PEWI: A Land Use Simulation Game

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Introduction

Digital simulations have supported student learning outcomes in science and agriculture. People in Ecosystems Watershed Integration (PEWI) is a digital online game designed to enhance teaching and learning about agricultural land use, and about science and engineering practices important to agriculture and the environment. Previous studies have assessed use of digital technology in agricultural education such as virtual reality (Wells et al., 2020) and smartphone devices (Smith et al., 2019), with mixed results. Simulation games can help students to understand ecosystem services and the science needed to address global ecosystem challenges, including the role of agriculture (Chaplin-Kramer et al., 2019; Costanza et al., 2014). There are few tools for classrooms that combine a realistic simulation about agriculture and land uses with a simulation of results of multiple ecosystem services which display instantaneously based on student choices (Chennault et al., 2020).

Teachers who use the game with their students can follow an inquiry approach based on the simulation structure of the game. Learners are presented with a default crop (conventional corn) on a realistic watershed, based on two Midwest landforms, with a river running through it. Students bring prior knowledge to test ideas about ways to change environmental conditions or effects such as how to change the levels of nitrate or phosphorous in water; sediment loads; levels of biodiversity, game wildlife, carbon sequestration, and others. The only way to change these levels in the game is to change the type, placement, or amount of land uses (up to 15) on the watershed. Changes to the land uses on the watershed cause instant results in Table or Graphic results areas. Teachers can direct students, individually or in teams, to provide reasons for their choices, monitor results, and retest in a short period of time to arrive at desired goals for outcomes in ecosystem services such as clean water and biodiversity.

An important audience for PEWI is high school and college students participating in science and agriculture courses. There are some fun animations including a “drone” flyover mode. The game also fits nonformal and club contexts such as 4-H and science fair applications. We created a separate online Teachers Guide on a free public Canvas Learning Management System site, which provides lesson plans we created, lesson plans from other teachers, resources for team-based learning, and career videos.

How it Works

The game facilitates the simulations of land uses, and visualization and calculation of land use outcomes, on an interactive watershed that is based on two Iowa landform regions, the Des Moines Lobe and the Southern Iowa Drift Plain (Prior, 1991). PEWI is designed as a visual interface that includes a watershed area, 15 contemporary land use options, seven weather conditions, five research-based physical feature maps, and three environmental service maps. Instructors can turn some features on and off. The schematics are realistic and professional, such as farm advisors would use. The game includes a glossary with 110 audiovisual entries that provide audio, visual and text content to serve accommodations and differential instruction.

The simulation is designed as 593 grid cells configured around a vector-graphic stream that results in a 2,383 ha (5,886 ac) watershed (Chennault et al., 2020). Nine maps that include topographic relief, flood frequency, strategic wetlands, sub-watershed boundaries, drainage class, and soil class help the student to make better land use selections. PEWI calculates the results for 16 ecosystem service outcomes and presents the results in the form of a numerical table that includes appropriate unit measures for each indicator. An upcoming version will add a financial element, which will help teach students about risks and costs when considering selection of land uses and managing for ecosystem services.

Implications / Results

Fulmer et al. (2018) noted that curricula that align with education standards have greater potential to contribute to student success. PEWI has been evaluated for its fit to two national education standards – the Next Generation Science Standards (NGSS) and the Agriculture, Food, and Natural Resources Standards (Anderson et al., 2020). The game aligns with nine high-school level NGSS student performance expectations categories, and 10 standards and 17 indicators from the AFNR areas of Environmental Service Systems, Natural Resource Systems, and Plant Systems (Anderson et al., 2020).

The game is available online for no cost and no prior software licenses are required, allowing schools and homes broader access. Through data analytics frameworks that are integrated within web site, we report at least ten thousand unique visitors. Faculty and staff have conducted professional development workshops at Iowa Association of Agricultural Educators Summer Conferences, and at the Iowa State University Science Bound Teacher Retreat and have staffed booths at science teachers' conferences.

Future Plans, Advice to Others, & Cost

The PEWI simulation was developed over seven years and funded by several internal and external sources of funding, including government and nonprofit and foundation funding. The game is currently funded by the National Science Foundation, in partnership with a College program which serves ethnically diverse Iowa students who earn ASTEM (agricultural, scientific, technical, engineering and mathematics) degrees. The grant will develop blockchain exercises that will analyze blockchain-enabled food supply chain systems and will accompany lesson plans, labs, and assessments and will be integrated into the game and the Teachers Guide. We are also seeking funds to research or evaluate the extent to which the game contributes to learning, and how teachers are able to integrate the game into instruction and career activities. This will require recruitment of schools and teachers.

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