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Enhancing STEM Education for the Online Environment

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Abstract

Innovative strategies for communicating science are necessary in the current global environment where many institutions are seeing an increased need to address educational needs through online platforms. Traditionally, many skills within STEM disciplines have been reinforced using a hands-on, applied approach in the laboratory setting. Recent worldwide events forcing many in STEM fields to transition to online environments present an opportunity to take advantage of rich data sets and available online tools to enhance learning and scientific curriculum. Strategies and best practices are emphasized here to assist science educators with the transition to the hybrid, blended, or virtual classroom and aid in the preparation of science teachers who must be ready to teach in a multitude of platforms [1, 2]. Several examples within the biological sciences are used to contrast a more traditional approach with virtual counterparts to demonstrate how these resources can improve learning and cognition.

Keywords: STEM, Science Education, Applied Learning, Innovative Strategies

1. Introduction

Recent worldwide events continue to challenge the existing paradigm of the face-to-face lecture modality of education, but this transition can be considered a pivotal opportunity to embrace existing and emerging technologies capable of ushering in innovative ways of communicating knowledge. Quality STEM education has been recognized as critical to economic growth and security [3]. Rapid growth in the nature and scope of online learning continues to strengthen the focus of flexible and virtual learning platforms. Asynchronous, synchronous contact and hybrid models are being utilized to facilitate teaching and learning in the STEM fields, and can be tailored to the learning styles of individual students. Flexible models for online academic courses allow educators to become decision makers, participating in the curriculum and delivery of their courses. These educators are incorporating a multiplicity of creative learning resources tailored to the interest and academic needs of their students. Numerous tools are available to assist educators in integrating scientific curriculum into the online environment. These can be software driven and include apps and programs, data driven to include integration of available data sets for real world application of conceptual ideas, and coordinated networks to encourage the sharing of ideas, tools, and data sets. Below we will expand on the incorporation of these tools within STEM disciplines, with particular examples from the biological field.

Many educators have exhibited a reluctance to transition to online platforms because they believe they do not offer the same effectiveness at teaching learning outcomes as the face-to-face model [4]. When we compare the two modalities, the main differences exist in the areas of learning activities and communication, so we will emphasize ways that instructors can take advantage of the online interface to deliver a broader range of content and more effectively communicate with their student audience. While the majority of the strategies and best practices suggested in this paper can be applied to a variety of subjects within the STEM disciplines, this paper will outline the options for science educators to expand their knowledge of software and data driven strategies to enhance learning and communication. Examples in learning resource collections and coordinated educator networks are shared to promote exploration of available content sources in online settings.

2. Software Driven Strategies

Science education has already experienced a reformation in the mid-19th century with a shift away from the traditions of memorization and recitation and towards the applied nature of these disciplines with the emergence of labs [5]. With recent limitations to face-to-face communication, the STEM fields are experiencing another challenge to standard practice and are improvising the marriage of hands-on practice with technological advances. Particular attention must be devoted to collaboration among

virtual lab partners generating innovative web learning activities that can be shared and strengthened through synergistic lab activities.

The modern era of a pocket-sized personal computer has ushered in a new generation of students self-trained in the art of independent, self-directed learning. Students of the modern era demonstrate an enthusiasm and adeptness in their flexibility to adapt to emerging technological tools. As educators, it is our responsibility to meet that willingness with a revision to our own standard operating procedures taking into account the advantages and best practices for engaging students through independent learning strategies.

First, we can and should consider utilizing a primary textbook that incorporates an online learning component, particularly if it is appropriate for the proposed subject. In the biological sciences, Mastering (Pearson), Achieve (Macmillan Learning), or Connect (McGraw-Hill) platforms are used by publishers to provide learners with access to an e-text and electronic note-taking options. These paired options can allow students to study at their own pace, and often include dynamic modules that adapt to student performance. These tools help students to direct their studying towards areas of weakness. These platforms also offer reporting options for educators, so they can assess learner performance and detect areas where there are breaks in knowledge transmission.

Electronic mobile applications (apps) that allow users access to computer software on mobile devices such as phones, tablets, or watches also show incredible promise for allowing educators to bridge the virtual distance and share additional content with relative ease. Websites can also be critical for facilitating the dissemination of course material or data. There are many websites with associated apps geared toward sharing tutoring videos in different subject areas. Examples include Kahn Academy and Crashcourse. Websites like Go-lab (golabz.eu) have made an effort to make available laboratory projects for STEM disciplines [5]. Some particularly useful applications in the biological sciences include Seek, an application that pairs with the website iNaturalist and encourages students to identify and document different organisms. There is a plethora of organismal-specific applications that can be very helpful for students learning taxonomy and identification and include apps like iBird, Merlin Bird ID, and Audubon for birds, Roger'sMushrooms for fungi, Leafsnap and Floraquest for plants to name a few. Laboratory applications, like Frog Dissection and Anatomy, can be incredibly helpful for virtual anatomical dissections.

In addition to what to study, virtual technologies can also be used to better communicate information about how to study. Examples include Crashcourse that has a whole series of videos devoted to providing student study skills. Flashcard applications can be used to assist with memory recall and some of these have downloadable decks that students can use for desired content. Applications like Evernote or OneNote can be used to assist and organize electronic notes.

3. Data Driven Strategies

With the emergence of a global sharing of data comes an incredible opportunity to teach our students how to use this data to ask questions and obtain real answers. In the Biological Sciences, there are many opportunities for real-world data to be mined from online sources to support research and laboratory activities. Examples in the genetic world include sources like the National Center for Biotechnology Information (NCBI), a clearing house for genetic repository data such as PubMed, Gene, BLAST, Nucleotide. In the life sciences, there has been a recent push to immortalize existing natural history collections at natural history museums, zoos, botanical gardens, universities, and herbaria through digitization. This effort is providing a rich source of electronic data for students to explore and analyse in class projects and research. Gapminder and data.gov provide massive data sets on everything from weather to demographics for students to explore and analyse.

4. Coordinated Educator Networks

Educator Networks are designed to facilitate collaborative and mentoring relationships among educators. Faculty mentoring networks have been created to assist educators with the implementation of specific teaching practices with a targeted goal. Examples include the Ecological Research as Education Network (EREN), a community of researchers from across the globe that brings together individuals at different institutions for a coordinated research effort in undergraduate research institutions. Often, these colleges do not have an abundance of research facilities or funding and this collaboration allows for individual faculty to pool resources in order to promote research activities

among their undergraduates. Quantitative Undergraduate Biology Education and Synthesis (QUBES) is a network of individuals and organizations committed to accelerating STEM education reform with an emphasis on teaching quantitative skills. The Network for Integrating Bioinformatics into Life Science Education (NIBLSE) is another amazing resource maintaining and developing learning resource collections to share resources, lessons, activities, labs, applications or modified versions of existing lessons and labs. Many of these networks exist to bridge gaps and encourage educator connections to help with the challenges of changes in education today.

5. Conclusion

The above examples in the biological sciences serve to raise awareness and support innovative strategies for meeting the needs of learners in our evolving global environment. Collaborative, interactive technology will engage students in the biological sciences providing a wealth of innovative experiences to challenge them and strengthen investigative and critical thinking skills. As science educators gain insights into available online tools and updated approaches to teaching, they will experience further reformation shifting away from traditional methods. Technological advances and state-of-the-art software coupled with well-designed mobile apps have the potential to strengthen collaboration and shared knowledge, enabling the incorporation of adaptive and dynamic learning tools. These accomplishments allow educators to challenge students to high ideals and motivate them to gain the knowledge and skills that they need to meet the challenges of our transitioning global environment. In response to the emergence and rapid growth of virtual learning platforms, there have been significant advances in curriculum development incorporating technology and enhancing STEM education in the online environment. Recommendations for future research focus on the ongoing development of online platforms incorporating engaging activities in the biological sciences and other STEM fields to improve coordinated learning resources and curriculum in the virtual classroom. By emphasizing collaboration and strengthening networks, the options for science educators to expand their knowledge and positively impact student learning are substantial and will provide powerful benefits to online instruction in the biological sciences as well as other STEM disciplines.

6. References

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