Out in the brownfields
An inquiry-based simulation for environmental science education

Dr Peter Bower, former professor of environmental science at Barnard College and Columbia University, USA, and team developed Brownfield Action, a network-based, interactive, digital space and simulation in which students explore and solve problems in environmental forensics.

This simulation transpornts students to a realistic but imaginary town with brownfields to be investigated and, given that actual fieldwork is often not feasible, enables them to address complex realistic scenarios.

Disseminated and used by educators across many institutions, Brownfield Action has been found to be an effective and realistic teaching tool that can help transform education.

Environmental scientists play a crucial role in tackling the complex issues affecting our planet today, including climate change, pollution, and the depletion of natural resources. One of the key issues addressed by environmental consultants entails the study of brownfields, properties that have been abandoned or are underutilised due to actual or potential pollution. Polluted sites can be environmental hazards as they are difficult to reuse or redevelop due to the presence of toxic substances, but after site investigation, many properties can be remediated, revitalised, and redeveloped.

Dr Peter Bower, former professor of environmental science at Barnard College and Columbia University, USA, has collaborated with the Columbia Center for Teaching and Learning to develop an interactive digital simulation that teaches environmental science students to tackle brownfield-related problems in an engaging way. This simulation is called Brownfield Action (BA).

The working of Brownfield Action
BA allows students to navigate brownfields in a simulated town and conduct environmental site assessments to locate and determine levels of pollution, especially of groundwater, and devise steps for redevelopment. The BA website has three key sections: the first section is for educators and assignment submissions, the second contains simulation-related resources, and the third is the BA simulation. The simulation can be accessed through the website.

When accessing the simulation, students enter an imaginary town spanning more than 150 acres of land. The town is visualised on a map that contains over 2 million spots where students can collect hydrogeologic (groundwater) data with tools commonly used by environmental consultants. These include laser-based devices known as theodolites, radars that penetrate underground, tools to analyse the properties of materials, measure magnetic fields or detect metals and gas, excavation tools, drilling technology, and tests to detect pollutants in the soil and groundwater. Additionally, the students can interview local people in the town and access historical records in the municipal government.

In the three-dimensional grid mapping the virtual town, students can see other details relevant to environmental site assessments, such as the topography, the depth to the water table and bedrock, and the type of soil. The map also clearly delineates specific properties and sites, such as roads, gas stations and diners, wells, homes, businesses, water towers, and government buildings.

Bringing BA to the classroom
The imaginary town simulated in BA has an underlying storyline designed to guide the students’ actions. The town is presented to a realistic but imaginary town with brownfields to be investigated and, given that actual fieldwork is often not feasible, enables them to address complex realistic scenarios.

As the storyline progresses, students face considerable ambiguity and will need to rely on their judgement and decision-making. Ambiguity is a key aspect of real-world environmental science, yet traditional laboratory exercises typically enable students to follow a list of instructions, preventing them from encountering the uncertainties that they would face as professionals in real life. In contrast with conventional class exercises, BA can increase the students’ awareness of their skills and knowledge, teaching them to apply them critically and creatively. The platform also fosters teamwork both inside and outside the classroom, as this company contracts with an environmental consulting firm (a student team) to perform an environmental site assessment of this brownfield property before the purchase of the factory. After considerable investigation, it is determined that the groundwater at the factory site as well as under adjacent properties is contaminated due to leakage from a septic field and the failure of underground pipes and tanks.

During class exercises, students can be divided into pairs or small groups and asked to act as environmental consultants hired to determine the nature and extent of the town’s contamination problems. The students’ investigations will reveal that the town’s pollution was caused by a factory that previously manufactured radio-luminescent signs and discarded radioactive materials into its septic field. Because running tests and using tools in the simulation costs money, educators can also ask students to compete in trying to solve the problem in cost-effective ways.

Making environmental education practical
The BA simulation platform is an innovative digital space where students can apply what they learned in class, while also getting a better grasp of what they would be expected to do as environmental consultants. In addition to being more entertaining than traditional worksheets, lectures, and lab work, the platform has notable educational advantages. By simulating a realistic world that users can independently explore, BA teaches students to approach complex scenarios with an open mind, overcoming hasty judgements, conducting detailed assessments, and considering multiple dimensions of a problem.

Student team using the Brownfield Action simulation to obtain data and make their water table map.

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A promising educational platform

The BA simulation and website have already been used by educators at many institutions across the United States. Larry Lemke, a professor at Wayne State University, introduced it as part of his Geologic Site Assessment class, while Professor Angelo Lamposaux at City University of New York incorporated it in the curriculum for his Phase II Environmental Site Assessment classes. BA has also been used by Professor Brett Bennington at Hofstra University and Professor Douglas M Thompson at Connecticut College to support the learning of hydrology and hydrogeology.

Feedback from educators has been overwhelmingly positive, suggesting that the platform helped their students understand how concepts learned in class can be applied in real-world settings. Students appeared to greatly enjoy assignments in the simulation, with some suggesting that BA had encouraged them to pursue environmental consulting careers. The platform’s visual and interactive nature, a hallmark of constructivist learning, is recognized as its real strength as well as its ability to replicate the complexities and uncertainties associated with real-world environmental problems. Bower suggests that the simulation could be integrated in environmental science programs and STEM higher education programmes to better prepare students for their future professional endeavours in a creative yet realistic way.

Marine 3D field of play in the BA simulation.

Personal response

How can Brownfield Action benefit/advance STEM education? What platform unique advantages and features?

Both of these questions demand an explanation of this pedagogical exercise for BA. Most STEM workers/educators use computers and other technology in their day-to-day practice. Technology can have powerful effects in putting constructivist principles into practice. An incredibly useful multimedia-supported learning environment must present the nuts and bolts of the problem being taught, provide a realistic context in which those basic principles operate, and allow students to explore the forms, relations, and implications of the data they encounter. Most importantly, the simulation should embody a rich and complex narrative, a compelling story — ideally including conflicting threads of information to unravel and false leads to decode — in which students must solve substantive problems, occupy constructivist roles, overcome hasty judgments, and resolve ambiguity.

Because there is no set of fixed outcomes, ambiguity is a fundamental component of BA imitating real-world investigations. This crucial feature is absent in most traditional, well-designed biology science exams, which often take a 'cookbook' approach to learning — that is, if the instructions are understood and followed, students know there is a solution that can be achieved before the beginning of the lab period. Student awareness of this ambiguity is an important aspect of the simulation. A student attempting to retrieve 'cookbook' expectations, deal with the insecurity of ambiguity, and find threads that lead to real solutions.

Unsurprisingly, the inquiry-based approach of BA produces conflicts with previously learned student behaviours that accompany traditional, lecture-absorbed, didactic methods. For example, students often become frustrated when outcomes do not provide the immediate sensation of being done or with a clear sense of the end in sight. Furthermore, student work habits typically involve a lack of effort revolving around the next test or assignment. For continued success in BA, students must own, internalise, and utilise concepts and information beyond the next test or assignment. For continued success in BA, students must own, internalise, and utilise concepts and information beyond the next test or assignment. It is designed to foster a respect for learning by placing students in a learning environment that tests that they can occupy constructivist roles, overcome hasty judgments, and resolve ambiguity.

of an environmental site assessment, the expertise to employ a variety of analytical methods to respond both critically and creatively to the simulation, and the ability to promote and advance the effectiveness of teamwork within the student companies. These pedagogical issues are raised with students directly in an effort to raise their awareness via metacognition and about their eventual transition to the challenges of life beyond the college classroom.

The BA laboratory experience also supports student learning. Lab sessions are designed to be seamless, integrated and continuously evolving from one lab to the next, and because the BA simulation is network-based, student companies can continue their work during the week anywhere there is internet connectivity.

More importantly, laboratory exercises for BA are integrated into the simulation and thus, need to be understood in the context of new information and reevaluated in the context of a final report to the development corporation.

For example, a standard lab exercise involving the sieving of sediment and the determination of particle-size distributions and porosity in BA becomes an investigation of sediment from a drill hole at the abandoned factory. The porosity data from this analysis must be combined with permeability data determined in a subsequent laboratory and with an understanding of D’Anio’s Law to calculate groundwater velocity. This calculation is important for predicting and understanding the nature and extent of the contaminant plume but also for legal, forensic, and planning purposes. Thus, students must not only learn about particle-size distributions, porosity, permeability, and D’Anio’s Law, but also must own this information in order to use it in the context of their investigation and final report. Finally, BA is unique in that it accurately replicates a real-world experience for students. At the beginning of BA, students are told that their education will be defined by those aspects of the experience that they ‘love’ and are able to use to influence their lives six months after the course is over.

How do you plan to improve and advance Brownfield Action in the future?

BA has been used in a multitude of ways depending on the level of the class, the amount of scaffolding required, and the class-time available (Bower et al, 2013). The BA website also contains a section where users describe the specifics and provide documents to demonstrate how they used the simulation. Currents users may add to this section. In addition, use of BA as a training tool for the environmental consulting industry is being examined.

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