Preparing the Next Generation of Sustainable Agriculturists: Developing Online Learning Modules about Biochar for Agricultural Educators

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Introduction

The agricultural industry is facing a constant challenge to become more productive with less land and fewer resources (Harlander, 2002). As a result, sustainable agricultural practices are essential to equipping future generations to increase food production with fewer inputs. The Pennsylvania Envirothon Inc. (2019) suggested, "Agricultural sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs" (p. 5). With an increased focus on environmental risks, many companies are also shifting their focus to sustainability as a key business priority (Ateeq & Ibrahim, 2024). As a result, to meet the increasing need for improved agricultural systems, agriculturists must investigate innovative solutions to improve productivity.

Biochar is a carbon-rich material that is produced by heating biomass with little to no oxygen through a process called pyrolysis (Rajakumar & Sankar, 2016). It is a charcoal-like product that is used as a soil additive to enhance nutrient availability, water retention, and the overall health of plants. Biochar is a promising tool that traces back to ancient civilizations that relied heavily on farming, as it bridged the gap between traditional farming techniques and sustainable farming techniques. Rajakumar and Sankar (2016) stated, "Higher nutrient availability for plants is the result of both direct nutrient addition by biochar and greater nutrient retention" (p. 177). Although biochar can be expensive to implement, it can also be a simple solution to increasing crop productivity through improved water retention.

Certainly, educational opportunities play a key role in preparing the next generation of farmers, scientists, environmentalists, and consumers. And, if educators and administrators are to provide coursework designed to meet the demands of a changing workforce, they must provide real-world examples showcasing varying needs in a changing agricultural system (Kőmíves et al., 2019). Furthermore, a key component in agricultural education is introducing new innovative technology and environmentally friendly concepts, such as biochar. Therefore, the purpose of these educational resources is to develop and design materials related to biochar for agricultural educators.

Program Phases

Funded by the National Science Foundation, the "Developing Effective Adaptation Strategies to Enhance Resilience" program is designed to present educational learning materials centered around agricultural system sustainability using biochar. By integrating a biochar unit into an agricultural education curriculum, we hope to encourage students and educators to think broadly about new innovations so they can best foster an atmosphere to improve the science of agricultural production. As a result, we designed 10 reusable online modules in Articulate Rise 360 related to biochar in agriculture to reinforce students' understanding of sustainable agriculture practices.

We designed the modules to be a self-led unit to introduce students to the concept of biochar as a sustainable agriculture practice. Felder and Brent (2005) suggested, "Students have different levels of motivation, different attitudes about teaching and learning, and different responses to specific classroom environments and instructional practices" (para. 1). As a result, all students learn at a different pace and respond differently to different teaching techniques.

Therefore, we created a self-paced unit that was flexible and adaptable to varying student and educator needs. Ten modules comprise the unit, and students must complete modules in sequence. The module topics include an introduction to biochar, how it works, the process of making biochar, its impact on water retention, financial concerns, and others. The modules provide detailed instructions for the students to follow and be completely independent. The modules include different learning objectives that will be covered in the module. This helps increase the amount of information students retain and decrease the amount of information they might skip. Each module includes different interactions for students, including digital flashcards with vocabulary from the text, multiple-choice questions to test their retention of the information presented, diagrams, and videos. Each module encourages students to think critically about the information and make the connection between biochar and issues involved in agriculture. At the end of each module, students will complete a knowledge check consisting of questions that students must answer correctly before they can complete the module. There is also an assignment bank assigned to each module with a minimum of five different assignments that teachers can assign at their discretion. Each assignment is unique to its respective module, and the information is tailored to the learning objectives.

Results to Date

Led by a team of subject matter experts, we received feedback that the modules were user-friendly and attractive to view. Educators appreciated the interactivity that Articulate Rise 360 allowed in the module and noted the varying learning approaches that the software provided. For example, some users appreciated the kinesthetic variety of the learning opportunities, some appreciated the audio files supporting the learning materials, and others acknowledged that they appreciated the variability that was afforded in the supplemental assignments. We recognized a need to improve the accessibility of different elements of the modules and are working to make them more accessible for different learning needs.

Advice to Others/Future Plans

In a world where agriculture is evolving daily, students must be prepared to adapt and contribute to sustainable solutions. As a result, we recommend that teachers implement these modules in units related to natural resources or conservation. Teaching students about innovative possibilities like biochar will expand their awareness of different agricultural innovations. By implementing a self-paced unit about biochar, educators can help bridge the gap between traditional agriculture and new sustainable innovations by moving at the pace needed by each student. We also recommend that teachers include these modules as potential resources for substitute lesson plans, as the self-paced modules are designed to be student-led.

Plans include completing usability testing on the modules with an advisory board of subject matter experts and agricultural educators. We will also investigate relevant learning standards to place at the front of each module for teachers to include in their administrative lesson plan notes. Ultimately, our goal for creating and publishing a self-paced unit including biochar was designed to cultivate a mindset around sustainability for youth to think outside the box for agricultural innovations and promote lifelong learning skills.

Costs and Resources

For educators and students, these modules are free to access. For future creators, we used an Articulate Rise 360 subscription to design the modules and learning materials.

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