

Simulation in an Online Watershed and Land Use Game for Agriculture and Science Education

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Introduction

Digital simulation games are a curricular option for teaching agriculture and science at the secondary level. Game-based instruction is neither new nor uncommon. The challenge, however, is to provide teachers with games that support students in the subject matter area, while meeting social and career goals. We created an online unit, PEWI: Watershed and Land Use Game, and an online Teachers Guide to support its use (Anderson et al., 2020). The game is a simulation, and enables students to interact with a realistic watershed based on 2 existing landforms, 15 contemporary land uses, and 5 physical features (maps) (Chennault et al., 2016). Teachers set the challenges, or students develop their own inquiries, depending on grade level and course goals. Students apply new land uses to the watershed to set the simulation in motion. Instantaneously, a results table and graphs will show changes in major ecosystem or yield indicators. The game assists students to learn in areas that are broadly desired but difficult to achieve through current curricula, such as ecosystem complexity (Parrott & Meyer, 2012) and community-based concerns (Penuel & Bell, 2016). We propose to (a) describe gaps in areas of agriculture and science education that the game could support, especially inquiry-based pedagogies; and (b) argue how PEWI may support STEM areas, especially in secondary schools that do not have a land lab or other field-based resources; and (c) for teachers and students who have lived experiences based on urban and suburban, rather than rural and agricultural, livelihoods.

Literature

An et al. (2016) reported that 80% of middle and high school teachers employ computer games in the classroom. Access has improved in the last decade, but is not equitable. In our rural and agricultural state, the student/computer ratio in public schools reached 1:1 in 2017 (Iowa), justifying greater use of digital curricular. Low connectivity in low income and rural areas continues, however, nationwide in rural and on rural tribal lands (Congressional Research Service, 2019). The pandemic reminded us affordable access cannot be presumed in schools or in the home, yet the demand for digital curricula is high. The predominant current complaint from teachers who are able to use digital games is documented as the mismatch of classroom content goals with apparent goals of the games (Bourgonjon et al., 2013). Secondary school teachers observed that commercial games frequently failed to match the content, grade, and unit learning goals set by teachers. Our PEWI game is considered to be a simulation. Simulations, however, can look and feel differently from each other. First, because games are composed of different features, simulation aspects may not be prominent or present at all stages of the game (Hamari et al., 2016).

How it Works

PEWI generates research-based results in realistic units (e.g., ppm, or English or metric tons), and measures pollutants important to water quality such as nitrate and phosphorous. The game also measures ecosystem services such as biodiversity and game wildlife; and soil quality

indicators such as erosion control; and prosperity indicators such as yield for corn, cows, and woody biomass, and more. The maps track effects of precipitation, drainage class, soil type, and topography on environmental outcomes. There is a drone mode, with animation. The game provides 110 glossary entries in video/text and audio to help meet accommodations and differentiation of instruction. The Teachers Guide provides lesson plans, tutorials, as well as other teachers' lesson plans. A Careers tab with videos of our racially and ethnically diverse student programmers and subject matter developers provides models for students contributing to STEM. Overlapping standards guide curricula in agriculture and science. The Agriculture, Food and Natural Resources (AFNR) Career Content Standards (National Council for Agricultural Education, 2015), and the Next Generation Science Standards (NGSS) (National Research Council, 2013) inform agriculture. Intentional "crosswalk" integrates the two sets of standards. Standards, historically, inform curricular selection, development, revision, and assessment (Fulmer et al., 2018). Science, technology, engineering, and mathematics (STEM) frameworks have variously included agriculture.

Results, Implications and Impacts

We will describe gaps in areas of agriculture and science education that the game could support by reviewing a prior analysis of alignment of the NGSS and AFNR standards to uncover patterns of goal and objectives that are insufficiently address in many classrooms (Anderson et al., 2020). The analysis revealed strong contributions in three areas, which we will paraphrase from both standards: (a) the game emphasizes ways to practice science and agriculture inquiry authentically; (b) the game provides opportunities for teachers to feature pressing, complex issues in science and agriculture (e.g., Penuel & Bell, 2016); and (c) students would be compelled to use inquiry-based, "if-then" reasoning based on actual measures due to the simulation structure of the game. We will also argue how digital aspects of PEWI may support STEM areas, specifically how teachers and students from secondary schools who do not have a land lab or other field based resources, and who may not bring prior agricultural or rural experiences into the classroom, may benefit from the game's simulation structure, lesson plans, and the glossary feature.

Future Plans and Advice to Others

A project funded recently by the National Science Foundation has paired us with our institution's "pre-college through college program to empower Iowa students of color to pursue degrees and careers in ASTEM fields." We explore how the game may serve diversity and inclusion goals. We also discuss how PEWI compares with respect to requirements for teacher-led facilitation versus asynchronous student engagement, and what that may mean for similar curriculum.

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