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Student Perceptions of Traditional and Simulated Learning in Greenhouse Management

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ABSTRACT

Environmental control (EC) units in the greenhouse environment help maximize yields and profits by minimizing energy and labor costs. Instructing students to properly and confidently employ ECs in greenhouse management is critically importance to food production advancement. This paper summarizes existing literature and comprehensive reviews on different teaching methods and student learning behavior for greenhouse environment control and survey tools for understanding student skills attainment. It also focuses on determining which survey items and tools successfully assess academic success, student engagement, and investigate if a particular educational tool developed is the best fit for specific learning outcomes. Findings demonstrate students are more interested in detail-oriented course materials, are receptive to feedback, and want to become confident applying their learning to real-world problems.

Keywords: Learning platform, Virtual reality, Learning behavior, Greenhouse management, Environment control

INTRODUCTION

Technological innovations are the driving forces for improving farm-production efficiencies: suffice the rising demands for food, high-quality products, management of environmental perturbations, and remain globally competitive. With decreasing access to extensive farming lands, and high risks associated with open field cultivations (droughts, floods, pest attack, high winds, etc.), farm systems are increasingly moving to EC greenhouse-based food production. However, careful scheduling and recordkeeping are necessary to efficiently operate and manage a greenhouse. The managers require appropriate education as well as technology-related qualifications and training. Training starts from planning and overseeing planting to eradicate pests and plant diseases. However, on-site training can be time-consuming, requires high levels of supervision, and may incur damage to crops and equipment, and results in accidents and injuries to trainees. Some are inaccessible for students for the risk of production loss, like in Controlled environment agriculture (CEA) technologies (Gómez, 2019). Therefore, the inclusion of computational tools and machine-to-machine communications, supported by intelligent interfaces, have become an increasingly important topic for many greenhouse production courses (Ray, 2017). This literature review explores the application of emerging technology-based educational approaches in the effective operation and control of greenhouses.

LEARNING BEHAVIOR OF STUDENTS

In general, individuals learn and react to teaching, taught either in or outside of the classroom, in many ways, depending on their learning behaviors. For students to succeed in active learning and retaining information, instructors need to be skilled regarding teaching approaches, learning methods, giving feedback, involving students in collaborative learning, and motivating them for independent learning. According to a study by the Mazandaran University of Medical Sciences (Afkhaminia, 2018), there is a meaningful relationship between students' developed skills (auditory skills, reading, creative thinking, time management, and work planning) and sources of support from the school. Another study surveying high school students about learning preferences showed students' desire to learn in technology-mediated interactive environments in conjunction with traditional classroom-based learning (Mills, 2018). Therefore, classrooms should embrace newer technology-based instructional methods for the best education possible for students allying with current and emerging technology. Feedback also needs to be delivered on a technology-based platform (for example, mobile learning environments, desktop-based simulated environments, virtual reality, or augmented reality) to meet the challenges of instructors' addressing everyone's question(s) and providing them with timely feedback; by assigning students formative tasks and provide automatic feedback for assessing task performance, provide detailed recordings of all the activities performed by students and automatically evaluate student performance, as well as provide training reviews. Therefore, considering the findings, teachers should welcome technology into their classrooms as a means of helping students learn material using an experiential learning approach.

METHODS OF EDUCATION

Traditional Learning

Greenhouse operation and management is an applied field of study, so it is mandatory to have hands-on experience aside from classroom-based education and weekly assignments. The typical traditional training method for greenhouse education expects students to use little to no technology to aid them in completing the time-prohibitive assignments. Without adequate time necessary to experience and successfully respond to the possible pitfalls, it leaves little means to observe or learn to respond to problems without an adverse effect on final crop production. In lab-based courses, accessibility to physical equipment and query support provides a learner with an opportunity to be involved in an entire crop-production process Akin to student populations, industry agricultural trainees also require opportunities to experience novel production technology. However, project-based learning can be slow and trainee delays will produce ill-effects and results of their actions, and may not be able to correct mistakes made during the production process. Service-learning is another growing and well-accepted technique where instructors integrate community service into their course curriculum, giving students hands-on experience while students give back to their community. However, appropriate, and effective course contents are pre-eminent as well. Experiential learning encourages reflection about experience and helps students develop new skills and attitudes (Lewis, 1994). Educators see as an integrated and holistic approach to education that adapts to real-world situations. Experiential learning theory (ELT) is much of the framework for modern education. Integrating ELT into course curriculum allows students to learn, and relearn, material from synergistic transactions between the person and the environment, which aid them in adaptation to real-world situations (Kolb, 2009).

Online Learning

Online learning is the teaching method where students learn using electronic technologies to access an educational curriculum. Through online learning, their critical thinking and evaluation skills improve as they find various sources to obtain assistance. Some students are more likely to engage with online learning than traditional teaching methods. However, there is no single answer of whether it is beneficial or creates more distractions and barriers. A study developed nine interactive e-tutorials. The findings suggest students perceived the tutorials as valuable and that the accessibility, design, and duration were deemed effective in user engagement (McGuinness, 2019). Several studies found the benefits of online learning of student involvement, student engagement, and student independence. A study of Belgrade Metropolitan University revealed students feel they should be challenged outside of the formal classroom setting, and those who did, performed better when learning independently (Raspopovic, 2017). Providing prompt feedback to students is vital to compensate for knowledge deficits, especially when online learning calls for an independent interaction. Although there is a lack of research on the long-term effects online learning has on student performance, this research is promising because it provides insight into what critical tools best serve learning populations.

Learning in Virtual and Augmented Environments

The most innovative and helpful technology for learning is virtual reality (VR). VR is a computer technology that facilitates immersion within simulated scenarios. It is a fast-growing and popular means for educational training programs. The most recognizable component of VR is a head-mounted display, which allows users to be immersed using display optics positioned in front of their eyes. VR may be effective in instruction as it appeals to learners and opens opportunities for active interaction with components through realistic immersion. Due to VR technology becoming more popular and widely available, using it for learning has produced several research opportunities. A VR training system could potentially be used in every classroom or course, such as virtual laboratories, visualizing machines, industrial plants, medical scenarios, and virtual maintenance and assembly. However, lack of training in the use of VR educational tools, lack of effective VR training modules, and inadequate capabilities to support such technology are common reasons VR has not been successfully integrated into classrooms. However, a portion of classrooms found ways to implement VR technology for supplemental instruction. SpeakUp, a nonprofit charity dedicated to helping teens communicate openly, surveyed U.S. teachers and students in 2016 and found five percent of instructors are using augmented reality (AR) or VR in their classroom, 11 percent of technology teachers are using AR or VR, and nine percent of students in grades 6-8 say they have experienced AR or VR in a classroom setting (Speak Up Research Initiative, 2016). While technology may assist educators in providing individualized student attention, a VR training modality also provides students with immediate and targeted feedback and assistance. A VR for horticulture students may assist project visualization without providing the physical resources necessary to complete assignments and projects, help students grow and maintain crops virtually and help with the use of equipment. At the University of Almería in Spain, faculty presented a virtual lab for teaching climatic control in a greenhouse environment. The tool consisted of a graphic screen connected to algorithms and a model in MATLAB to understand the issues involved in the climatic control of greenhouses (Ma, D., Carpenter, 2019). The virtual lab aided students in applying their knowledge of agriculture learned in the classroom when making changes to the environmental controls without damaging the production outcomes. To better understand how students react to VR, a study was conducted introducing three different assessment methods (Vesisenaho, 2019). Students showed high positive reactions to the simulations that afforded more significant activity and independence by using self-assessments to gauge emotional involvement, qualitative reporting on the experiments, and brain imaging methods for capturing performance and emotions.

EVALUATING STUDENT LEARNING

Survey methods have been used when assessing student engagement and performance for different teaching methods. Pre-tests and surveys help establish a baseline for the study and may help determine the appropriate student grouping. In contrast, post surveys reveal student engagement in the study, levels of learning, and overall student performance. Surveys have also been used to validate new platforms and methods of teaching. The following measures have been collected using surveys in many educational studies to evaluate student learning.

Academic Success

Student learning is a primary goal when developing and conducting an educational research study. Grade point average and standardized test scores such as the SAT are predicted variables for college success. However, there are other success indicators not explained by the standardized variables. The Psychology department at Southern Illinois University investigated the strength of college readiness skills in predicting student GPA (Komarraju, 2013). The college student inventory (CSI), like Student Readiness Inventory Survey (SRI) is intended to act as an early alert system for first-year college students who are at higher risk of challenges at school. Questions are distributed in three scales: Academic Motivation, General Coping, and Receptivity to Support Services (Slanger. 2015). Like SRI and CSI, another tool - the Academic Success Inventory for College Students (ASICS) was deployed to examine undergraduate nursing student strengths and weaknesses (Brown, 2020). Several schools and programs have adopted ASICS as a helpful tool in helping determine how well students will perform in school or on specific tasks. Virtual reality is a newer technology, which is not as widely available in the classroom alongside traditional teaching methods. Therefore, it is pertinent that research assesses academic success from VR technology. A study looked at the effectiveness of VR in physics whereby students used a virtual reality physics simulation (VRPS) (Kim, 2001). The study population was split into three groups – (i) not using the VRPS program (the control) and instead taught by traditional methods; (ii) using the VRPS with a teacher acting as a supplement; (iii) actively engaged in the VRPS without any teaching assistance. Results indicated students were more satisfied with the VR instruction and a teacher to help guide them when they needed help. The study results show a positive impact for the future of VR in education alongside traditional teaching.

Student Engagement

Student engagement plays a pivotal role in how well students grasp information and is a critical factor in academic achievement. The University Student Engagement Inventory (USEI) is a tool developed to identify student involvement in learning which focuses on the conceptualization of engagement as a multidimensional construct, including cognitive engagement (CE), behavioral engagement (BE), and emotional engagement (EE) (Maroco, 2016). To assess the impact of immersive VR on learning, a survey tool, Classroom Engagement Inventory (CEI) was given to public school students (Schneider, 2019). The survey questions were divided into four sections: Behavioral Engagement (BE), Cognitive Engagement (CE), Disengagement (DE), and Affective Engagement (AE), like the USEI. Other studies have used the CEI or have incorporated vital concepts to help with understanding the engagement of students in a VR learning experience.

Quality Metrics of Educational Platforms and Tools

It is just as important to validate the training tool itself to validate student engagement and success from different learning methods, whether by validating the labs planned for traditional methods or VR simulations. Here, we examine three metrics for assessing the quality of VR experiences as measured through survey methods: usability, sense of presence, and simulator sickness.

System Usability Scale (SUS) is the most widely used standardized questionnaire for the VR assessment of perceived usability (Lewis, 2018). Purdue University investigated the usability of two different independent VR systems to validate low-cost, commercially available tools, which could eventually be made available for academics (Webster, 2017). Students participated in one of two VR experiences, and after VR exposures, they responded to SUS. All SUS factor scores across the study were markedly high. The findings suggest a promising future for VR in education. A presence questionnaire (PQ) is another popular means to assess VR. Presence is a construct of intentional focus, and employment is helpful when determining the level of attention one has when entering virtual environments (VEs). A study aimed to teach students to drive a virtual automobile using VR scenarios (Silva, 2016). Throughout the research period, the students sat in an armchair and were put into the first-person view of the driver's seat of an automobile in a virtual city. Upon completion of the VR driving, the students completed the PQ. Presence questionnaires help researchers determine the quality of the immersion in VEs. The third method of assessing VR educational tools is a simulation sickness questionnaire (SSQ). A well-developed VR simulation will limit the effect of simulator sickness on participants, making the assessment a vital tool to question participants on results when developing VR systems.

CONCLUSION AND FUTURE RESEARCH

This paper has summarized many survey studies for educational research to understand student engagement and success from different teaching platforms and methods. Traditional, online, and VR methods of teaching information were discussed and compared to the learning behavior of students. Findings from other studies demonstrate that students prefer engagement through learning, are interested, detail-oriented, receptive to feedback, and want to become confident learners. Engagement in the classroom is significant when introducing students to environments, problems, and assignments unattainable or expensive to establish in real-world training scenarios such as emerging technology-based education, such as desktop simulation, VR, and AR. Immersive technology may provide more practical learning while reducing distraction. Teachers would likely welcome technology into the classroom as a means of helping students better understand and grasp course materials, especially when training experiences involve high-risk environments and complex hands-on practices.

Developing a successful teaching method also involves its efficacy assessment based on students' perceptions about their learning. This review shows a need for extensive future research and development of content-specific survey tools, especially those which help collect student perceptions of VR-based learning and validate teaching tools. Future research should develop both desktop-based and VR-based simulated environments to train students to operate greenhouse environment controls, manage production and assess the efficacy of such simulated platforms successfully and confidently. Proposed assessments may be conducted using validated survey tools developed to (i) understand students' immersion in the virtual greenhouse environment,

(ii) their interaction with ECs and its interface, (iii) successful understanding of operations, and (iv) confidence in effective transfer of knowledge for real-world practices.

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