Engagement and Cognitive Effort in Chemistry Education Through Virtual Reality: Examining the Negative Impacts of VR

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CONTEXT 1/4

- ✓ **Engagement and motivation of chemical students** are a real problem → lack of motivation, absenteism, important demotivation, risk-taking, …

- ✓ The chemical sector is associated with significant potential risks (health hazards, physical dangers, flammability, widespread contamination, toxicity to aquatic life, and explosions) → it is **crucial to maintain a high level of engagement and attention** among chemistry students in order to enhance chemical safety

CONTEXT 2/4

- ✓ **VR can be a useful and effective tool to increase engagement and motivation**

➔ immersion, interaction, and imagination are the key features of VR that enable students to experience real-world scenarios, enhance their learning motivation, their engagement and yield positive learning outcomes (Birkheim, 2024; Broyer, 2020; Brown, 2020; Chen, 2024; Sari, 2023).

« The Lorraine Project for Digital Environment in Sustainable Learning ("PLEIADES") to develop a comprehensive approach to digital and educational transformation, breaking down social, disciplinary, and geographical barriers. »

PLEIADES

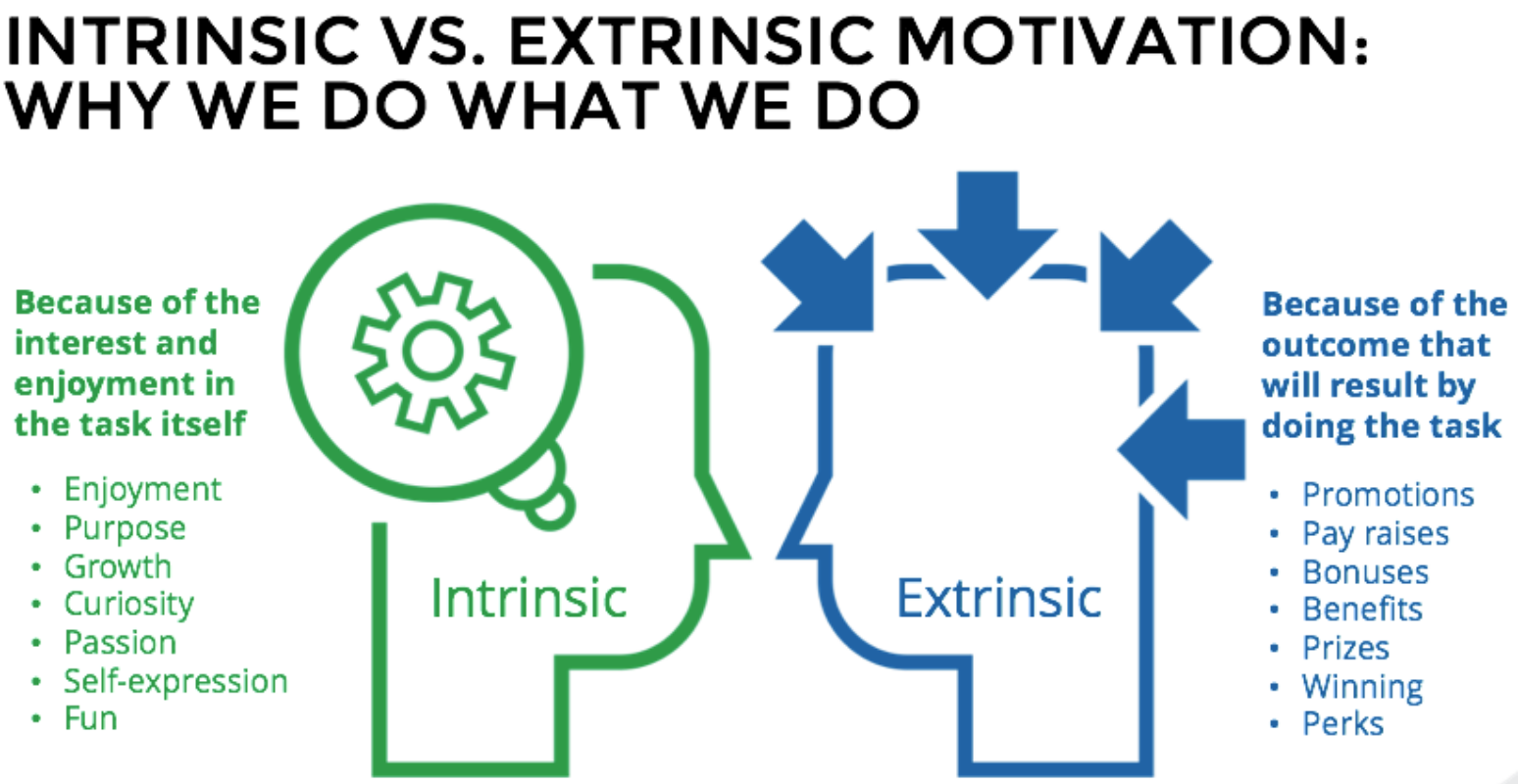
ANR-21-DMES-0010

CONTEXT 3/4

Several advantages of VR for chemical students (Rzanova, 2024) **:**

- ✓ Creating realistic simulations of chemical processes, experiments, and reactions, allowing students to practice in a safe and controlled virtual environment.
- ✓ Visualizing molecular interactions and reaction mechanisms at the atomic and molecular level.
- ✓ Interacting with process flow diagrams (PFDs) and process and instrumentation diagrams to better understand the operation of chemical plants.
- ✓ Simulating hazardous scenarios to prepare students for real-world challenges.
- ✓ Collaborating in a shared virtual environment to solve complex chemical engineering problems.
- ✓ Receiving immediate feedback on their decisions to enhance learning
- ✓ *Etc*.

CONTEXT 4/4



Reproduction of Vallerand's hierarchical model of intrinsic (IM) and extrinsic (EM) motivation, with education, interpersonal relations, and leisure as example life contexts. Reproduced from Vallerand (1997)

CONTEXT 4/4

INTRINSIC VS. EXTRINSIC MOTIVATION: WHY WE DO WHAT WE DO

Because of the interest and enjoyment in the task itself

- Enjoyment
- Purpose
- Growth
- Curiosity
- Passion
- Self-expression
- Fun

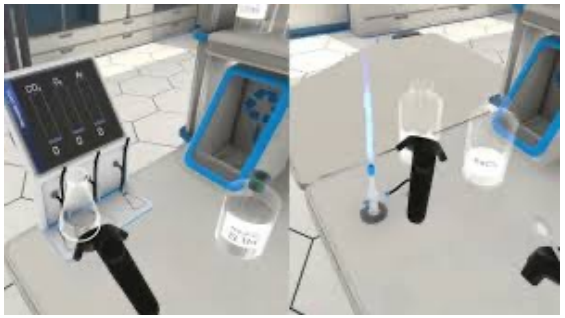
Intrinsic

Several studies show that …

Extrinsic

will result by doing the task

- Promotions
- Pay raises
- Bonuses
- Benefits
- Prizes
- Winning
- Perks



METHOD 1/3

Our question ➔ A specific VR system can enhance motivation and engagement among chemistry students.

Participants :

N = 64 first-year chemical students from the University of Lorraine

✓ including 37 women and 27 men

✓ average age of 18.63 years (SD = 2.18).

Independent factors:

✓ An experimental group (n = 34) ~~and a control group (n = 30; CANCELLED)~~

✓ Two sessions : Pre (before the lecture) *vs*. Post-test (after the lecture)

Rem.: All participants were native French-speakers, had no experience of VR and had no severe visual impairment.

METHOD 2/3

The VR system :

- ✓ Specifically created (« PLEIADES »)
- ✓ Each user can freely navigate through the laboratory, exploring its various areas and equipment.
- ✓ During exploration, questions are presented within the VR environment.

For example, a Non-Playable Character (NPC), depicted as a chemist, appears wearing two different professional outfits. The student is then tasked with selecting the most appropriate outfit for the chemist by clicking on the correct one.

METHOD 3/3

Dependent factors ➔ Measures:

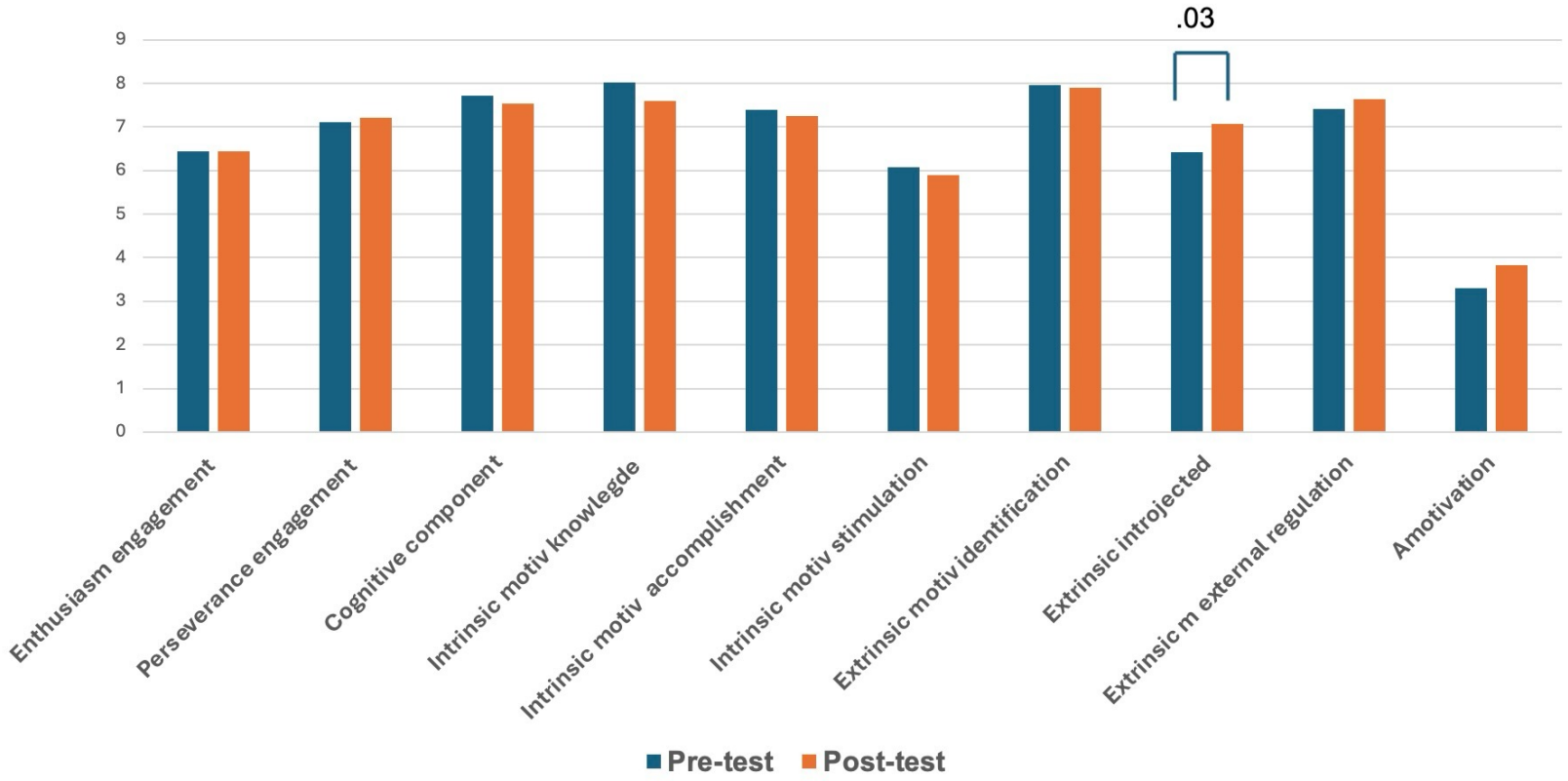
- ✓ **Motivation of participants** → the Academic Motivation Scale (AMS; Valleyrand, 1989, 1999, 2011) = Likert scale with 28 items:
  - 3 dimensions of intrinsic motivation : knowledge, accomplishment, stimulation
  - 3 dimensions of extrinsic motivation : identification, introjection, external regulation

- ✓ **Perceived engagement** → the School Engagement Scale (Brault, 2010, 2018) = Likert scale ➔ Behavioral, Affective, and Cognitive engagement

- ✓ **Mental workload** → the NASA Task Load Index (NASA-TLX; Hart, 1988) ➔ Mental Demand + Physical Demand+ Temporal Demand + Performance + Effort + Frustration

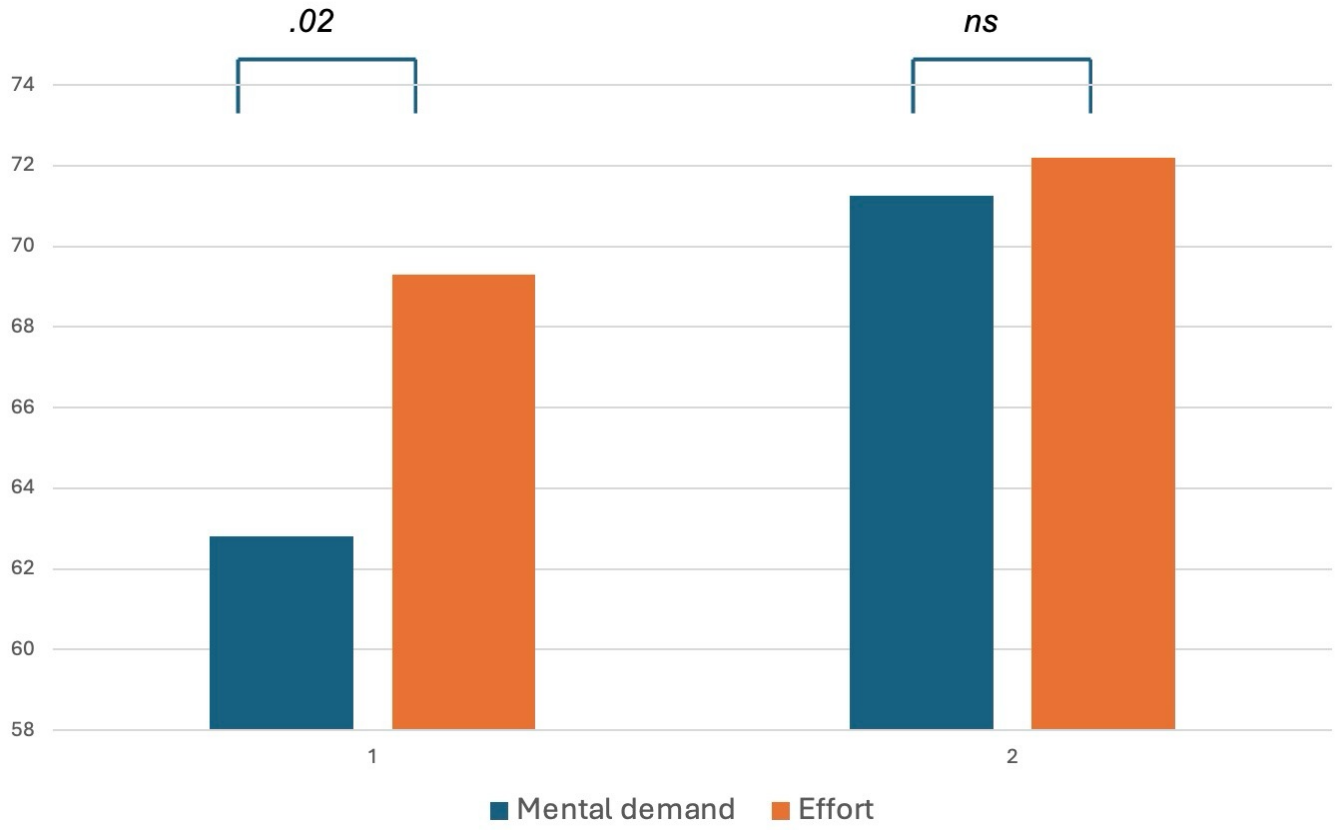
MAIN RESULTS 1/2

No impact on motivation, on engagement !.. (except for extrinsic motivation…).



MAIN RESULTS 2/2

A negative impact on mental workload and subjective effort !..



DISCUSSION

Our experiment with chemistry students suggests that :

- ✓ VR does **not have a positive impact on their cognitive, behavioral, or affective engagement**
- ✓ VR **did not enhance students' interaction** with learning materials or improve their understanding of abstract and complex concepts through immersive scenarios
- ✓ VR **did not encourage active participation** or promote engagement through interactive learning experiences

➔ Although several methodological biases may limit the generalizability of our findings, these contrasting results call for further investigation in future research !...

DISCUSSION

Why???
Maybe several false postulates / remarks:

1. « *Everyone loves VR* »
2. VR can induce motion sickness
3. VR doesn't look real
4. Students do not want engage effort
5. « *The design of VR systems by experts in the domain (here, in chemistry) is good* »
6. « *The transfer from VR to natural settings is evident* »

Thank you for your attention …

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