TIPS, TRICKS & TECHNIQUES

Virtual Reality: Flight of Fancy or Feasible? Ways to Use Virtual Reality Technologies to Enhance Students’ Science Learning

REBECCA HITE

ABSTRACT

Virtual Reality (VR) is an emerging technology that provides K–12 students with unique experiences for robust science learning by transporting them to a virtual world where they may engage directly with scientific phenomena. This is because VR creates lifelike three-dimensional spaces where students can manipulate objects; hear, see, and sometimes feel the environment; and explore places that mimic attributes of the real world. VR holds great utility in science education by engaging students in science topics that may be otherwise inaccessible to them in the real world. This inaccessibility may stem from the content (being too small, large, or abstract), safety issues (too hazardous or dangerous), not having access to the materials in their context, possessing physical or cognitive disabilities where they need to do the activity repeatedly or differently, or having cultural, religious, or ethical concerns related to conducting specific science experiments. This commentary discusses how three key types of VR hardware (VR viewers, desktop VR systems, and head-mounted displays) can be incorporated into science standards, curriculum, and instruction by delineating the pros and cons of each. The commentary concludes with specific, stepwise guidance in ideating, designing, and implementing VR-based experiences for K–12 students in the science classroom.

Key Words: Curriculum; instruction; virtual presence; virtual reality.

How VR-Enhanced Instruction Can Help Students Learn Science

Generally, VR is a viable option for science learning when the real world is inaccessible. Given that the real world is ideal for gaining knowledge or practicing a skill, this option may not be accessible to or safe for the learner. VR has been used in higher and vocational education for training when the real world is too dangerous or hazardous, like applying a medical procedure for the first time on a live subject. This can also extend to the classroom as there are science experiments that are safer to conduct in VR. Examples include culturing bacterial cells or modeling viral spread. Since these experiments are generative for students’ development of science knowledge and skills, VR provides a safe yet viable alternative.

However, there are other aspects of inaccessibility to consider that VR can help to alleviate. VR can help students access scientific phenomena that are too small, in the past, or into the future. For example, students can view how microscopic macromolecules...
aggregated on early Earth to form coacervates or how increasing temperatures will impact Earth’s ecosystems in the near future. Other aspects of inaccessibility include cost and capital. It may be cost prohibitive to engage in certain activities with supplies that are limited, complications (such as need for high amounts of scaffolding), or need for repetition to gain proficiency. In these cases, VR can provide all the materials and on-demand information within the Virtual Learning Environment (VLE) and reset the experiment for repeat trials. Notably VR can provide a more equitable science learning experience for students who are chronically absent or who may need remediation or enrichment. Also, for students who have religious, cultural, or ethical concerns toward dissection, VR provides a high-quality alternative to access the vital science knowledge and skills derived from participation in dissection activities.

- **Key Strategies for Determining When to Incorporate VR into the Curriculum**

Start with your state’s science standards or the Next Generation Science Standards (NGSS). Decide which topics within the standards are currently inaccessible to your learners or may be enhanced by VR. Next, consider what activities from those topics that may be too dangerous, hazardous, small, abstract, costly, complicated, or disconcerting for your learners. Developing this list will help inform your next step, which is to review the major types of VR hardware and software available for science learning.

- **Three Major Types of Virtual Reality Hardware**

There are three major types of VR hardware used in K–12 science education: VR viewers, desktop VR systems, and head-mounted displays (see Hite et al., 2019). Each type of technology has pros and cons (see Figure 1) when used in the science classroom.

**VR Viewers**

VR viewers use a set of polarized lenses to create a visual three-dimensional (3D) effect. Students turn their head to have a 3D screen follow their movements and use a small button on the upper left to interact with the VLE. One application useful to science education is a virtual field trip of Berlin’s *für Naturkunde* Natural History Museum on *Google Expeditions*. Using Google Cardboard 3D viewers, students can tour the Earth’s rich biodiversity and learn about preservation strategies to mitigate species loss.

**Pros.** A VR viewer can be made from simple materials found at home (e.g., cardboard, magnets, fasteners, and rubber bands) and a one-time purchase of lenses (around $3 each). The major hardware cost is procuring a VR-enabled device, like a late-generation smartphone, which is needed to place inside the viewer to run specialized VR software applications (known as apps). Many of these apps are free for download and educational use.

**Cons.** However, many VR viewer apps tend to cover niche subjects, so there may not be a high-quality app for the curriculum topic you need. Other cons of viewers are they are nondurable and cumbersome when used for long periods of time. This may cause a certain type of discomfort known as VR sickness, when individuals experience wooziness due to sensory inputs (Kim et al., 2018). Last, but not least, users’ perceptions of virtual presence may be poor as students can be easily distracted by the outside environment, have limited abilities (e.g., the sole means of interaction is through a single button) to interact within the VLE, and have reduced sensory engagement.

**Desktop Systems**

Desktop-based VR systems use a modified desktop (or laptop) computer with head-tracking sensors that map to dots on polarized eye-wear. Desktop systems use a mouse or a stylus pen for the user to more fully interact (for virtual presence) within the virtual world. *Newton’s Park* by *zSpace* provides a virtual physics playground where students can test how various forces (e.g., gravity and friction) compare from Earth to the moon and the other known planets in our solar system by toggling features and experimenting with 3D objects.

**Pros.** Desktop systems use elements (e.g., eyewear, stylus) that are familiar to students so they don’t feel as confined by the technology itself (Hite et al., 2019). Also, there are many apps available for K–12 students that use tools like Unity 3D for independent app development.

**Cons.** Desktop systems are more costly than VR viewers because they require purchase of specialized hardware and often software. However, when not in VR mode, desktop systems operate as a standard personal computer, ideal for school settings.

**Head-Mounted Displays**

Head-mounted displays (HMDs) are commonly found in video gaming and industry. Unlike desktop systems, the user is more fully engaged in the virtual world (sensory immersion) and is able to interact by using some form of joystick or glove for more naturalistic hand motions. *Breaking Boundaries in Science* is an *Oculus* app that allows students to relive the famous discoveries of three women scientists: Jane Goodall, Marie Curie, and Grace Hopper. Voiced by Jane Goodall herself, students explore immersive vignettes of the lived experiences of these women in their historic and scientific endeavors.

**Pros.** HMDs have a wide array of hardware and software options. Given that they are able to produce a robust sense of virtual presence, they may be useful for robust science learning.

---

**Figure 1.** Three types of VR hardware: VR viewers, desktop systems, and head-mounted displays.
Cons. HMDs are expensive ($500) and unlike desktop VR can only be used for VR-based applications. One of the cons of HMDs is its greatest strength, which is its ability to induce virtual presence. Virtual worlds may become too real for certain users and induce what is known as VR phobia, a sense of fear or belief that what is occurring in the VLE is happening in real life. This robust sense of virtual presence is why VR has been used as an effective means of exposure therapy for phobia treatment (Park et al., 2019), yet VR phobia can be a real concern for K–12 learners.

Key Strategies for How to Incorporate VR into Your Instruction

So, when you are ready to use VR in your biology teaching, make sure to ask yourself the following questions for successful implementation:

- Which science topics (standards) would be best suited to VR-assisted instruction?
- Which VR hardware has the best apps for those topics selected from the standards?
- Which type of VR hardware is best suited for my students? (Consider which type is easiest or most intuitive for them to use, which is less likely to break due to rough handling or induce VR sickness or VR phobia.)
- Which type of VR hardware (and software) is best suited to my budget?
- How much class time should I dedicate to help students learn how to use the technology?
- How much class time should I dedicated to having students use the technology to learn?
- How will I use the VR to support their learning? (Consider if you want to start your students with a VR-based experience and then real world experience, or vice versa.)
- What is my plan if a student becomes VR sick or VR phobic?
- How can I design assessments that take into account the 3D nature of the technology to assess the learning they have gained from using VR for science learning?

Technology-enhanced instruction has the ability to supplement your science instruction. By leveraging these tools in thoughtful and specific ways, your students can have a greater variety of science experiences for greater science learning.

References

Hite, R. (2016). Perceptions of Virtual Presence in 3-D, Haptic-Enabled, Virtual Reality Instruction. PhD dissertation, North Carolina State University.
Hite, R., Childers, G. & Jones, M.G. (2019). Review of virtual reality hardware employed in K-20 science education. In A. Zhang & D. Cristol (Eds.), Handbook of Mobile Teaching and Learning (2nd ed., pp. 1–12). Springer.
Hite, R., Jones, M.G., Childers, G., Chesnutt, K., Corin, E.N. & Pereyra, M. (2019). Teachers’ pedagogical acceptance of novel 3D, haptic-enabled, virtual reality technology. Electronic Journal of Science Education, 23(1), 1–34.
Kim, H.K., Park, J., Choi, Y. & Choe, M. (2018). Virtual reality sickness questionnaire (VRSQ): motion sickness measurement index in a virtual reality environment. Applied ergonomics, 69, 66–73.
Park, M.J., Kim, D.J., Lee, U., Na, E.J. & Jeon, H.J. (2019). A literature overview of virtual reality (VR) in treatment of psychiatric disorders: recent advances and limitations. Frontiers in Psychiatry, 10. https://doi.org/10.3389/fpsyt.2019.00505.
Rotolo, D., Hicks, D. & Martin, B.R. (2015). What is an emerging technology?. Research policy, 44(10), 1827–43.
Sheridan, T.B. (1992). Musings on telepresence and virtual presence. Presence: Teleoperators & Virtual Environments, 1(1), 120–126.

REBECCA HITE (rebecca.hite@ttu.edu) is an assistant professor of science education in the department of Curriculum and Instruction at Texas Tech University, Lubbock, TX 79409.
Abington Heights High School, Clarks Summit, PA
American International School of Muscat, North Chesterfield, VA
Arcadia High School, Phoenix, AZ
Archbishop Curley High School, Baltimore, MD
Arroyo High School, San Lorenzo, CA
Athens High School, Troy, MI
Ayala High School, Chino Hills, CA
The Barstow School, Kansas City, MO
Bethlehem High School, Bardstown, KY
Bishop Garcia Diego High School, Santa Barbara, CA
Brentwood Academy, Brentwood, TN
Broad River Elementary, Beaufort, SC
Cabarrus Kannapolis Early College High School Concord, NC
Canadian Valley Technical Center, OK
Caney Valley High School, Ramona, OK
Cardinal Gibbons High School, Raleigh, NC
Carrollton High School, Carrollton, NC
Castle Park High School, Chula Vista, CA
Center for Advanced Professional Studies, Overland Park, KS
Central Carolina Technical College, Sumter, SC
Central Falls High School, Central Falls, RI
Central Magnet School, Murfreesboro, TN
Charleston High School, Greenup, IL
Chelan High School, Chelan, WA
Chester High School, Chester, PA
Clayton High School, Clayton, MO
Colonia High School, Colonia, NJ
Coronado High School, Colorado Springs, CO
Cuyahoga Community College, Macedonia, OH
Darnell-Cookman School of the Medical Arts, Jacksonville, FL
DeVry Advantage Academy, Chicago, IL
Dora R-III School, Dora, MO
Dougherty Valley High School, San Ramon, CA
Eastern Mennonite High School, Harrisonburg, VA
El Centro College, Dallas, TX
Emmett High School, Emmett, ID
Fairhaven High School, Fairhaven, MA
Florida SouthWestern State College, Naples, FL
Freedom High School, Freedom, WI
George Washington High, Charleston, WV
Gillette College, Gillette, WY
Grafton High School, Grafton, WI
Grand View University, Des Moines, IA
Greater Lowell Technical High School, Tyngsborough, MA
Greater New Bedford Regional Vocational Technical High School, New Bedford, MA
Greensburg Salem High School, Greensburg, PA
Harmony School in Innovation, Katy, TX
Heathwood Hall Episcopal School, Columbia, SC
Hillsboro High School, Hillsboro, OR
Hilltop High School, Chula Vista, CA
Holt High School, Holt, MI
The Independent School, Wichita, KS
Kenmore West High School, Buffalo, NY
Kent County High School, Windsor, MD
Kettle Run High School, Nokesville, VA
Lake Metroparks, Concord, OH
Lakeville North High School, Lakeville, MN
Lexington High School, Mansfield, OH
Los Fresnos High School, Los Fresnos, TX
Martin Luther College, New Ulm, MN
Mary Persons High School, Forsyth, GA
Marysville High School, Marysville, KS
Metropolitan Community College, Omaha, NE
Midland Park High School, Midland Park, NJ
Minnetonka High School, Minnetonka, MN
Moscow High School, Moscow, ID
Mount Abraham Union High School, Bristol, VT
Nassau Community College, Garden City, NY
Northampton Area High School, Northampton, PA
Palm Tree School, Fairfax, VA
Panorama High School, Panora, IA
Perkins High School, Sandusky, OH
Pike View High School, Princeton, WV
Putnam City High School, Oklahoma City, OK
Riverside City College, Riverside, CA
Salem High School, Salem, IN
Saltsburg High School, Saltsburg, PA
Seabury Hall, Makawao, HI
Seneca East High School, Attica, OH
Sherando High School, Winchester, VA
Skyline High School, Sammamish, WA
Snow College, Ephraim, UT
Southeast Community College, Lincoln, NE
Southern Wells High School, Poneto, IN
St. Andrew’s Episcopal School, Potomac, MD
St. Clair High School, St. Clair, MI
State Library of PA, Lykens, PA
Stillwater High School, Stillwater, OK
Stouffville District Secondary School, Whitby-Stouffville, ON, Canada
The Summit County Day School, Cincinnati, OH
Sunlake High School, Land O’ Lakes, FL
Tiffin Columbian High School, Tiffin, OH
Unionville High School, Kennett Square, PA
University Christian High School, Hickory, NC
Valley View High School, Archbald, PA
Vincennes University, Vincennes, IN
Visitation Academy – Saint Louis, St. Louis, MO
West Mifflin Area High School, West Mifflin, PA
Worthington Christian High School, Worthington, OH
York Community High School, Marion, IL

The mission of the NABT BioClub is to recruit, support, nurture, and promote students who have an interest in biological sciences for personal reasons, academic preparation, the betterment of society, and possible career opportunities by providing guidance, resources, and activities to meet these goals.

Look for the BioClub logo to indicate recommended articles for NABT BioClub members. If you are interested in forming a chapter of the NABT BioClub, contact NABT at office@nabt.org.