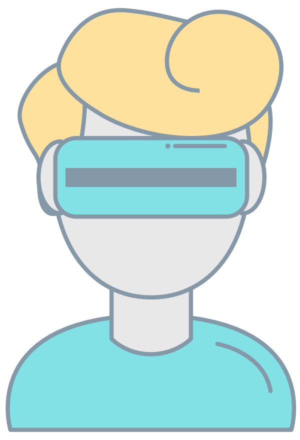
VIRTUAL REALITY
in Chemistry Labs (VL)

VR: Computer technology that is used to create or access an artificial environment, experienced through sensory stimuli and is affected by interactions with it.

Immersive VR lab experiences have shown to increase learning effectiveness by **76%**.
(Bodekaer, 2016)



89% of 50 reviewed studies demonstrate increased student achievement with VL.

(Bortnik, Stozhko, Pervukhina, Tchernysheva, & Belysheva, 2017, p.3)

2.8% better than traditional labs: more memorable, better retention.

(Dunnagan & Gallardo-Williams, 2020, p.26)

VL experiences are as effective, or better than, traditional lab experiences. They are a great alternative for those that cannot go to a lab in person due to disability, pregnancy or other reasons.

(Winkelmann et al., 2020)

54%

54% of high school and first year undergrad students "strongly agree" that VL improved their learning

46% of students "agree" that VL improved their learning.

(Agbonifo, Sarumi, & Akinola, 2020)

71%

71% of students think VL takes lesser time to complete.

13% of students think the VL takes more time than real world labs.

(Winkelmann, Keeney-Kennicutt, Fowler, & Macik, 2017)

83.7%

Canada has the greatest projected compound annual growth rate for AR and VR spending.

41% of investors say VR technologies are most applicable to education - tied with healthcare. This is second to gaming at 61%.

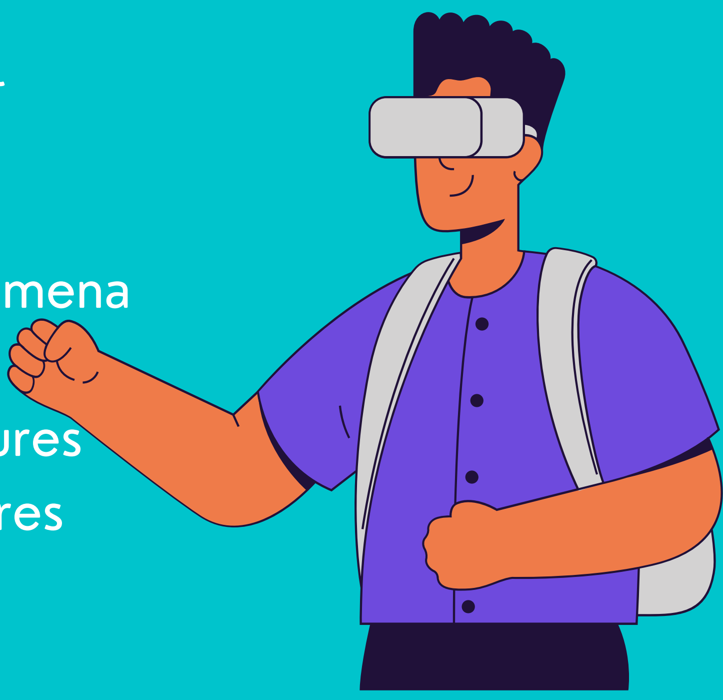
(International Data Corporation, 2019; Delaney, 2019)

VL is increasingly used in high schools and university-level Chemistry courses to supplement and even replace hands-on lab experiments. **VL has been shown to enhance research skills and develop analytical Chemistry process skills as effectively, if not better than, regular hands-on experiments.** This allows students with challenging circumstances to participate and learn at their own pace, taking care of attendance issues and minimizing distractions.

(Ali & Ullah, 2020; Bortnik, Stozhko, Pervukhina, Tchernysheva, & Belysheva, 2017; Davenport, Rafferty, & Yaron, 2018)

Benefits to Literacy

- Visualize complex concepts
- Observe reactions at the atomic level
- Simulate real-world scenarios
- Manipulate and explore abstract, unobservable, molecular-level phenomena
- Get familiar with reagents, apparatus, equipment and experimental procedures
- Learn appropriate lab safety procedures without real risk



Benefits to Education

- Learner-centred, active, experiential, inquiry-based experiences are shown to improve learning effectiveness
- Provide immediate feedback to students, allowing them to correct misconceptions instantly
- Perform dangerous experiments without risk, such as explosive, biohazardous or radioactive reactions
- Access cutting-edge technology and research, comparable to Ivy League research labs

Word cloud created on wordart.com using keywords found in research papers listed in the References.

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Although initial set-up is expensive, VR saves operational costs in the long-run. It minimizes overhead costs, lab maintenance, reagent and equipment consumption costs, and general lab safety and operational costs.

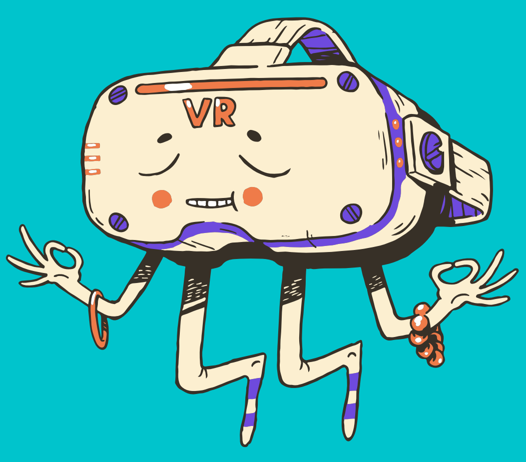
Using existing technology, i.e. smartphones, VL can be more readily accessible in schools and at home. Google Cardboard offers an affordable VR experience, with a template to DIY as well. Other VR headsets including Samsung Gear and Oculus devices can range from $20-$600 each.

(Robertson, n.d.)

VL replaces costly equipment and/or those instruments that are generally inaccessible to high school students. These include, but are not limited to:

- IR Spectrometer
- NMR Spectrometer
- PCR Thermocycler
- Particle Accelerators
- Fermentors and incubators
- Electrophoresis Chambers
- Analytical Balances
- Fluorospectrometers
- Electron Microscopes

Final Remarks



VR is not meant to replace hands-on experiments, nor does it need to. When used with the right goals for student learning and development, it works to enhance the learning experience. Additionally, when VR is combined with teacher coaching, a remarkable 101% increase in learning effectiveness has been observed (Bodekaer, 2016). VL is motivating and stimulating for students; it allows them to work independently or collaboratively, in a safe and cutting-edge technological environment. As a supplement to traditional labs, VL can provide an infinite learning potential to students.

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