Investigating the impact of immersive technology on computational thinking development in engineering training.

Presentation
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Background- Emerging Technologies

Immersive Virtual Reality

VR immerses users in a computer-generated three-dimensional environment.

The CAVE (Cave automatic virtual environment) and Head Mounted Display devices (HMDs).

Internet of thing (IoT)
Network of smart devices.

Cloud computing
Allows system integration and process automation..

Artificial Intelligence (AI)

Intelligence demonstrated by machine using data science.

Additive Manufacturing (AM)
Three-dimensional printing that creates models in small layers at a time.

Problem Statement

The problem is national crisis in STEM due to limited technological training to meet industry demands.

National crisis in STEM

- Digital literacy.
- Diversity and inclusion in STEM fields.
- Changes in core skills and abilities required to do existing jobs due to technological advancement.

(Pellas et al., 2020; Radianti et al., 2020; T et al. 2020)

National Science Foundation priorities

- Investing in Science, technology, engineering, and mathematics (STEM) Research and Development.
- Upskill STEM Workforce.
- Foster Problem solving capabilities like CT.
- Increase diversity and inclusion in the STEM industry.

(NSF reports, 2021)

Literature Overview – Computational thinking (CT)

1

Definition

- Set of thinking and problem-solving skills derived from computer science.
- Frequently used words describing CT include abstraction, problem-solving, and algorithmic thinking.

2

Framework

- Decomposition
- Abstraction
- Algorithmic Design
- Pattern recognition

3

Implementation

Fostering CT in STEM education using:

- Active learning.
- Project-based learning.
- Problem-based learning.
- Coding and robotics activities.

4

Assessment

- Observation, performance tasks, and surveys.
- CT survey scale by Korkmaz : five-point Likert scale with 29 observable variables that can be measured under five factors.
- Five factors- creative thinking, algorithmic thinking, critical thinking, problem-solving skills, cooperative thinking.

(Gong et al., 2020; Tang et al., 2020, Brennan & Resnick, 2012, Daungcharone, 2017; de Jesus & Silveira, 2019; Orozco-Garcia et al., 2019; Korkmaz et al. 2017)

Literature Overview – Virtual Reality (VR)

1

Benefits

- Foster student engagement, motivation, skills acquisition, academic performance.
- Foster cognitive abilities, digital skills, and interpersonal communication.
- Visualization, immersion, interactivity.

3

Learning Paradigm

- Behaviorism - Classroom management, student-centered.
- Cognitivism – Active learning.
- Constructivism - Experiential and interactive pedagogy.

2

Framework

- Virtual Environment.
- User interface.
- Tracking system.

<u>Instructional Design Framework.</u>

- Interactive.
- Collaborative.
- Gamification elements.

4

Learning Theory

- Cognitive Theory of Multimedia Learning.
- Experiential learning.

(Philippe et al., 2020; Hickman & Akdere, 2017; Dong, 2016; Chen, 2020; Guo, 2019; T et al., 2020; El-Mounayri et al., 2016; Radianti et al., 2020)

Gap in literature

01 Limited research on VR and CT conducted in HBCUs.

02 Little systematic work currently exists on how researchers have applied VR for higher education purposes especially engineering education.

Statement of purpose

To examine the student and faculty perceptions and attitude to the use of VR space in the curriculum.

Research Questions

RQ1

What are student and faculty attitude and perceptions towards VR in engineering training at HBCUs?

RQ2

What are student and faculty attitude and perceptions towards using VR to develop CT in engineering training at HBCUs?

RQ3

what are the factors that influence students' experiences while using VR environments in engineering classes at HBCUs?

Significance and Contribution

A

Virtual Reality

Research evidence of the effectiveness of VR to improve CT capabilities.

B

Literature

Contribute to CT development literature.

C

Technology Policies

Improve practices and policies in VR in STEM education.

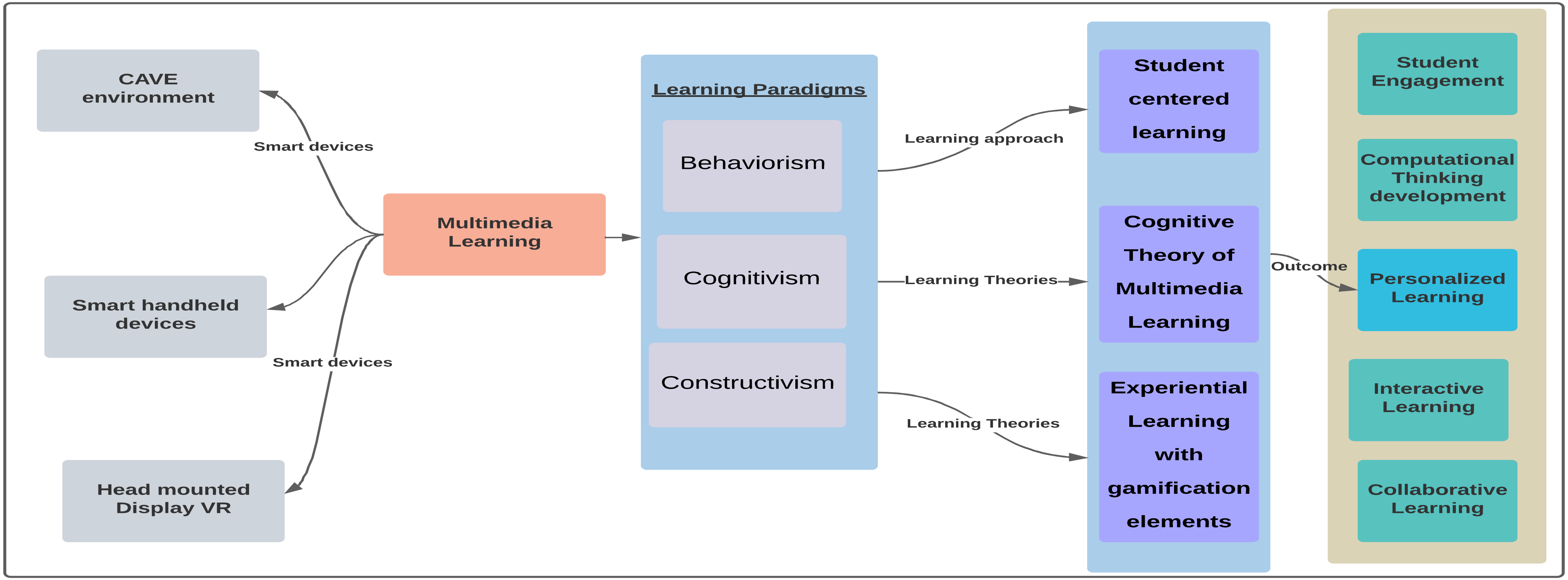
D

CT development

Provide information for practitioners and educators on CT development.

Conceptual Framework

Adopted from the Cognitive Theory of Multimedia Learning and Experiential Learning.



(Mayer, 2009; Kolb et al., 2014)

Research Design

Approach Qualitative method

AIM — To gain in-depth understanding of participants perception, attitude, and behavior towards the use of immersive VR in the curriculum to enhance learning.

Research design — Cohort observational study.

Participants — The study took place in an HBCU.
38 students enrolled in first year engineering class (freshman engineering 120).
4 faculty member.

Data Collection — Face-to-face in-person interview, focus group interview, direct classroom observation.

Data Analysis — Thematic coding.

Data collection procedure – Students

- Two direct classroom observations sessions using an observation protocol.
- Each observation lasted approximately 60 minutes.
- Five focus group interviews containing 5-8 participants after exposure to the VR space.
- Each focus group interview lasted approximately 10 minutes.

How do you think this VR space can impact your learning process or learning experience?

How do you think this VR space can improve your problem-solving skills?

Can you please share your experience with the VR space?

Do you have any concerns about the use of the VR space?

How do you envision the VR space in the next five years or in the coming years at this HBCU?

Data collection procedure – Faculty

- Face-to-face in-person interviews.
- interview lasted approximately 10 minutes.

Interview questions

How do you envision the incorporation of AI and VR into classrooms at HBCUs in the next few years?

Do you have any experience with Virtual Reality (VR), cybersecurity, or AM?

Do you have any concerns about the use of immersive technology in engineering courses?

What are your thoughts on integrating immersive technology into the engineering curriculum?

To what extent do you believe smart VR-based learning will be helpful in developing creative thinking, algorithmic thinking, critical thinking, problem-solving skills, and cooperative thinking?

Do you prefer VR-based learning to the conventional approach? Why?

VR space setting

Classroom Setting

Flipped classroom setting.

The instructor collaborated with the VR space facilitator to present VR models to students.

Class Content

Introduction to the VR space and its benefits in AM and engineering design was presented at the start of the CAVE session.

Students were required to submit reflective assignments in the form of an essay, a presentation, a class forum, or a portfolio.

LEARNING OBJECTIVES

- Visualization tools.
- Computer Aided Design (CAD).
- 3D printing.
- Cyber-physical systems.
- Identify and defend against threats.

VR activity

Each group of 8 students spent approximately 15 minutes interacting with three-dimensional models.

The students viewed three VR models and manipulated 3D models by grabbing, rotating, zooming, and dropping it.

Data Analysis procedure

Thematic Coding

1. Become familiar with collected data
2. Code the collected data
3. Generate themes
4. Review themes
5. Define themes
6. Report findings

Results R1 – Faculty

Perception and Attitude – Positive

- VR should be incorporated into the STEM curriculum to ensure that students are adequately prepared for the workplace.
- VR has a positive impact on student engagement and motivation to pursue STEM-related careers.
- VR is important in developing CT capabilities.
- VR-based learning should be used in conjunction with face-to-face learning.

Concerns

- Ethical, licensing, and data privacy issues. - using the VR space in a clean and appropriate manner.
- Limited technical skills among educators in creating VR applications.
- Accessibility.
- Need for a well-planned roadmap for incorporating VR into the classroom.

Quotes

- *"My thoughts. My thoughts are it's needed. We know that research shows that active learning is a lot better than students just reading things from the book. So an immersive experience basically antes up that whole active learning phenomenon".*
- *"In my experience, it forces the students to re-imagine or re-envision the topic, the concept, and what they're actually learning."*
- *"The CAVE environment that it is going to really build your ability to understand that spatial reasoning, which is something that probably means nothing to you right now, especially where you are as your trajectory and your matriculation is future engineers*
- *" But you know VR based learning expands the mind. I mean you can get inside of. For example, we have a space station model that you can actually make a tour through it. You can actually get the sensation that you're out in space and looking down to Earth. So it expands your thinking and adjust how you see things, your perception as to what's really happening, you don't get that exposure with other technologies",*

Results R2 – Students

Observation

- Highly engaged and interested in the CAVE environment.
- Constantly collaborating, asking questions and contributing creative ideas.

Perception and Attitude – Positive

- VR is unique and realistic experience.
- VR as a helpful tool for developing practical skills, safety habits, and real-world problem-solving abilities.
- Enhance experiential and active learning, which is conducive to CT development.

Concerns

- Dizziness.

Quotes

"It was pretty cool"

"I would say it was pretty unique. I have not been in virtual reality CAVE before. I have experienced virtual reality in game before, but I never did anything like that. I thought that was pretty cool"

"it can help us improve our practical skills and safety habits and all that."

"Well, like I said, it's just basically putting them in real world situations. Like I can say these. This right here, yeah, we can create a model and break it apart and make us learn it piece by piece and bring it back together and learn the functionalities of the parts."

"I mean it help in putting on real life situation without actually spending more. That's how it will help because you can learn, you can make mistakes without messing anything up or, you know, damaging anything that costs a lot of money. You can make those mistakes early, so when you finally do get into the field its going to be perfect."

Results R3 – Factors

- Active learning
- Realistic and Immersive
- Visualization
- Interactive
- Cost- effective

Quotes

- *"yeah, because it catches everybody's attention in my opinion. Like you can sit there and watch somebody teach and learn when you're actually in it you feel much better and pay more attention and also interactive."*
- *"I feel like it's good for visuals or something."*

"I would say I am a hands-on learner. So, for me to learn, I need to see things and actually do it myself. So, I feel like if I learn how to, you know, put something together in virtual reality I can do it in real life.",

" Well, like I said, it's just basically putting them in real world situations. Like I can say these. This right here, yeah, we can create a model and break it apart and make us learn it piece by piece and bring it back together and learn the functionalities of the parts."

Conclusion

1

Participants demonstrated high engagement and interaction levels and a positive attitude towards the VR space.

The key design elements of incorporating VR into engineering training are active learning, realism and immersive experiences, visualization, interaction, and cost-effectiveness.

4

2

Immersive technology can significantly increase diversity and inclusion in STEM fields by fostering Accessible and inclusive learning, engagement and collaboration, skills development and career Readiness

VR in the engineering curriculum was seen as a valuable tool in improving students' learning experience and CT skills

3

5

Future work – Quantitative method to investigate the relationship between VR space and CT development

THANK YOU