Engaging STEM: A Guide to Interactive Resources

ENGAGING STEM: A GUIDE TO INTERACTIVE RESOURCES

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ACCESSIBILITY INFORMATION

We believe in creation of free, open, and accessible educational resources.

Accessibility Features of the Web Version of this Resource

The web version of this resource has been designed with accessibility in mind.

Organizing content

- Content is organized under headings and subheadings.
- Headings and subheadings are used sequentially (e.g., Heading 1, Heading 2).

Images

- Images that convey information include alternative text (alt text) descriptions of the image's content or function.
- Graphs, charts, and maps also include contextual or supporting details in the text surrounding the image.
- Images do not rely on colour to convey information.
- Images that are purely decorative do not have alt text descriptions. (Descriptive text is unnecessary if the image doesn't convey contextual content information).

Links

- The link text describes the destination of the link and does not use generic text such as "click here" or "read more."
- If a link will open or download a file (like a PDF or Excel file), a textual reference is included in the link information (e.g., [PDF]).
- If a link must open in a new window or tab, a textual reference is included in the link information (e.g., [NewTab]).

- For citations and references, the title of the resource is hyperlinked, and the full URL is not hyperlinked.

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INTRODUCTION

The disruption in education due to the COVID-19 pandemic has given educators an opportunity to rethink the ways we design and teach in both online and blended learning environments. Emergency remote teaching has shown us just how important it is to address issues of online inclusivity in general, and at the college level in particular. Over the past year and a half, we have had the opportunity to leverage Open Educational Resources (OER), open technology (H5P), interactive web resources, and create rich and interactive web experiences for our learners.

This guidebook will benefit STEM (Science, Technology, Engineering, and Math) faculty teaching courses at the post-secondary level as well as the Open Educational Community. Within this guidebook, readers will be able to explore multiple resources, including some 'ready-to-use' ideas for classroom practice. Also included are specific examples of how STEM faculty have meaningfully integrated educational technology to meet the diverse needs of their students.

We invite you to explore innovative approaches used in teaching STEM within higher education and engage your own students through active participation rather than passive observation. We hope that you will be inspired to try new initiatives.

This book is written by authors from Community Colleges in Ontario — George Brown College and Niagara College — which provide a blend of theory and hands-on learning, as well as applied research, entrepreneurship, and social innovation opportunities. It is published under a Creative Commons license (see https://creativecommons.org/). We believe that knowledge is meant to be shared, and such sharing does not diminish value to its creator.

The Purpose and Scope of this Guide

The purpose of this guide is to help those who are involved in the process of choosing an interactive STEM resource (for blended or online learning) to make informed decisions by exploring some resources (tested by STEM teachers in their classrooms). This guide presents a range of online STEM resources for choosing hands-on activities. It does not contain a comprehensive survey of all available interactive resources, but rather, it provides a critical analysis of the presented resources and ideas for in-class use.

Although this guide is focused on interactive online STEM resources, we give some consideration to the broader scope of blended/online teaching and learning. This includes considerations related to: designing opportunities for active learning, ways of engaging learners, addressing diverse students' needs, providing multiple means of representation of subject matter, ways of supporting learners in using online platforms, tools for the development of scientific literacy and global citizenship, and possible technology tools for

developing both teachers' and students' digital and media literacy. All of these are considerations to be aware of in the process of choosing a resource for teaching and learning in the classroom (online, blended, or face-to-face).

In an effort to help make decisions about the adoption of resources, we present high-level descriptions of these interactive resources and some real-life examples of their use. Although we are mainly focused on resources for blended or online learning, these resources can be used in face-to-face teaching as well.

Book Organization

Let's briefly describe the main themes covered in this guide and its chapters. Part 1 serves as a foundational and theoretical base for the full book. In Part 2, we discuss our rationale for using virtual labs and simulations in science courses and provide an overview of three online resources that can be used for teaching and learning science and mathematics. In Part 3, we examine interactive technologies using multimedia to present information in the forms of digital maps, videos, and text. Also included in Part 3 is an overview of two resources and sample activities which illustrate the possible use of geomedia projects in an educational setting. In Part 4, we introduce resources for electronic and electrical fundamentals courses to illustrate the use of these resources as stand alone or in a blend with more traditional teaching methods. In Part 5, we consider resources that can provide learners with a hands-on experience in environmental science courses. Part 6 discusses H5P and faculty creativity in designing rich and engaging HTML5 activities for diverse learners.

Every resource in this guide — tested in our own classrooms — is accompanied by an overview of its main features, pedagogical considerations for using the resource, and a sample activity.

We hope this guidebook will not only be a great help for faculty teaching Science Technology Engineering and Mathematics courses, but that it will also support many of us who are still on the learning curve in our understanding of affordances of interactive online resources as well as how to create hands-on activities to engage and inspire our learners.

PART I
PART 1: PEDAGOGICAL CONSIDERATIONS

In this part we discuss instructional considerations for creating engaging and interactive learning environments and hands-on STEM activities. This part serves as the foundational and theoretical base for the rest of the book.

Topics discussed in this part:
-Universal Design for Learning
-Active Learning and Media Affordances
-Accessibility Considerations
-Benefits of Using Interactive Resources
-Challenges when Implementing New Educational Technology
-Skills for Digital Age
-Simulations and Learning Domains

1.

WHY INTERACTIVE STEM: INSTRUCTIONAL DESIGN CONSIDERATIONS

Elena Chudaeva

Active Learning is based on Constructivism, a learning theory that asserts that learners construct their own understanding of a topic by building upon their prior knowledge. Implementing active learning therefore means shifting the focus of instruction away from knowledge transmission to learners' knowledge construction through the creation of guided tasks, interactions, assignments, and environments that cultivate deep, meaningful learning. A closely related theory—Social Constructivism—holds that active learning best takes place when the construction of knowledge occurs in collaboration with others. Also, when choosing educational technology, it is always useful to make informed decisions based on the quality of the content, pedagogical effectiveness, ease of use, and accessibility. In general, it is wise to choose the most accessible resource which meets instructors' needs, and plans for accessibility gaps in advance to ensure equal access to the curriculum for users with learning accommodations (MERLOT, 2020).

The Benefits of Using Virtual Labs, Online Simulations, and Interactive Web Resources

Active learning methods ask students to fully participate in their learning by thinking, discussing, investigating, and creating. In active learning classrooms, students may be asked to practice skills, solve problems, struggle with complex questions, propose solutions, and explain ideas in their own words through writing and discussion. Active learning methods are especially effective for student learning when compared to classes that primarily consist of lecturing.

Faculty also argue that virtual labs are preferred when costly apparatuses and supplies are needed, or dangerous experiments are involved, but real labs are also needed to familiarize learners with real life future professional tasks and equipment. In general, teachers report that they do not differentiate one lab from the other and support the fact that both labs are essential to achieve a holistic view of reality as they both display interesting and useful features, suitable for learning (Tsichouridis et al., 2019).

Research shows that virtual labs may lead to an increase in non-cognitive outcomes such as motivation and self-efficacy that can result from doing virtual labs and lead to greater educational and life outcomes (Heckman

& Kautz, 2012; Heckman et al. 2006; Makransky et al., 2016). Additionally, using simulations and virtual labs as gamification of the curriculum can be fun for students (Aljuhani et al., 2018; Carnevale, 2003).

Importantly, online labs may be most beneficial for students with special needs (Viegas et al., 2018) and interactive resources may be a good way to conduct problem-based learning and developing analytical thinking skills (Klentien & Wannasawade, 2016).

Interactions in Learning Environments

Anderson (2008) discusses three main types of interactions in learning environments:

- teacher-student.
- student-student.
- student-content.

These interactions are critical components of the educational process. Active learning activities support all these interactions and provide meaningful and deep learning experiences for students. Read chapter 2, Towards a Theory of Online Learning from the book The Theory and Practice of Online Learning edited by Terry Anderson.
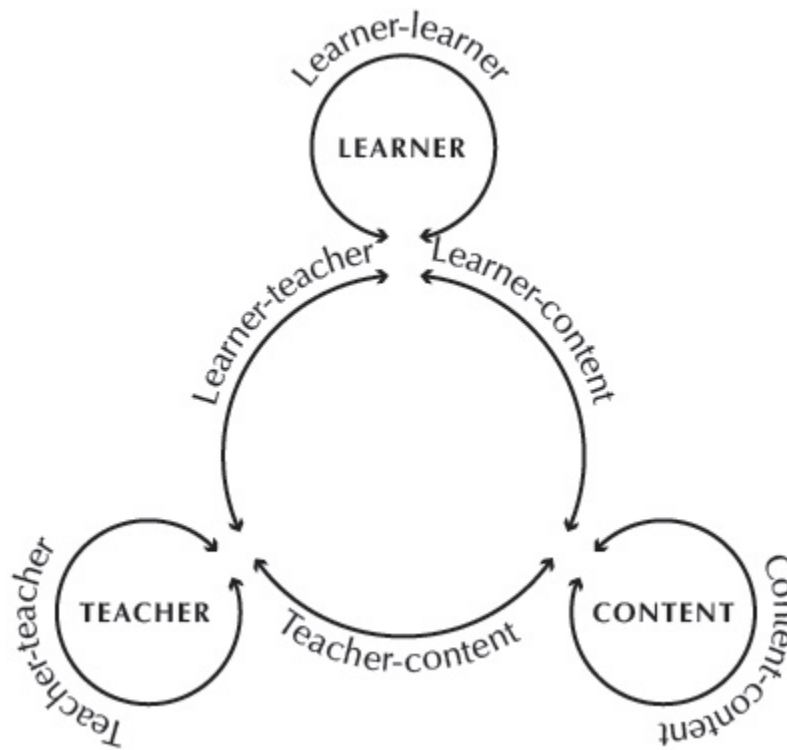
Note. From *The Theory and Practice of Online Learning* (chapter 2) [Image], by Terry Anderson, 2008, Athabasca University. Creative Commons License (CC BY-NC-ND 2.5 CA).

This figure illustrates six types of educational interactions:

- learner-learner;
- learner-teacher;
- learner-content;
- teacher-teacher;
- teacher-content;
- content-content.

By providing interactive and immersive experiences for students we focus on student-content interaction. Student-content interaction has always been a major component of formal education, even in the forms of library study or reading textbooks in face-to-face instruction. According to Anderson (2008), Web 2.0 supports these more passive forms of student-content interaction, but also provides a host of new opportunities, such as immersion in micro-environments, exercises in virtual labs, and online computer-assisted learning tutorials.

Community of Inquiry

Introducing active learning activities, virtual labs and simulations help build and support a community of inquiry among learners.

An educational community of inquiry is a group of individuals who collaboratively engage in purposeful critical discourse and reflection to construct personal meaning and confirm mutual understanding (CoI Framework, n.d.).

The Community of Inquiry (CoI) theoretical framework represents a process of creating a deep and meaningful (collaborative-constructivist) learning experience through the development of three interdependent elements – social, cognitive, and teaching presences (CoI Framework, n.d.). Visit CoI Framework website for more information.

Community of Inquiry
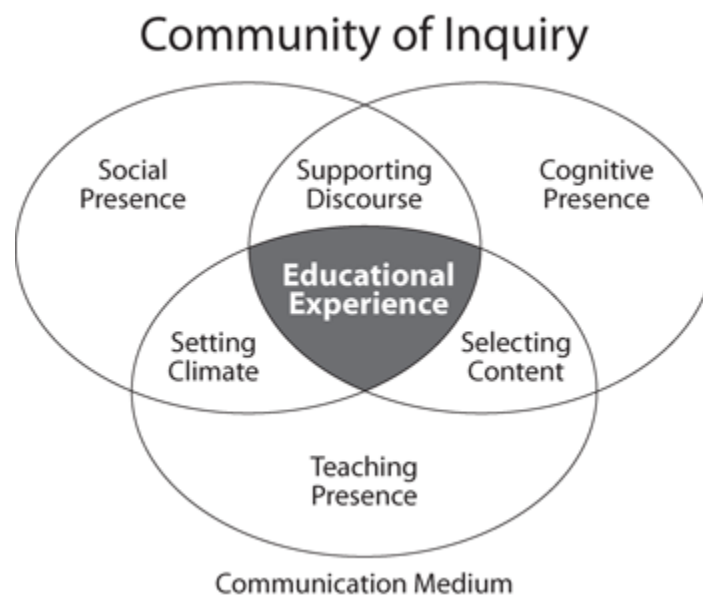
Note. *Community of Inquiry* [Infographic]. CoI
Framework. https://coi.athabascau.ca/coi-model/

All three presences produce educational experience. The intersection between social and cognitive presence supports discourse. The intersection between cognitive and teaching presences supports selecting content. The intersection between social and teaching presences supports setting climate.

Social Presence is "the ability of participants to identify with the community (e.g., course of study), communicate purposefully in a trusting environment, and develop inter-personal relationships by way of projecting their individual personalities" (Garrison, 2009, p. 352).

Teaching Presence is the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes (Anderson et al., 2001).

Cognitive Presence is the extent to which learners can construct and confirm meaning through sustained reflection and discourse (Garrison, Anderson, & Archer, 2001).

Using available interactive web resources or creating your own rich web resources can support all three elements of CoI in your own courses. For example, incorporating interactive activities (e.g., H5P) can enhance cognitive presence; providing an opportunity to discuss real life applications of the course content can support social presence; active learning and collaborative exercises, which allow students to learn from one another, can reinforce teaching presence.

About Design of Virtual Science Lab Activities

Science lab activities are inquiry processes, and thus the Inquiry Framework suggested by de Jong et al. (2013) proved quite useful for thinking about the design of the virtual lab activities. This Inquiry Framework involves five steps:

1. Orientation.
2. Conceptualization.
3. Investigation.
4. Conclusion.
5. Discussion.

During the **Orientation** phase, students are introduced to the problem: we motivate students to learn. In the **Conceptualization** phase, students learn about theoretical concepts related to the problem under investigation. The **Investigation** phase is about free exploration of the virtual science world or guided experimentation. During the **Conclusion** phase, students look back at their results and state conclusions. And lastly, the **Discussion** phase is critical for successful implementation of virtual science labs. Designing online lab activities this way also supports the social, teaching, and cognitive presences of the CoI framework mentioned earlier. Any support for developing self-regulated learning skills will help students use virtual labs successfully.

Read an illustration and sample activity of this approach in the article Supporting Students in Using Virtual Science Labs. Also, watch Design of Science Virtual Labs and Student Support.

Possible Challenges

Examining possible challenges is important for both educators and administrators. While external barriers to implementing new technology should be addressed at the institutional level, there are many other challenges faced by educators when attempting to implement new instructional technology in the classroom.

First, we will explore challenges educators may experience followed by a discussion of some potential solutions to these challenges. The first challenge may be an internal barrier which includes the instructor's attitudes and beliefs about the role of educational technology and pedagogy, confidence in their knowledge and skills, and resistance toward technology in the classroom. We have identified three general areas that should be addressed when integrating new technology into curriculum: access (internet connectivity issues and access to technological devices), training, and support. All three of these areas are applicable to teachers as well as students. To successfully implement new resources in the classroom, sufficient time and effort should be given to teachers' professional development.

Potential challenges related to technology integration may include the following:

1. Some students may not have access to the resources due to technical issues with their devices.
2. Creating online hands-on activities requires additional time and effort for faculty.
3. Community of practice plays a crucial role in supporting faculty using new tools, but this is an add-on to teaching responsibilities.
4. Integrating new resources in meaningful way requires multiple attempts and iterations.
5. Creating meaningful asynchronous active learning opportunities for diverse learners is very challenging.
6. Finding a balance between direct instruction and free exploration in designing learning activities may require the support of an instructional designer and a learning- by-doing approach to faculty professional development .

Importantly, when adopting new classroom technologies, educators face the problem known online as the "double innovation" problem (Cleaver, 2014). This problem means that there is an additional layer of preparation teachers must work through. The teacher must first learn the technology well enough to utilize it in a classroom setting before deciding how to integrate the technology with classroom objectives and curriculum (Johnson, Jacovina, Russell, & Soto, 2016). The double innovation problem still results in additional preparation time.

Recommendations

Over the past couple of years, instructors have greatly increased their use of educational technology. However, we would like to share some strategies which may encourage instructors to continue using new technology as well as support their innovation in teaching and learning.

Teaching is a personal experience. Thus, in providing instructors with the choice of what technology tools to use will help make the process more comfortable.

Here are some suggestions for educators adopting innovative technology:

1. Build in time for initial training. Be patient!

2. If possible, seek instructional support from the Teaching and Learning Centre at your institution.

3. Create alternative assessments (in case a student does not have access to technology, or the technology tool is not fully accessible).

4. Be aware of accessibility features of a particular resource.

5. Create a community of practice to be able to share successes and challenges with your colleagues and support each other.

6. Share best practices and activities with other educators. Learn from and with peers.

7. Be ready to make mistakes and learn from them.

8. When introducing new technology in the classroom, make sure to allocate time for your students to learn the tool as well. When it comes to the actual use of new tools, unexpected challenges may arise.

9. Lastly, and perhaps most importantly, enjoy the learning process — of both yourself and your students! It can be a very rewarding experience to learn something new while also seeing your students learning new things.

Additional Resources

EDUCAUSE Learning Initiative: 7 Things You Should Read About Instructional Strategies for Active Learning.

"Do not grow old, no matter how long you live. Never cease to stand like curious children before the Great Mystery into which we were born," — *Albert Einstein.*

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2.

A NOTE ABOUT SKILLS FOR DIGITAL AGE

Elena Chudaeva

"*Success in education today builds not just cognitive but character fortitude*" (OECD, 2021, p. 3).
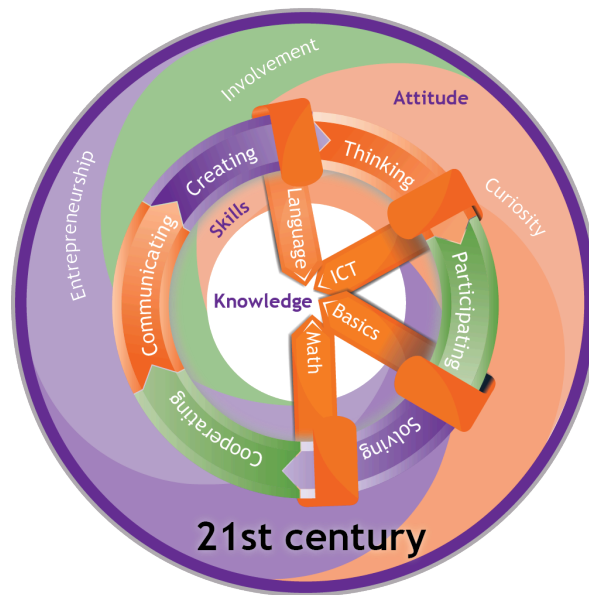
Note. (BeeBringer, 2018). Creative Commons CC0 1.0 Universal Public Domain Dedication.

Technological progress, new business models, climate change and the COVID-19 pandemic are changing every aspect of Canadians' lives, including schools, workplaces, and expectations at school and at work. With more and more automation and use of robots, it is likely that the capacity to contribute to the creative process will become more valued in the coming decades (OECD, 2021). These changes impact the skills Canadians need for jobs and the way they develop these skills (Future Skills, n.d.). According to OECD (2020), Canadians require opportunities to upskill and retrain throughout their working life to remain employable as the world of

work evolves. In this changing world all learners will need to develop such skills as creativity, critical thinking, problem solving, communication, digital fluency, scientific literacy, and resiliency in order to be successful.

Studies show that creativity and soft skills such as social and emotional skills are closely related to student well-being and academic performance (OECD, 2021). Additionally, research shows that employers are looking for these soft skills when hiring new employees in addition to subject matter expertise and knowledge (Pate, 2020; Petrone, 2019). For example, research by LinkedIn Learning has found in recent years that "creativity" was the "soft skill" most demanded by companies (Pate, 2020; Petrone, 2019).

This guidebook is about STEM activities; however, adding Art to STEM can help to develop a more holistic approach to education. Introducing STEAM (Science, Technology, Engineering, Art, Mathematics) resources into the curriculum allows both educators and students to develop the core competencies mentioned above to succeed in the digital age. Integrating a STEAM approach to designing learning material and activities also supports the development of multiple literacies. The term multiple literacies refers to our ability to 'read' the world and interpret the many formats, sources, and media through which we obtain information. In addition to the visual, audio, linguistic, and spatial ways of meaning-making, we need to include digital literacy and technological literacy.

Digital literacy relates to our ability to locate, evaluate, and synthesize digital sources. Technological literacy relates to our ability to use technology both ethically and safely. Integrating online resources into curriculum allows learners to practice these skills in addition to mastering subject matter.

Skills for Future Success

The Information and Communications Technology Council of Canada identified the following categories of valuable and necessary skills for future success (Ivus et al., 2021, p.22):

Technical skills:

- Digital literacy.
- Information/media literacy.
- Digital engagement.
- Data and analytics competencies.

Human (soft) skills:

- Digital curiosity.
- Interpersonal communication.
- Confidence.
- Flexibility/adaptability.
- Digital engagement.

"Digital engagement" appears in both categories because it is a multidisciplinary skill. We believe that incorporating interactive web resources to our curriculum helps develop and practice all of these skills.

Learning Compass

Additionally, OECD Learning Compass 2030 identified Knowledge, Values, Attitudes, and Skills as important components for students' future success:

- **Knowledge** includes theoretical concepts and ideas in addition to practical understanding based on the experience of having performed certain tasks.
- **Attitudes** and **values**, a key component of the OECD Learning Compass 2030, refer to the principles and beliefs that influence one's choices, judgements, behaviours and actions on the path towards individual, societal and environmental well-being.
- **Skills** are the ability and capacity to carry out processes and be able to use one's knowledge in a responsible way to achieve a goal. They involve mobilizing knowledge, skills, attitudes and values to meet complex demands. The OECD Learning Compass 2030 distinguishes between three types of skills: cognitive and metacognitive skills; social and emotional skills; and practical and physical skills.
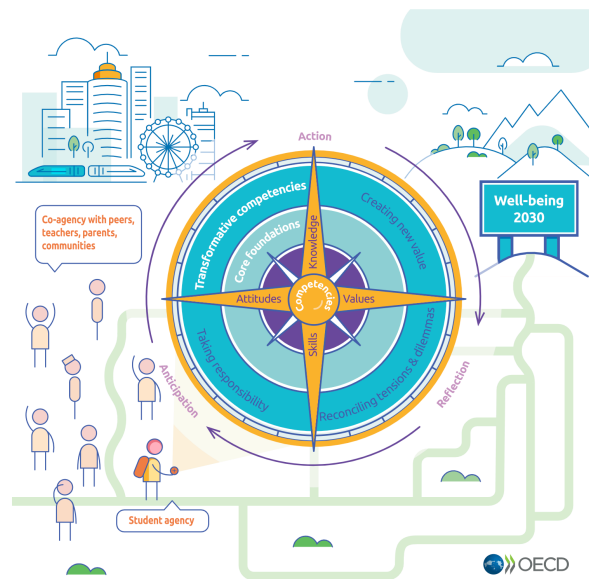
Note. The OECD Learning Compass 2030
[Image]. OECD. https://www.oecd.org/education/
2030-project/teaching-and-learning/
learning/">https://www.oecd.org/education/
2030-project/teaching-and-learning/learning/

The Learning Compass 2030 defines the knowledge, skills, attitudes and values that learners need to fulfil their potential and contribute to the well-being of their communities and the planet.

Integrating interactive digital activities into curriculum helps develop subject matter expertise, provides students with an opportunity to develop skills for the digital age, and develop creativity and innovation among teachers. Resources discussed in this book allow for the creation of flexible learning environments enabled by technology that extends outside the classroom (i. e., blended and online learning, field trips, and so on).

Additional Resources

EDUCAUSE Learning Initiative: 7 Things You Should Know About Digital Literacies.

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3.

A NOTE ABOUT UNIVERSAL DESIGN FOR LEARNING, ACCESSIBILITY, AND MEDIA AFFORDANCES

Elena Chudaeva

About Universal Design for Learning (UDL)

	Engagement	Representation	Action & Expression
Access	Recruiting Interest	Perception	Physical Action
Build	Susteining Effort & Persistence	Language & Symbolism	Expression & Communication
Internalize	Self Regulation	Comprehension	Executive Functions
Goal	Purposful & Motivated	Resourceful & Knowledgeable	Strategic & Goal-Directed

Note. Universal Design for Learning Guidelines [Table]. Adapted from UDL Guidelines. https://udlguidelines.cast.org/

Principle 1: Provide Multiple Means of Engagement

It is critical to devote a considerable amount of effort to attract learners' attention not only on the first day of classes but throughout the semester. According to CAST (2018), information that learners do not attend to, or that does not engage learners' cognition, is inaccessible. Research shows that students are engaged when they actively participate in their learning and can meaningfully contribute to class activities. It is also important to create a safe and positive class climate to allow for the sharing of and learning from diverse perspectives. To learn more, visit Multiple Means of Engagement .

Principle 2: Provide Multiple Means of Representation

It is important to think about different means of representation of course content. Learners differ in how they perceive and comprehend the information presented to them. Some students may grasp information more quickly or efficiently through imagery or sound rather than printed text. Learners also differ in what motivates them to learn. Some are highly engaged by novelty, while others prefer strict routines. According to CAST, there is no one means of representation that is optimal for all learners. Providing options—simulations, video, text, and images—will benefit all learners. By striving to provide multiple means of representation of materials in an effective and meaningful way, faculty will develop their own media and digital literacy and model these skills and attitudes. This, in turn, will help learners develop their 21st-Century skills. To learn more, visit Multiple Means of Representation .

Principle 3: Provide Multiple Means of Action and Expression

When we approach teaching and learning with UDL in mind, we design assessment opportunities differently. To address our students' diverse needs and provide them with equal opportunities to demonstrate what they know, UDL Guidelines suggest designing more than one way for learners to interact with the material. For example, providing a choice to work with peers or work alone may help students manage their time better and reduce stress related to doing an assessment. Choice also helps develop self-motivated and self-regulated learners who take responsibility for their own learning. To learn more, visit Multiple Means of Action and Expression .

The UDL Guidelines offer a set of concrete suggestions that teachers can apply to any discipline or domain to ensure that all learners can access and participate in meaningful and challenging learning opportunities. These guidelines also provide opportunities for teachers to be creative and let their personalities shine in online learning environments.

About Assessing Accessibility Features of Online Resources

Learner variability forms the foundation of UDL. All instructional materials—whether developed or adopted—must be usable by all students regardless of disability status. MERLOT (2020) supports education institutions and individuals by finding innovative ways to use technology to advance their academic mission. MERLOT assists with academic technology projects, shares information across the university, and provides high quality project design and development in support of academic technology initiatives around the world. Their efforts align with WCAG 2.0 AA accessible technology requirements.

According to MERLOT (2020), accessibility considerations during adoption of any STEM platform or resource should be one of the key components of the decision-making process. Some steps you can follow include:

- Reading accessibility statements on the resource web site (for example, PhET accessibility statement).
- Reviewing vendor's accessibility documentation (a Voluntary Product Accessibility Template, VPAT) that describes the product accessibility support (this a technical documentation, so help of an accessibility consultant may be required or Internet search of unknown terms may be a clever idea, too).
- Select the most accessible platform that meets your pedagogical requirements.
- Plan for accessibility gaps (for example, prepare alternative assignments or activities).
- Talk to an accessibility consultant or UDL coach at your institution.
- Explore CAST website and learn more about UDL and Accessibility.

The UDL framework (CAST, 2018) supports the Ontario government's mandate under AODA legislation and The Ontario Human Rights Commission Policy on accessible education for students with disabilities and it serves as proactive guide for curriculum development in keeping with accessibility policies in all colleges and universities in Ontario. It is important to familiarize yourself with accessibility laws in your area (for example, AODA in Ontario and AODA Requirements for Educational Institutions, Inclusive Education in Alberta, and Inclusive Education Resources in British Columbia). All in all, be prepared. It is important to have a strategic plan and a pilot run of a new activity.

About Media Affordances

It is also important to consider media affordances when designing STEM activities. I believe we can create meaningful activities with technology that adds value to face-to-face teaching, online learning, or any combination of these two. Tony Bates argues that technology is only one element of media, and it is important to think about affordances of the media for educational purposes when designing activities. The

following provides ideas on how you can design hands-on activities for successful science exploration, keeping these three characteristics of media in mind (Bates, 2019):

- Broadcast (one-way) or communicative (two-way) media.
- Synchronous or asynchronous technologies, including live or recorded media.
- Single or rich media.

On one hand, from a learner's perspective, rich media can be overwhelming because it may provide a lot of information in a brief period. When designing activities, we need to think about concepts such as cognitive overload and Vygotsky' Zone of Proximal Development (ZPD) (Bates, 2019). If students are presented with information at too complex of level or too quickly for them to properly understand, cognitive overload may occur. ZPD is the difference between what learners can do without help and what they can do with help. So, to design meaningful activities we need to know our students. On the other hand, using an online interactive simulation as a rich medium can encourage achievable learning goals in science education that would otherwise be difficult to achieve with a simple medium such as a textbook. So, it is really important to ask yourself Why? Why do I choose this tool? Technology is just a tool not a learning outcome.

Technology-enabled teaching and learning, when implemented effectively, has the power to have a positive impact on teaching and learning but can have a negative impact when not implemented appropriately.

Additional Resources

Practical examples of how to make online courses engaging and accessible.
Designing STEM Hands-on Activities.
EDUCAUSE Learning Initiative: 7 Things You Should Know About Accessibility Policy.
EDUCAUSE Learning Initiative: 7 Things You Should Know About Universal Design for Learning.

References

Bates, A.W. (2019). Understanding technology in education. In Teaching in a digital age. 2nd edition. (chapter 6) https://opentextbc.ca/teachinginadigitalage/.

CAST. (2018). Universal Design for Learning guidelines version 2.2. http://udlguidelines.cast.org.

MERLOT. (2020). Accessibility and Virtual STEM Platforms. https://virtuallabs.merlot.org/accessibility.html.

4.

SIMULATIONS AND LEARNING DOMAINS

Alexander McGlashan and Elizabeth Chernick

As an Instructional Strategy, simulation is rich with multiple domain learning: Cognitive, Psychomotor, and Affective (Bloom's, 2018).

The Taxonomy of Educational Objectives, known as Bloom's Taxonomy (Bloom, Engelhart, Furst, & Krathwohl, 1956) is one of the most recognized learning theories in the field of education.

In a Simulation, learners are encouraged to become self-directed, and to take ownership of their learning and task achievement. Tasks are goal oriented and relevant to the real world. Learning in the cognitive and psychomotor domains is enhanced by the affective domain, thus increasing its impact on learning.

Cognitive Domain

In a Simulation learning environment, learners are encouraged to understand specific theoretical concepts and to apply these concepts in "real-world" examples. Once tasks are successfully achieved, students practice analysis and evaluation of their own and peer work. Learning in the cognitive domain is enhanced by the affective domain.

Psychomotor Domain

The psychomotor domain in a Simulation is activated through hands-on practice where real-life skills are practiced. Physical tasks are established, and response is guided so that mechanisms to carry out tasks develop. Complex, overt responses are practiced. Learners also develop skills in adapting existing tasks and originating new tasks. In addition, anticipated movement (whether physical or metaphorical, as in narrative) is a strong motivator (Zull, J. cited in Puchta, H., 2013, p. 4).

Affective Domain

The importance of emotional engagement in learning has become increasingly recognized as neuroscience develops knowledge of the brain as an "organ of emotion". Herbert Puchta stresses the importance of brain

changes and learning. (Puchta, 2013, p. 1). He quotes neuroscience researcher James Zull, who concludes that "change is most extensive and powerful when emotion is part of the learning" (Puchta, p. 1).

Emotions play a key role in learning, "...release of certain chemicals (dopamine, adrenaline, serotonin and others) makes growth of neuronal networks possible." (Puchta, p. 1). A few key findings about how the brain impacts learning:

- memory depends on the relevance of content to the learner; real world content stimulates brain chemicals during learner engagement;
- "the brain needs to be in control"; when the learner feels she is "in control" (learner-centered), learning is enhanced;
- learning creates joy; the pleasure system in the brain rewards us for understanding; there is joy in goal-oriented action (achieving success);
- when learners discover new things, or learn through personal discovery, more reward chemicals are released into the body; creates a sense of ownership; develops thinking skills and metacognition (Puchta, 2013).

References

Bloom, B. S.; Engelhart, M. D.; Furst, E. J.; Hill, W. H.; Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals*. Handbook I: Cognitive domain. New York: David McKay Company.

Bloom's taxonomy. (2023). Centre for Teaching Excellence. University of Waterloo. https://uwaterloo.ca/centre-for-teaching-excellence/catalogs/tip-sheets/blooms-taxonomy.

Puchta, H. (2013) March 13. "Emotional Engagement for Adult Students" plenary speaker at 20th TESOL Arabia International Conference, Dubai.

PART II
PART 2: ACTIVE LEARNING FOR SCIENCE AND MATHEMATICS

To assist teachers in becoming familiar with using science and math resources for active learning, this section focuses on virtual labs and simulations. This section introduces Open Educational Resources (OER) as well as touches on paid vendors of science virtual labs. It also explains the benefits of using virtual science labs and simulations for teaching and learning and provides sample learning activities.

Resources discussed in this part:

-PhET Interactive Simulations

-LabXchange

-Beyond Labz

5.

WHY USE VIRTUAL LABS FOR SCIENCE COURSES

Elena Chudaeva

What is Virtual Science Lab?

1. A virtual lab is an on-screen simulator that helps test ideas and observe results.
2. Virtual labs are a great way for learners to practice in a safe, online environment.
3. Learners use advanced technology to perform a series of experiments that yield authentic results.

Why Use Virtual Science Labs and Simulations for Teaching?

Virtual science labs and online simulations foster skills such as:

1. Engagement and curiosity.
2. Visualization of scientific concepts.
3. Skill-building to work in real wet labs.
4. Learning from mistakes.
5. Visual learning.
6. Engagement of kinesthetic learners online.
7. Community of learners.
8. Digital skills practice.
9. Report-writing skill development.

Why Use Virtual Science Labs for Science Courses?

Some reasons why it is beneficial to use this educational technology in the classroom are:

1. To create a true-to-life learning experience.
2. To provide unique active learning opportunities for general education students.
3. To achieve an understanding and appreciation of scientific principles and scientific method.

Online labs, experiments, simulations, and visualizations allow learners to interact with and review scientific concepts. Students are able to manipulate parameters and observe different results (which is not always possible in a real wet lab). Online interactive science resources expand access to science education. It is not only science students who can do experiments, but students taking general education science courses can benefit as well. The combination of skills that students are able to practice while working with online simulations give them a competitive advantage in the future workplace. If faculty are inspired and curious, there is no limit to what students can learn.

Additional Resources

Article "How Virtual Labs are Revolutionizing Science Education" is about Labster. Labster is a paid resource with 200+ science simulations and virtual labs. They are worth exploring.

6.

PHET INTERACTIVE SIMULATIONS

Elena Chudaeva

About PhET Simulations

Here are some facts about PhET Interactive Simulations for Science and Math:

1. The resource was founded in 2002 by Nobel Laureate Carl Wieman.
2. It creates free interactive math and science simulations.
3. PhET sims are based on extensive education research.
4. PhET sims engage students through an intuitive, game-like environment where students learn through exploration and discovery.

In the following sections we will briefly discuss available teacher supports, accessibility of PhET simulations, and a sample activity. Thus, accessibility should be a key factor when selecting new virtual science labs or simulations. Watch A Brief Introduction to PhET video.

Teacher Support

Teachers have access to simulation-specific tips and video primers, resources for teaching with simulations, and activities shared by our teacher community. Watch a video on using PhET for guided inquiry: Tim Herzog Discusses Using PhET for Guided Inquiry in College Chemistry.

Accessibility and PhET

All instructional materials must be accessible to all learners. PhET accessible interactive simulations include verbal descriptions and feedback, the use of sound and music to represent foundational science and mathematical relationships, and alternative navigation that moves beyond mouse or touch inputs. Watch this video for more details: Accessibility and PhET.

SAMPLE ACTIVITY

Energy Skate Park Basics

Energy Skate Park Basics simulation is a particularly helpful review of the concepts of kinetic and potential energy, forces, and motion.

What to do:

1. Go to Intro

- In the top right corner select Bar Graph and Speed.
- Start the simulation.
- Observe changes in energy and in speed.
- Change mass.
- Observe how this affects energy and speed.

Answer these questions:

- Have you noticed that when kinetic energy increase, potential energy decrease? Good!
- What happens with mechanical energy?
- Thermal energy?
- Was there anything surprising?
- Is energy conserved in this simulation? Why?

2. Go to Friction

- In the top right corner select Bar Graph and Speed.
- Start the simulation.
- Observe changes in energy and in speed.
- Change friction.

Answer these questions:

- How does this affect motion, speed, and energy?
- Have you noticed that now we have thermal energy with friction? Good!

- What happens with mechanical energy?

Reflection questions:

- Was there anything surprising?
- Is energy conserved in this simulation? Why?
- Can we get rid of friction? Why?
- How can we reduce friction?

Come up with 2 examples of situations when force of friction is useful and 2 examples when it is harmful.

P.S.: This activity, developed for students taking a general education Physics college course, can be done as a group activity during class time, or it can be assigned for homework. It can also be used to facilitate discussion about the concepts.

7.

LABXCHANGE

Elena Chudaeva

Some Facts about LabXchange

1. LabXchange is a free resource for remote and hybrid learning from Harvard.
2. LabXchange is an online community for learning, sharing, and collaboration.
3. It is a community for educators, learners, and researchers.
4. It curates world-class digital content.
5. It allows instructors the ability to integrate research into their course materials.
6. This platform fosters communities of instructional practice.

Teacher Support

Check out Remote Learning with LabXchange, which has a clickable icon labelled "clusters". When clicking on each cluster, users are provided with a pathway which consists of a mix of resources such as videos, text, simulations, narratives (for example, stories from real scientists), and documents. These various resources help learners to gain mastery over specific topics. Clusters will help you quickly start learning and teaching online with LabXchange. These clusters can be cloned or adapted depending on your teaching needs. Additional suggestions related to the pathway for further learning are also provided.

LabXchange and Accessibility

LabXchange is building accessible digital content for online learning. LabXchange uses Hubble Studios, an eLearning company that develops custom online education content to build their interactive content. For more details on accessibility features of this resource, read the article Building Accessible Digital Content for Online Learning.

SAMPLE ACTIVITY

Phase Change

About Phase Change simulation:

Matter exists as solids, liquids and gases, and can change state between these. The model shows a liquid material on the left (small atoms). The amount of heat energy is shown by kinetic energy shading, with deeper shades of red representing more energetic atoms.

What to do:

On the right side of the barrier is a solid material (large atoms).

Run the model.

How much energy can penetrate the barrier?

Remove the barrier.

How quickly do the more energetic atoms melt the solid?

Reflection questions:

1. What have you learned about states of matter and their properties?
2. How does this simulation help you?
3. How do particles move in solids and liquids?
4. How does temperature affect particle motion?

8.

BEYOND LABZ SCIENCE VIRTUAL LABS

Elena Chudaeva

Why Beyond Labz?

Learning by doing

Experience
Open ended lab activities enable students to learn to think like a scientist

Effortless
Instructors and students can set up quickly and focus on the lab, not the mess!

Accessible
Labs you can use 24x7 at home and in the classroom

Levels
Secondary and University

Note. [Infographics]. Beyond Labz. https://www.beyondlabz.com/

Facts about Beyond Labz:

1. It is a digital simulation platform built upon actual experimental data and the most advanced models available.
2. Each lab supports hundreds of experiments.
3. Instructors can develop their own activities.
4. Beyond Labz is a paid vendor.

"We believe students should learn science by doing science."

— Beyond Labz

Watch Beyond Labz Youtube channel.
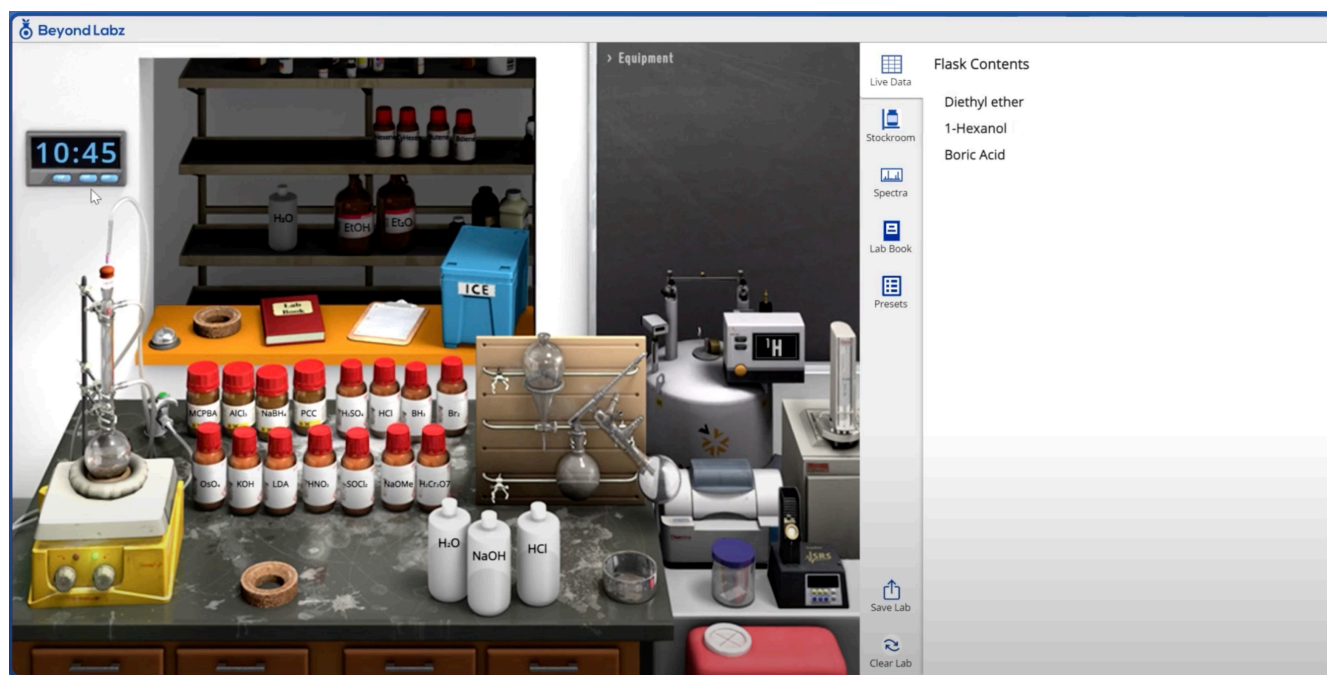
Note. [Image]. Beyond Labz Youtube. https://www.beyondlabz.com/

There are many advantages of using Beyond Labz. First of all, Beyond Labz has hundreds of preset lab activities. Secondly, it also provides the ability for instructors to create their own lab activities as you would do in a real wet lab. For example, with various lab equipment in front of you, there are millions of possibilities. It is also easy to meet the needs of your students and accommodate different levels of knowledge, skills, and interests. Beyond Labz is different in this sense from Labster. Labster has pre-designed activities with built-in questions and additional resources. It is worth exploring different online science simulations to see which resources meet one's teaching and learning needs. The best resources depend on the context.

Accessibility and Beyond Labz

This is a paid vendor, so we recommend making a request and reviewing the vendor's accessibility document before adopting the product. Each platform should have, at a minimum, a Voluntary Product Accessibility Template (VPAT) that describes the product accessibility support.

Note: If you are unfamiliar with how to interpret accessibility documentation, seek guidance from accessibility experts on your campus.

SAMPLE ACTIVITY

Cesium in Oil and Water Experiment

What to do:

- Go to "Density" lab.
- Click on the clipboard in the top right corner of the screen.
- Open preset list.
- Then choose "Cesium in Oil and Water" and click on it. All the equipment will be set up.

Purpose: To explore what happens when you drop cesium metal in oil and water.

Materials: Two graduated cylinders; olive oil, water, two cesium balls; timer; lab book.

Procedures:

1. Drop the ball in the 1st cylinder. Write down the time it takes to reach the bottom.
2. Drop the ball in the 2nd cylinder. Write down what happens.
3. Fill out the table below.
4. Click "Exit" to leave the lab.

Data Recording

Fill out the missing information:

	Cylinder (from left to right)	Liquid type	Liquid volume, ml	Time, seconds
1				
2				

Analysis

What have you observed?

Conclusion

Summarize your observations and explain using physics terms.

Check this Fluid Virtual Lab Activity.

For more ideas watch:

1. About Beyond Labz Virtual Labs.

2. Design of Science Virtual Labs and Student Support.

9.

ADDITIONAL RESOURCES

Elena Chudaeva

The following activities provide simulations of real-life processes and repeatable experiments which students can observe, explore, and learn from:

- NASA Climate Kids Games and other interactive activities on Weather&Climate, Water, Energy, Plants&Animals and more. [NewTab] https://climatekids.nasa.gov/menu/play/.
- BBC Bitesize: [NewTab] https://www.bbc.co.uk/bitesize/guides/zq7t4j6/test.
- Chemistry4kids. [NewTab] http://www.chem4kids.com/extras/quiz_matterstates/index.html.
- Physics4kids. [NewTab] http://www.physics4kids.com/.
- Biology4kids. [NewTab] http://www.biology4kids.com/.
- Geography4kids. [NewTab] http://www.geography4kids.com/
- Paid vendor of science virtual labs Labster. [NewTab] https://www.labster.com/.
- Gismos, World's largest library of math & science virtual labs and simulations. [NewTab] https://gizmos.explorelearning.com/.

Read more about:

- the benefits of interactive and active learning. [NewTab] https://teaching.cornell.edu/teaching-resources/engaging-students/active-learning.
- active learning. [NewTab] https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/developing-assignments/assignment-design/active-learning-activities.
- interactions in learning environments. [NewTab] https://open.merelearning.ca/ssi/chapter/interaction/.
- Community of Inquiry. [NewTab] https://coi.athabascau.ca/coi-model/.

Example of Interactive Science Activity created in h5p. [NewTab] https://youtu.be/VJZ4riSc0-U.
    EDUCAUSE Learning Initiative. 7 Things you should know about virtual labs. [NewTab] 7 Things You Should Know About Virtual Labs.

PART III
PART 3: GEOMEDIA

This part aims to assist teachers in becoming familiar with utilizing web-based user-friendly interactive-maps and digital documentaries to help foster active teaching and learning within the field of Geography and beyond. In order to do so, the first section defines and connects the studies of geomedia (such as georeferenced media) and ecocinema (such as environmental documentary) which together form engaging and educational geomedia projects. The second and third sections offer examples of practical open educational resources (OERs), which include interactive maps and environmental documentaries, as well as sample activities and guiding questions, that teachers can implement as presented or reference to help guide their own active teaching and learning goals.

Resources discussed in this part:
– Climate Central's Surging Seas: Risk Zone Map
– The Anthropocene Education Program

10.

WHAT IS GEOMEDIA?

Michael Long

This part defines geomedia projects and has been adapted from research in my book chapter, 'Geomedia as a Pedagogical Tool: Toward Sustainability Competence' in The Emerging Role of Geomedia in the Environmental Humanities (2022), published by Rowman and Littlefield. In that research, I explore how geomedia, which can refer to "interactive technologies using multimedia to present the spatial information in the form of digital maps and georeferenced photos, videos and texts" (Motivate and Attract Students to Science, 2021), can be paired with ecocinema, which can refer to educative and issue-based environmental documentaries (or 'eco-docs') and short digital documentaries, such as video essays found on YouTube, Vimeo and other platforms. The pairing of geomedia and ecocinema, here called geomedia projects, is the amalgamation of interactive and/or digital maps and eco-docs, which are particularly helpful pedagogical tools for engaging with geography subject matter.

One example of the merging of geomedia and eco-docs is the Geo-Doc created by Dr. Mark Terry. In his book, The Geo-Doc: Geomedia, Documentary Film, and Social Change (2020), Terry explores the potential of combining digital documentaries with geomedia in order to foster positive social change by high-level changemakers. In particular, Terry's Geo-Doc project, the Youth Climate Report (YCR), has been adopted by the United Nations and presented at numerous recent Conference of the Parties (COP) held yearly by the United Nations Framework Convention on Climate Change (UNFCCC).

The YCR is a Geographic Information Systems (GIS) map that contains georeferenced short documentaries, created by youth from around the world, about pressing environmental issues. One of the many benefits of the YCR is that the georeferenced digital documentaries help to bridge the communication gap between scientists and policymakers by presenting the information in digestible ways. Another benefit of the YCR is that the Geo-Doc can be used as a pedagogical tool because it offers a substantial database of issue-based information on topical subjects like climate change, permafrost, and sea-level rise, as well as providing opportunities for experiential education through creating and/or interacting with the interactive maps and documentaries.

The geomedia project resources offered in this OER, namely Climate Central's Surging Seas: Risk Zone Map and The Anthropocene Education Program, are the practical applications of my geomedia research, aimed towards active teaching and learning. Specifically, these geomedia projects can help to simultaneously teach issue-based topics (sea-level rise, and climate change) and soft skills (such as values thinking, futures thinking, and systems thinking) while also helping to achieve goals of experiential learning (through active

engagement) and Universal Design for Learning (through multiple means of engagement with learning materials).

References

Long, M. J. (2022). Geomedia as a Pedagogical Tool: Toward Sustainability Competence. In *The Emerging Role of Geomedia in the Environmental Humanities.* Edited by Terry, Mark Ph.D. and Michael Hewson, Ph.D., Rowman and Littlefield. https://rowman.com/ISBN/9781666913422/The-Emerging-Role-of-Geomedia-in-the-Environmental-Humanities

Motivate and Attract Students to Science, 'Geo-media' General Description. MASS. http://www.mass4education.eu/geo-media. Accessed November, 2023.

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Youth Climate Report. (2021). The United Nations Climate Change Secretariat. https://youthclimatereport.org/. Accessed November, 2021.

11.

CLIMATE CENTRAL'S SURGING SEAS: RISK ZONE MAP

Michael Long

About Climate Central's Surging Seas: Risk Zone Map

Surging Seas: Risk Zone Map is an interactive program by Climate Central (CC) which is an independent climate change research and communication organization that analyzes and shares facts about climate change with the public and policymakers in easily accessible ways. It does so by amalgamating science, data, and technology to tell stories through capturing visuals about climate change, sea-level rise, extreme weather, and energy. CC's Sea-Level Rise program provides current and projected data on sea-level rise and coastal flood hazards, across the globe, through user-friendly maps and tools.

The Surging Seas: Risk Zone Map series, in particular, were the first interactive online maps presenting sea-level and coastal flooding information, backed by peer-reviewed science, and the most recent iteration was featured by the White House Climate Data Initiative.

SAMPLE ACTIVITY

In 1938, British scientist, Guy Stewart Callendar, argued that the link between rising Carbon Dioxide (CO2) concentrations in the Atmosphere and a rise in global temperature would have other subsequent and varying changes on the Earth's climate patterns. Now, the vast majority of climate scientists (95-98%) know that recent climate changes are due to the burning of coal, oil and gas.

The effects include changes to existing weather events such as hurricanes, floods, droughts, wildfires, and more. However, in this activity, we will focus on the effects of climate change on the

world's oceans because they cover 70% of the Earth which means they take the large brunt of the change. In short, sea-level rise is an increase in the level of the planet's oceans because of global warming which contributes to a) added ocean water from melting glaciers and ice sheets, and b) the expansion of warming seawater. As the temperature of the atmosphere rises due to the burning of fossil fuels and the release of excess greenhouse gases (such as carbon dioxide) the oceans absorb this heat which causes the water molecules to expand.

Moreover, as the atmospheric temperature rises, land-ice (such as in Greenland and Antarctica) is also affected and melts into the oceans at an accelerated rate, which contributes to the amount of seawater. According to the National Oceanic and Atmospheric Administration (NOAA), the global mean sea-level rise has been approximately 8-9 inches since 1880. It is projected that sea levels are likely to rise even more in response to historic greenhouse gas emissions, which threatens low-lying island nations, global coastlines, freshwater supplies, and wildlife habitats from increased storm surges, flooding and damage to coastal areas.

Video Essays

Please watch the following Video Essays:

'This is what Sea Level Rise will do to Coastal Cities,' by The Verge Science (7 minutes)

'6 Major US cities could be underwater within 80 years — here are the disturbing 'after' images'by Business Insider (3 minutes)

Interactive Map

Instructions:

1) Open Climate Central's Surging Seas: Risk Zone Map .

2) Click the '-' minus button on the bottom-right of the screen to scroll outward and see more of Vancouver, British Columbia, Canada.

3) Click the double-arrow beside 'Water Level' on the bottom-left of the screen, then click 'Show Current Coast'.

4) Click the double-arrow again, and scroll through the various levels of sea rise (1 to 10 in feet) to learn how Vancouver may be impacted.

5) Use the search bar on the top-right of the screen to learn about sea level rise in locations of your choosing.

Supplemental Resources

Read, watch and listen to the following material:

- Reading Material – NOAA Climate.gov 'Climate Change: Global Sea Level'.
- Watching Material – The Verge Science 'Sea level rise is so much more than melting ice' (Video Essay, 6 minutes).
- Listening Material – NPR 'Why Scientists are Racing to Save Historical Sea Level Records'(Podcast, 12 minutes) .

Guiding Questions

1. Can you define Global Warming?
2. What is the connection between the Greenhouse Gas Effect and Global Warming?
3. Can you define Climate Change?
4. What is the difference between Climate Change and Global Warming?
5. Can you describe how Climate Change leads to Sea Level Rise?
6. How much Sea Level Rise has occurred and is projected to occur?
7. What are and will be the impacts of Sea Level Rise on people and health, infrastructure and economies, coastlines and environment, and weather events?

References

Climate Central. (2021). Surging Seas Risk Zone Map. https://ss2.climatecentral.org/#12/ 40.7297/-74.0072?show=satellite&projections=0-K14_RCP85-SLR&level=5&unit=feet&pois=hide. Accessed November, 2023.

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12.

THE ANTHROPOCENE EDUCATION PROGRAM

Michael Long

About The Anthropocene Education Program

The Anthropocene Education Program (AEP) is a joint effort between The Anthropocene Project (TAP) and the Royal Canadian Geographical Society (RCGS) that is available through Canadian Geographic Education. The AEP is an interactive tool for teaching the impact humans have on the planet and includes a documentary (Anthropocene: The Human Epoch 2019), short films, audio clips, augmented reality (AR), 360 virtual reality (VR), and interactive gigapixel photos. TAP was created by renowned documentarians Edward Burtynsky, Jennifer Baichwal, and Nick de Pencier (Manufactured Landscapes 2006, Watermark 2013) to provide engaging ways for learners to comprehend and connect with the scale of human-induced changes to the functioning of the planet.

SAMPLE ACTIVITY

The AEP is founded on the research conducted by the Anthropocene Working Group (AWG), which is a scientific committee that seeks to gather evidence and recommend whether the Anthropocene Epoch should replace the Holocene Epoch as the current time frame on the Geologic Time Scale. At the moment, the Anthropocene is under consideration as a new Epoch by leading geological and scientific institutions around the world. However, for this geologic time change to become official, there need to be indicators to track that change. As the AWG has discovered, there are not only individual indicators of this human impact, but there are entire categories of indicators including

Global Warming and Climate Change, Terraforming, Techno-Fossils, Anthroturbation, Extinction, and Extraction.

In this activity, we will learn about the history and science behind the Anthropocene Epoch, and the AWG and their 6 categories of anthropogenic harm to the planet. In doing so, we will also exemplify this harm by focusing on the category of Terraforming, which is the widespread transformation of the surface of the planet by human activity. Although there are numerous ways to access the AEP, such as on-loan classroom kits, we will utilize the free online resources. These materials include a 360 virtual reality video and interactive gigapixel photos taken by Edward Burtynsky that contain embedded visual triggers which reveal audio clips and short films about the particular category under study. When using geomedia projects in education, it is necessary to supplement the AEP's content with instruction and external materials in order to achieve the desired learning outcomes.

Documentary

Watch the documentary: 'Anthropocene: The Human Epoch' (87 minutes). You can access the film through your Kanopy account. If you are having trouble gaining access, please follow these instructions. We recommend that you watch the entire documentary, but please focus on the segment beginning at 12 minutes, titled 'Carrara, Italy.' If accessing Kanopy is not feasible, consider substituting the documentary for the video essay listed below in part 3.

360 Virtual Reality and Gigapixel Photo

Navigate through the interactive materials below, which are intended to provide an experiential account of one of the AWG categories. Although there are many AEP materials that elaborate on the various categories of harm outlined by the AWG, which you are free to explore (Techno-Fossils, Extinctions), please focus on the AWG category of Terraforming, in particular.

360 VR Film Instructions:

1) Open the attached link;

2) Play the video (8 minutes), and use your mouse to scroll around the screen.

Note: If you do not have sound, click and unclick the volume icon.

Gigapixel Photo Instructions:

1) Open the attached link;

2) Locate all 9 triggers that are embedded into the photo, and watch, listen or read the information found in each trigger.

Note: There is a 'Hint' button in the menu at the top left of your screen to help locate triggers.

Supplemental Resources

Read, watch, and listen to the following material:

- Reading Material – CNN 'Has humans' impact brought about a new era for the Earth?'.
- Watching Material – It's Okay To Be Smart '100,000,000 Years From Now' (Video Essay, 6 minutes) .
- Listening Material – The Guardian's Audio Long Read 'The Anthropocene Epoch' (Podcast, 39 minutes).

Guiding Questions

1. What is the Geologic Time Scale?
2. What are the time frame and key characteristics of the Holocene Epoch?
3. What are the time frame and key characteristics of the Anthropocene Epoch?
4. What is the Anthropocene Working Group (AWG)?
5. What are the 6 categories of anthropogenic harm to the planet outlined by the AWG?

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PART IV

PART 4: NI MULTISIM SOFTWARE AND NI MYDAQ

This section will introduce resources for Electronic and Electrical Fundamental courses at the secondary and post-secondary level. Introducing students to Multisim and the myDAQ also introduces and familiarizes students with the NI product ecosystem which can be leveraged for ever increasing levels of complexity for upper year undergraduate and graduate use in courses focused on control systems and instrumentation. It will also explain the Instructional Strategy Decision Framework and how it may be used to design learning activities.

Resources discussed in this part:

-NI Multisim

-myDAQ

13.

WHY SIMULATION?

Alexander McGlashan

When faced with constructing and measuring an electrical circuit for the first time, students are often (legitimately) afraid of touching anything out of fear of electrocution. Simulation allows students to experiment with the concepts of electricity without concern for the risks. For example, a student can indeed "blow" a component in the simulation, but because the component is virtual there is no harm done and the student can learn from the mistake without the stress that normally comes with "smoking" parts in the lab.

Additionally, a benefit of Simulation and the learner centric paradigm is that students are freed from the limitations of lab time. For example, they may only have two or three hours of access to a lab per week with equipment that allows them to perform "real" experimentation. With Simulation, however, students can be located anywhere and perform labs and practice their skills as long as they have a computer or a tablet.

During the real (minimized risk) phase of the lesson, much of the experimentation is done in a manner that is indistinguishable from the pure (totally on a computer screen) simulation. In fact, the instrument control panels (which are displayed on the computer screen) are the same as in real wet labs. The difference lies in the fact that the student must now build the circuit with physical components. The device, which connects to the circuit, minimizes any risk to both the student and the circuit should the student make an error. As a result, the student can experiment and practice their skills with the comfort of knowing that they are unlikely to damage anything or themselves. The device used for this phase can be plugged into any computer, and as a result, the student can perform these activities anywhere and at any time as long as they have with a computer and the device.

The previous phase bridges the pure (totally on a computer screen) simulation experience with the true lab experience. As a result, when students finally begin to experiment in a "real" lab, they have already developed not only a level of comfort with electricity, but also their skills to manipulate and measure it.

Constraints

This instructional strategy depends on students having access to a computer with the required simulation software and a device known as a "DAQ" which provides a smooth progression between a purely virtual simulation and a real experience. Whereas in a lab environment where the equipment can be shared among a large user base, this strategy is most effective if every student has access to their own personal copy of

the software and their own "DAQ" allowing them to perform the experimentation according to their own schedule. The current cost per student is approximately $200 (March 2014).

Students will have an additional learning curve associated with the introduction of a new software tool. There is always the danger of students spending too much time and effort focusing on the technology being used to facilitate the simulated experience rather than on the desired outcomes.

Preparation

Prior to the lesson proposed here, students must be properly familiarized with the simulation software. Additionally, it is important to frame the experience for the student to bring relevance to the activity and explain how the activity will develop their skills for real world applications.

Teachers or facilitators should mentally prepare their students for the reality that the circuit or simulation may not operate as expected. In fact, it is unlikely to operate correctly the first time. It is important for students to know that these issues are common and that a great deal can be learnt about circuit dynamics while troubleshooting a malfunctioning circuit.

14.

INSTRUCTIONAL STRATEGY DECISION FRAMEWORK

Alexander McGlashan

This lesson facilitates the development of skills which allow students to perform basic electrical measurements within the context of a technical fundamentals course found in many Engineering Technology programs. In this lesson students cycle through a series of activities progressing through simulated, real (minimized risk), and real environments.

- "simulated" refers to activities that are virtual or exist in a purely computer-mediated environment

Simulating a Basic Circuit Using NI Multisim
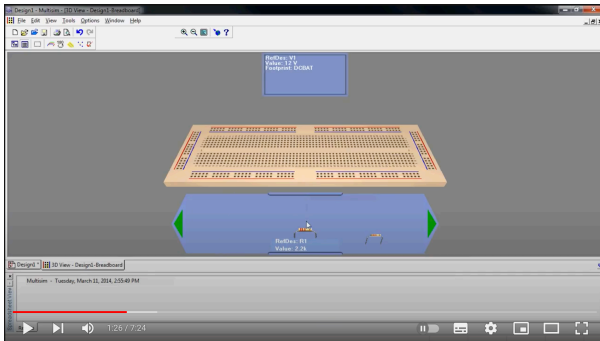
Click on the image to watch a video showing a simulating a basic circuit using NI multisim.

- "real (minimized risk)" refers to activities that are computer-mediated, yet replicate real measurements (via a physical device plugged into the computer) within a controlled environment; a hybrid or bridge between simulated and real

Transitioning Between a Simulated MyDAQ to a Real One
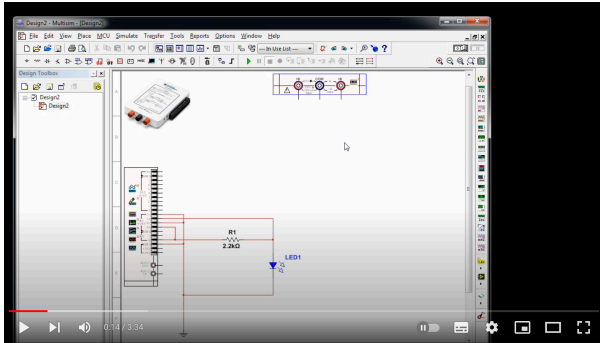
Click on the image to watch a video showing a transition between a simulated MyDAQ to a real one.

- "real" environment refers to activities carried out in a true lab environment only (no computer mediation)

Traditional, Physical Test Instrumentation

15.

USING NI (FORMALLY NATIONAL INSTRUMENTS) MULTISIM SOFTWARE AND NI MYDAQ MODULE

Alexander McGlashan

About NI Multisim Software and NI myDAQ

What is NI Multisim?

Multisim provides simulations of analog and digital circuits with the added benefit that the instrumentation used in the software can also be used in the analysis of real-world circuits.

What is NI myDAQ?

The myDAQ is a data acquisition module capable of emulating typical pieces of electronic test instrumentation such as a multimeter, signal generator, oscilloscope, and logic analyzer. The myDAQ can be used in direct combination with NI Multisim, and as a stand-alone test instrument.

These resources can be used in Electronic and Electrical Fundamental courses at the secondary and post-secondary level.

Introducing students to Multisim and the myDAQ also introduces and familiarizes students with the NI product ecosystem which can be leveraged for ever increasing levels of complexity for upper year undergraduate and graduate use in courses focused on control systems and instrumentation.

The combination of NI Multisim and the NI myDAQ were used for many years as part of the Niagara College Photonics program in a 'flipped lab' configuration that provided students with the flexibility of working from home using virtual instruments and an iterative process of 'demonstrate, simulate, and fabricate'. An advantage of virtual instrumentation (VIs) is that VIs connected to simulated circuits operate in an identical fashion as VIs connected to real circuits.

Challenges

In the early 2000's, the business model heavily supported undergraduate academic outreach. With the transition of National Instruments to 'NI' the broader public appears to have shifted its focus away from undergraduate markets. The cost of software and hardware (specifically the NI myDAQ) for academic

purposes has increased in recent years, yet there have been no updated improvements to the hardware. Unfortunately, many sponsored web resources appear to have been orphaned in the last few years, but there is still a strong community of users and academics using the myDAQ (and its more powerful and expensive sibling the myRIO).

There are competing technologies at a similar price point (although lacking integration with NI Multisim or LabView) such as Digilent's Digital Discovery Module which enjoys widespread use. A relatively new player to the field is the Espotek Labrador which is entirely open source (hardware and software) and extremely inexpensive. Not surprising given the difference in price point, the software is not nearly as powerful as the other two examples, but perhaps in time as more users adopt it, that may change.

Check out: Instructional Strategy Decision Framework using NI Resources.

Read: A Complete Facilitation Guide that can be lifted from a series of posts by clicking on the top menu titled Simulation in Action – A Lesson Outline to navigate the facilitators guide.

SAMPLE ACTIVITY

Lab #1

Learning objective

Build a simple circuit on a solderless breadboard and familiarize yourself with basic electrical measurements using the NI myDAQ.

Skills

Build a simple circuit on a solderless breadboard using a resistor and Light Emitting Diode (LED) which is powered using the myDAQ

Lab #2
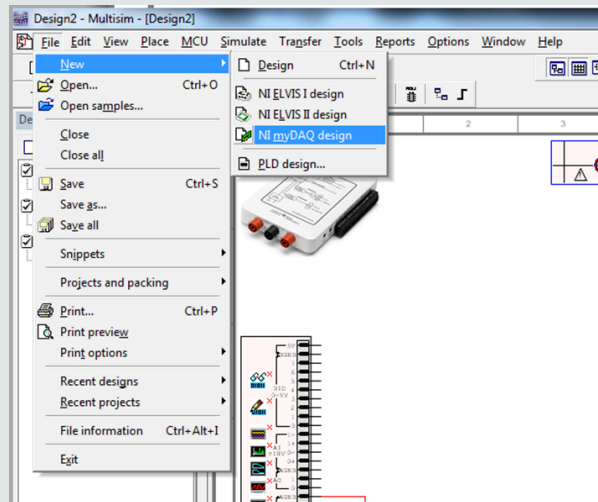
Learning Objective

Measure resistance through an electrical simulation and experimentally using the NI myDAQ.

Lab #3

Learning Objectives

- Use NI Multisim to simulate measurements of voltage and current.
- Use the NI myDAQ to measure the voltage and current in simple circuits.

Check full versions of these labs for details:

Connecting your First Circuit.

Measuring Resistance.

Measuring Voltage and Current.

Additional Resources

Check out the additional labs .

PART V
PART 5: DATA USE IN ENVIRONMENTAL SCIENCE

Authentic activities that foster progressive mastery of the topic, cognitive development and enhancement of research and investigative skills are critical in engaging learners in STEM. When we say authentic activities, we mean relevant, current, based on real-life examples, and real-time data. The following two resources ("NOAA Data in the Classroom" and "VirtualUrchin") provide opportunities for such engagement within Environmental Sciences and more specifically related to environmental issues. These resources are versatile. They are customizable to suit the needs of the course, the desired learning objectives, and various skill levels. These resources can be easily adapted for use in fully online (asynchronous), hybrid, and in-class modes of course delivery.

Resources discussed in this part:

-NOAA Data in the Classroom

-VirtualUrchin

16.

NOAA DATA IN THE CLASSROOM

Marta Wolniewicz

About NOAA Data in the Classroom

NOAA Data in the Classroom provides a set of easy-to-use interactive activities, supported with real-time scientific data visualizations and tools that simulate the process of authentic scientific investigation in order to explore current environmental issues (NOAA, 2021). Each of the five themed topics (and activities within) can be used independently and in combination with other resources to meet and support learners' development, as well as course objectives and outcomes.

Why use NOAA's Data in the Classroom?

There are multiple benefits to utilizing this resource in STEM.

1. The NOAA Data in the Classroom integrates engaging, science-driven, and easy-to-use activities that allow learners to analyze real-time data from various planetary systems (terrestrial, atmospheric, aquatic) and then discuss findings to better understand and address current environmental problems. Each of the topics (or modules) includes a set of resources such as Teacher's Guide and "Student Activity Sheets" (described in more detail here) to accommodate the needs of the learning activities and the course.

2. One of the great benefits of this resource is its integrated scaffolding of each topic (module) of interest into five steps of increasing level of learning complexity and cognition (for more information, please see the section on Pedagogical Approach on the NOAA website). The first two steps are teacher-driven, while the latter 3 provide opportunity for learner-driven inquiry. This 5-step-structure not only enhances opportunity for topic mastery, but also increases learner's competency in being self-directed.

3. In addition, this scaffolded approach mimics an authentic process of scientific investigation. By integrating scientific questions, real-life data, and sequenced problem-solving challenges, learners practice and develop the critical skill of scientific inquiry.

4. Finally, the resource is designed in accordance with the principles of Universal Design for Learning (UDL). In addition to fostering development of independent learners, Data in the Classroom

activities use multiple means of representation. The content is presented in various modes to support learning (text, videos, data visualizations such as maps, graphs, and interactive activities).

SAMPLE ACTIVITY

Coral Bleaching

A sample activity where the "Coral Bleaching" module of NOAA Data in the Classroom is used, in combination with other resources, to assess one of the current threats to coral reef ecosystems and to examine humanity's role in the fate of reefs in the future.

Introduction

Coral reefs are some of the most biodiverse ecosystems on this planet and thanks to this role have been dubbed the "rainforest of the sea" (NOAA, 2019). In addition to providing shelter for many marine organisms, coral reefs offer coastal protection, job and recreational opportunities, and food for a large proportion of humans (NOAA, 2019). However, coral reefs face many threats because of human activities. In turn, these threats undermine the ecological services that reefs provide. Thus, protecting the well-being of coral reefs is vital to not only maintaining the stability of these marine ecosystems, but also to the benefits that humanity draws from healthy coral reefs.

Objectives

In this activity, you will explore the importance, as well as the biology and ecology, of reef corals. You will examine the role thermal stress has on coral bleaching, by determining how bleaching is measured and monitored. You will examine how different species respond to bleaching and consider the significance of this variation for conservation purposes. You will apply what you have learned to determine the well-being of reefs in the Florida Keys. Finally, you will forecast the fate of reef corals based on future temperature projections and recommend conservation strategies to protect reef corals and thus preserve the valuable services these ecosystems provide.

What to do:

Step 1: Background information on the importance of coral reefs.

- To learn more about the ecological and human significance of coral reefs see NOAA's Ocean Today – "The Coral and the Algae".

Step 2: Coral biology and ecology. Knowledge of reef biology and ecology is critical in understanding why reefs may experience stress due to changes in their physical environment (e.g., heat exposure) that are outside of the normal temperature range that results in bleaching.

- Please watch NOAA's Ocean Today "The Coral and the Algae" to learn about the animals of coral reefs, how corals gain most of their energy for survival thanks to a symbiotic relationship with algae, and why the corals experience bleaching. A descriptive format (supported with images) to illustrate the process of bleaching is also available in LEVEL 3, "Background" section, of NOAA Data in the Classroom "Investigating Coral Bleaching Using Data in the Classroom".
- To better understand reef ecology, its geographic range and ideal habitat requirements such as depth and sea surface temperature, click on and complete all activities in NOAA Data in the Classroom, LEVEL 1, "Investigating Coral Bleaching Using Data in the Classroom".

Step 3: Measuring heat stress and reef sensitivity to estimate severity of coral bleaching events.

- To learn about the temperature threshold that causes bleaching, to determine how heat stress is measured from sea surface temperature data and used to estimate bleaching severity, please complete all activities in LEVEL 2 of the "Investigating Coral Bleaching Using Data in the Classroom". Please note that the last activity in this module is a video that features multiple threats that coral reefs are facing. This video is also available via NOAA's Ocean Today: "Corals Under Threat". This video will be helpful when evaluating conservation options for reefs.
- Heat stress impacts different coral species in various ways. To determine how reef corals vary in their sensitivity and response to bleaching events analyze Figure 2 from a research paper by Hughes, T.P., et al. (2017). This activity will provide some insight into potential conservation options for reef corals.
- In addition to loss of color, a characteristic effect of coral bleaching, other changes to reef ecosystems occur because of thermal stress. In LEVEL 3 of NOAA's Data in the Classroom scroll down to the section on "Identifying the Effect of Bleaching on Coral Reefs". Use the images of 4 geographic regions to identify characteristics of healthy and unhealthy reefs by examining the visuals before and after bleaching, respectively.
- Apply this knowledge of reef characteristics to determine the quality of reefs at Cheeka Rocks, Florida; Cozumel, Mexico; Goff's Caye, Belize and Batu Rufus, Raja Ampat, Indonesia via "virtually swimming" at the sites. This activity is the last in the LEVEL 3 NOAA's Data in the classroom (i.e., optional: Surveying Coral Reefs).

Step 4: Apply what you have learned to analyze the bleaching event in the Florida Keys (by

completing LEVEL 4 in NOAA's Data in the Classroom). Use the student worksheet for LEVEL 4 to support the completion of this exercise.

Step 5: Assess the fate of reef corals given the temperature projections from the Intergovernmental Panel on Climate Change's (IPCC) most recent report (IPCC, 2021) and your knowledge about heat stress threshold. For this activity a range of temperature projections (based on various carbon dioxide emission scenarios associated with different levels of human activity, see Figure SPM.8 in Summary for Policymakers) are used. Discuss what the likely impact is on coral reefs based on the projected temperature for each scenario by 2050.

Reflection

In Steps 1 through 5 you have learned about

- the role of coral reefs,
- their biology,
- ecology, and
- the stresses these ecosystems experience because of continued human activities.

You also learned how different pathways humanity chooses to take in the future would either reduce or increase the stress on natural environments. As a global citizen and a beneficiary of ecosystem services that coral reefs provide, decide on the pathway that we should take to preserve coral reef ecosystems. Propose strategies that would help humanity achieve this pathway and, in the process, maintain the health and increase the resilience of coral reefs.

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17.

VIRTUALURCHIN

Marta Wolniewicz

About VirtualUrchin

The "VirtualUrchin" (University of Washington, 2020) and "Sea Urchins for educators", two support sites with full sets of resources for in-class labs and activities, may be used in combination to explore concepts in biology, ecology, and issues in environmental science. Both sites include additional resources and links to support teaching and learning in STEM.

Why use VirtualUrchin?

1. Virtual Urchin offers flexibility as it utilizes various modes of delivery that can be used in a range of courses to support different learning outcomes. Thanks to a variety of freely available, online interactive tools, the educator may choose to use activities ranging from microscope basics, basic biology, development, embryology, ecology, and environment to facilitate learning.
2. These virtual activities (both computer and mobile compatible) engage learners as they mimic "real-life lab experiences" that can act as an alternate to, or preparation for hands-on lab experiences. The virtual tools may also offer the first exposure of various lab equipment to students and thus provide an opportunity for learners to become familiar with valuable lab skills and procedures. For example, microscope interactive tutorials allow learners a low stakes approach to become confident users and handlers of a microscope, which is a vital lab tool.
3. This website includes additional resources and links to support teaching and learning. For example, the teacher resources include descriptions of activities, lesson plans, and links to the most recent research on various topics of interest.
4. These learning activities are structured to scaffold learning and may include background information to help learners familiarize themselves with a topic or an issue (i. e., "our acidifying ocean" module, described in the sample activity below), a virtual lab experiment (set up with clear objectives, procedures, and a glossary), data analysis with clear step-by step instructions, discussion of implications, and proposed solutions to environmental issues.
5. Many activities also offer opportunities for extended learning (i. e., visit sections labeled "dig deeper", "hands-on activities", "the great unknown", and/or links to research publications) to increase the scope

of understanding of the topic.

SAMPLE ACTIVITY

Our Acidifying Ocean

Introduction

According to Ritchie and Rose (2020), in 2019 humans emitted 36 billion tons of carbon dioxide into the atmosphere (emissions that were 3,600 times higher than the pre-industrial levels, cf. 1750). Human emissions of carbon dioxide, and other greenhouse gases, are a primary driver of climate change (IPCC, 2013). However, carbon dioxide emissions are also responsible for another problem – change in ocean chemistry. As the ocean absorbs approximately 30% of carbon dioxide from the atmosphere, a series of chemical reactions leads to ocean acidification (NOAA, 2020). These chemical changes in marine ecosystems have long-term implications on the organisms that live in the ocean particularly those that build their skeletons or shells from calcium carbonate (NOAA, 2020).

Objectives

In this activity, you will examine how our actions lead to ocean acidification and analyze the impact these chemical changes have on living organisms. This will help you design a plan to reduce humanity's impact on the ocean.

What to do:

Step 1: Ocean acidification and vulnerability of organisms.

- Access Virtual Urchin – Our acidifying ocean and click on "Learn", Part 1, of the activity. In this activity you'll learn about

1) what ocean acidification is;

2) how human activities contribute to changes in ocean chemistry;

3) examine the organisms that are vulnerable to those changes.

This activity will prepare you to complete a virtual experiment designed to determine the impact of ocean acidification on a marine organism susceptible to chemical changes.

Step 2: Run the experiment.

- In the virtual experiment, you will test the development of urchin larvae under normal and acidified conditions. To complete the experiment, follow the step-by-step procedure included in the lab. The experiment can be accessed via "Experiment" (Part 2) of the Virtual Urchin – Our acidifying ocean or by clicking "Enter Lab" on Page 4 of "How to" in the last section of the "Learn" module.

Step 3: Analyze the data from the virtual experiment (Step 2) to determine the impact that ocean acidification has on larval development of sea urchins and its associated ecological implications.

- Click on Part 3 "Analyze", to:

1) measure the length of sea urchin larvae for each treatment (representing acidified and normal chemical conditions of the ocean);

2) calculate larval length averages for each condition;

3) compare the results.

Draw conclusions about how changes in ocean chemistry affect ocean organisms directly (i.e., the size, shape, and thus survival of sea urchin larvae) and indirectly (via changes in food webs, for organisms that depend on the urchin larvae for their survival).

Reflection

In Steps 1 through 3 you have learned that human actions on land can alter ocean chemistry. In turn, these chemical changes carry a broader ecological burden by affecting the stability of marine food webs with cascading effects on larger ecosystem functions.

Discuss the need for action that ensures the stability of the ocean's life-sustaining ecosystem.

Propose strategies to reduce the impact each of us has, as global citizens, on the marine environment.

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PART VI
PART 6: H5P IN EDUCATION

H5P [NewTab] (HTML5 Package) is an interactive tool that allows for the creation and sharing of interactive material. Such material includes videos and presentations, various forms of quizzes, charts and simple games. When H5P is accessed, it offers a wide range of 'content types'. When used, these 'content types' can be shared with other users as well as with students.

Because H5P is flexible (contains diverse 'content types') and is compatible with several Learning Management Systems, it is an ideal piece of software. It accommodates a variety of learning preferences as well as different modes of course presentations.

For more ideas check H5P Studio eCampus Ontario [NewTab]: one stop shop to create, share, and discover interactive learning objects. eCampusOntario H5P Studio is provided as part of our set of Open Publishing tools.

Types of H5P content discussed in this part:
– Fill in the Blanks
– Branching Scenario
– Combination of several content types

18.

EXAMPLES OF H5P INTERACTIVE ACTIVITIES

Howard Gerhard

Here is an example of student interactivity using H5P. It illustrates principles that are effective in helping students navigate unfamiliar areas of a course. The principles illustrated are:

- An Anticipation Guide.
- Scaffolding.
- Formative assessment.
- Using a game, a fun way to measure students' understanding of course content in preparation for an exam, a reading or further lectures.

Scaffolding

There are many aspects to 'scaffolding' in education (Stanier, 2015). Generally, it refers to a gradual introduction of material with numerous supports which are removed only when the student has demonstrated mastery of the content. One specific strategy that can be used in scaffolding is linking new learning with prior learning. What the student already has in their head can be used as an anchor to which new ideas and concepts can be attached.

We've all eaten, or turned up our noses and refused to eat, the foods in the H5P fill-in-the-blanks exercise 'Selective Breeding:'[NewTab]

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://ecampusontario.pressbooks.pub/engagingstem/?p=1007*

My purpose in including this exercise was twofold: first to introduce the idea of selective breeding which has been practiced since the beginning of the domestication of plants and animals to suit human needs by showing

the evolution of familiar fruits and vegetables; and secondly to introduce the idea of genetically modified foods which in essence is a continuation of selective breeding but with a vengeance. How does it differ in method and intention?

Formative Assessment

Have students grasped the underlying concepts that generated the First Industrial Revolution, and are they now prepared to move on to greater amounts and more specific detail?

Formative assessments test the readiness of students to move on by testing their current knowledge (Thomas, 2019). In this H5P game, I've tried to gauge how much of the lectures and readings students have incorporated into their understanding of the 18th century, British Industrial Revolution.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://ecampusontario.pressbooks.pub/engagingstem/?p=1007

Games in Education

The idea that games can be effectively used in educating young people goes at least as far back as Plato:

"No compulsory learning can remain in the soul…. In teaching children, train them by a kind of game, and you will be able to see more clearly the natural bent of each" (Plato, The Republic, Book VII).

The idea of using a game as a pedagogical tool in teaching a History of Technology course presents us with both advantages and challenges. The advantages seem obvious. Stories, plots and characters are provided by historical events themselves. To enhance student curiosity into the development of technology, instead of this multiple-choice quiz on the First Industrial Revolution, I might have chosen Captain Cook's journeys of exploration using Harrison's newly invented chronometer, Edward III and the use of early canon during the Hundred Years' War or the spread of technology along the 14th century Silk Road, to mention but a tiny sample. The possibilities are endless.

However, there is some suspicion among the general public and many educators as well, that video games

can have a negative effect on those playing them. The fear is that video games can be addictive, can contribute to a growth in a violent culture or reinforce gender and racial stereotypes. These concerns are not usually supported by statistical or researched evidence but persist nonetheless. Compare these fears with the much-publicized concerns that permeated the media regarding television a generation ago.

Since their introduction in the 1970's, video games have only grown in popularity as a pastime and as computers. The Internet made its appearance in education in the beginning of the 1980's. Games then have inserted themselves into the grab-bag of tools that the educator has come to rely on. This, despite the fact that post-secondary education today is still founded on a written culture where the written and read word constitute the basis for the transfer and exchange of ideas and information.

According to an EDUCAUSE's article 7 Things you Should Know About Game Based Learning, [NewTab] "gaming can create a dynamic that can inspire learners to develop skills and competencies as they focus on the activities of the game. Games, both analog and digital, can immerse players in other worlds and give them experiences that help them see their own worlds in new ways. Play, structured or otherwise, can create opportunities to reflect, grow, and learn."

Additional Resources

EDUCAUSE Learning Initiative:

7 Things You Should Read About Gamification/Game Principles in Instruction. [NewTab]

7 Things You Should Know About Games and Learning. [NewTab]

Simulations, Games, and Learning. [NewTab]

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ACKNOWLEDGEMENTS

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Marta Wolniewicz

Marta Wolniewicz is a professor in the School of Liberal Arts and Sciences (LAS) at George Brown College (GBC). Marta teaches a variety of natural science courses and is currently co-developing a fully asynchronous course on Science of Sustainability. Marta earned a Master of Science degree (Geography and Environmental Science) at the University of Western Ontario with a focus on freshwater and forest management. She earned a Ph.D. at Trent University in Environment and Life Sciences and subsequently held a post-doctoral fellowship there which led to multiple projects in support of pollution control policy initiatives. Marta's commitment to life-long learning and to enhancing students' educational experiences are evident in her pedagogical strategies and her engagement with the teaching and learning process. During her career at GBC, Marta served as Universal Design for Learning champion and the Science faculty representative on an Academic Excellence and Centre for Preparatory and Liberal Studies partnership project, "Building Capacity to Measure Essential Employability Skills."

Howard Gerhard

Howard Gerhard has been at George Brown College since 1969 initially teaching ESL and then Academic Upgrading. On behalf of the College, he has taught at locations as far-flung as Seattle, Washington and London, England. Currently he teaches General Education courses in the School of Liberal Arts and Sciences focused specifically on the History of Technology. Throughout his career he has been interested in the role that technology plays in education and has done research in educational technology by developing such teaching aids as video games and virtual reality.

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