.**
- **Immersive technology is not just a tool, but a bridge that connects theoretical knowledge with practical application. By doing so, it equips students with the necessary skills and experiences for success in STEM fields.**
- **Integrating immersive technology catalyzes inclusion and the development of CT skills, contributing to developing a skilled and diverse technical workforce.**