Teaching the Essence of Science with a Game?

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Essence Of Science

The essence of a scientist's life involves thinking about puzzles. Often the puzzle is something that just doesn't make sense, forcing the question: Why? To solve the puzzle, the scientist first observes and collects evidence. Is the problem real? Can it be defined? Is it likely to have general applicability or is it something more likely to be a unique, one-time occurrence? The more general the problem, the more interesting it is because understanding this problem could lead to understanding far more. But first, the problem must be described. This means collecting evidence and documenting that evidence by taking notes.

But a random set of notes is often just a jumbled collection. To give the collection some meaning, the notes and thoughts need some organizing and pruning. A good collection would emphasize those that are most important. This means crossing off those with less relevance. Can some pattern be found with the ones that are left? Do some of the clues suggest possible areas for further exploration? Some computer programs offer a good way to organize the notes by moving them around — easier than crossing them off and rewriting in ever diminishing space. Organizing notes helps to reinforce those most likely to be important and to recall small items.

Armed with more focused thoughts, the scientist often searches in a library to get some ideas and learn what has already been discovered. This is inquiry. The scientist asks questions of the library related to each of the discovered clues. Upon finding related information, the scientist takes more notes. These notes, however, are of a different nature. They generally result from information that is widely accepted, not clues from a specific puzzle or problem. While this information is often called facts, the scientist knows that convincing new information often leads to changes in many old facts. Regardless, evidence from the library is treated differently from that of the single puzzle. Thus, these notes are usually kept separately, then organized and pruned as before. This facilitates thinking about their relationships with the collected clues.

The scientist often goes on to come up with alternative hypotheses or explanations. Then he or she devises and runs well controlled experiments that can rule out one or more of the alternative explanations. This is done because it's impossible to prove that something is correct. It is only possible to prove that something cannot be true. Advances in our understanding of the world are made in this way (Platt, 1964; Wolfs, 2010).

Using Science To Teach Science

Each of the steps in this process provides a challenge, but each advance can bring satisfaction and enjoyment. Indeed, while the process may sound like work, it is far from what most people think of as work. Each step involves doing something that the scientist has decided to do. The scientist is in control of what he or she does; no one else. The ideas come from within. It is a process that motivates; it is a process that is fun.

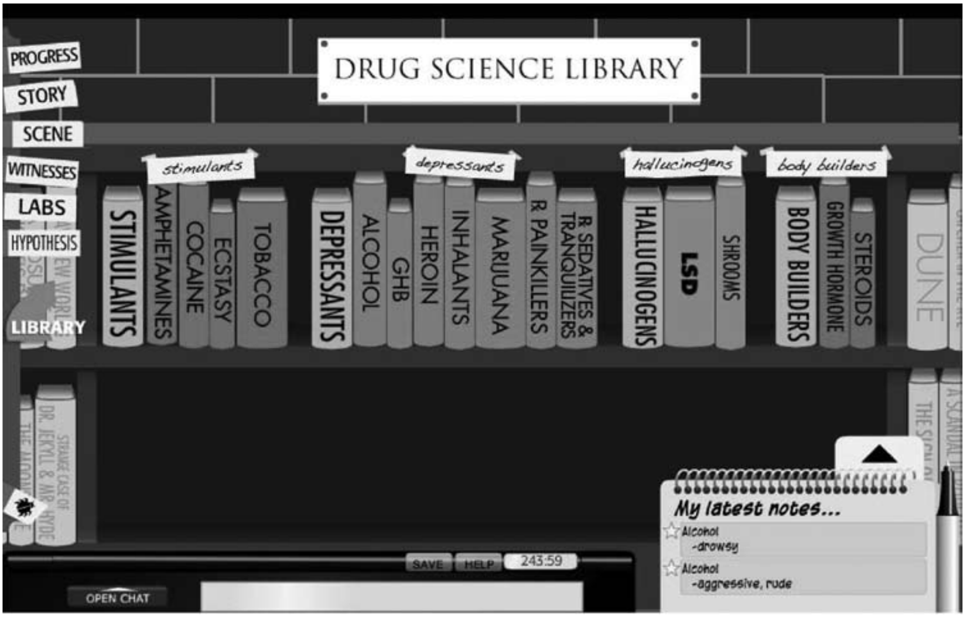
We know, because three of us spent our lives as scientists. We also devoted a great part of our lives to teaching. When we found ourselves working together in a small company devoted to learning, we naturally thought about this process and wondered if the process could be incorporated into a game that might motivate and engage young people while helping them learn. We took the idea to a branch of the NIH, the National Institute for Drug Abuse. There we proposed developing a web-based video game that could teach how science works while being oriented around a topic that youth need to understand. Our proposal was funded three years ago and the resulting game, Drug Scene Investigators (DSI), has now been played by hundreds of middle and high school students. Evaluations tell us that not only does the game teach the essence of science, students love the game, improve their knowledge about drugs of abuse, and, importantly, acquire a greater interest in science.

The Game

The game introduces students to one of five short stories, each of which involves a young person who has abused a drug. The puzzle challenge to game players is to identify the drug. They begin by selecting clues from the stories, witnesses, and scenes, and from doing laboratory experiments. Upon running a cursor over text in the story, comments of witnesses, clues discovered in a scene, or results of experiments, text phrases become highlighted. If they think that a highlighted item might be an important clue, they collect the evidence by clicking it. This puts a summary of the item as a note in a virtual notepad. And, by collecting evidence they have started to become scientists.

A virtual library is provided consisting of up to 19 books on shelves, each about two pages in length. Four of the books describe the general classes of drugs: stimulants, depressants, hallucinogens and body builders. Each of the other 15 describes an abused drug in one of these categories. A book is opened by clicking on its spine. As with clues, if a passage becomes highlighted upon pointing at it with the cursor, and if the student believes ▶

this passage contains relevant evidence that supports or refutes a collected clue as being related to the drug or drug class in question, it also can be clicked. This places a summary of the passage in a separate section of the notepad, one devoted to library notes on a particular drug or class of drugs. Thus, the game teaches inquiry as students need to seek information that will indicate if discovered evidence supports a particular drug or drug class being responsible for the problem described in the story. Through inquiry, they accumulate knowledge that experts have judged to be our best understanding.



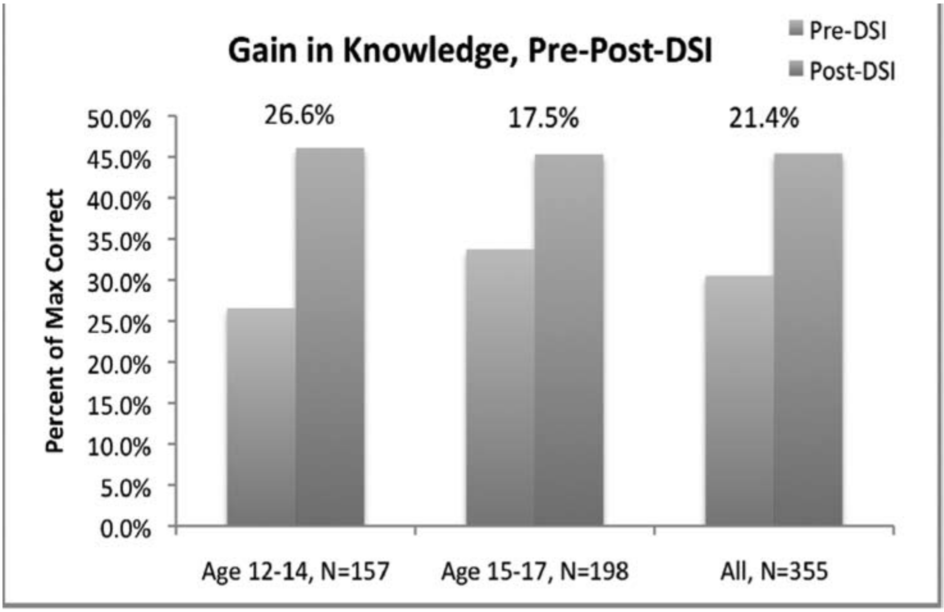
If students are not selective in taking notes, their notepads can become cluttered. We encourage them to be selective at the time of note-taking, in part to avoid this problem and in part to encourage them to think for a moment about what they just read. Regardless, we provide a way to delete notes they believe are not important and ways to move related notes together. This is organization of information, a process fundamental to coping with complexity of any sort.

Each library book includes a series of three-question quizzes. Each selected answer is accompanied by a message telling students why that choice is or is not correct. The quizzes are designed to help students by reinforcing important information that they should discover during their inquiry into each library book.

DSI also incorporates a way for students to link their discovered evidence with their inquiry-derived library notes. After reading library pages, students form a preliminary hypothesis as to the class of drug and the likely drug. While they can never prove it is true, they can rule out alternative hypotheses. To assist students with this process, we ask them to develop links between their discovered evidential notes and their inquiry-based library notes. They must create four linked notes to support their hypothesized drug and, more importantly, provide linked notes as evidence to refute alternative drugs. We assist again with this process by naming three drugs to refute. If their hypothesized drug is not correct, one of the three will be. By linking evidence with library information that supports or refutes their hypothesis, students are practicing evidence-based reasoning.

Did It Work?

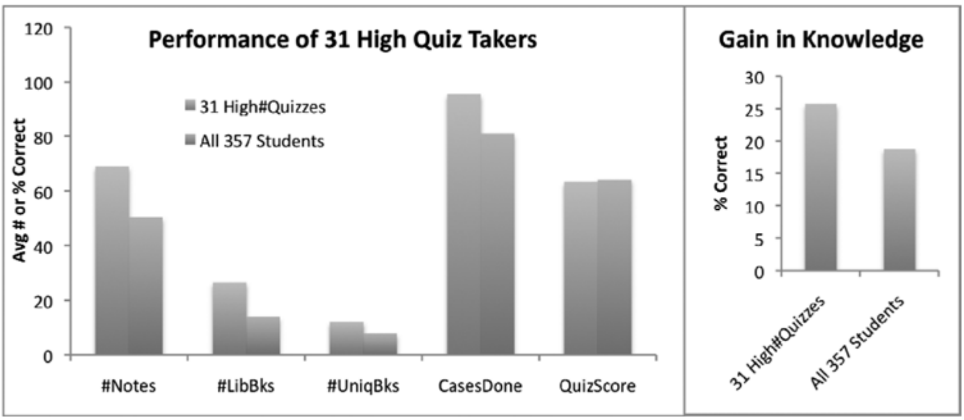
We have developed three versions of the game. The most recent, Version Three, was evaluated by 357 students ages 12-17. They answered surveys before and after completing one to five cases. In addition to questions on demographics, behavior, and interest, the surveys included 15 questions that asked students to make comparisons of the effects on the body of different drugs. Since the game focused on one drug at a time and the library-page quizzes were drug specific, the questions proved to be difficult. In spite of this, students achieved an overall gain in knowledge averaging 21.4%. Younger students, ages 12-14, started with lower scores but gained the most, showing a 26.6% gain in knowledge over what they knew pre-DSI. The older students, ages 15-17, started with more knowledge, but still gained an additional 17.5%. The differences were highly significant ($p<0.000$). Thus, the game appears to work by increasing knowledge of drugs by players of all ages.



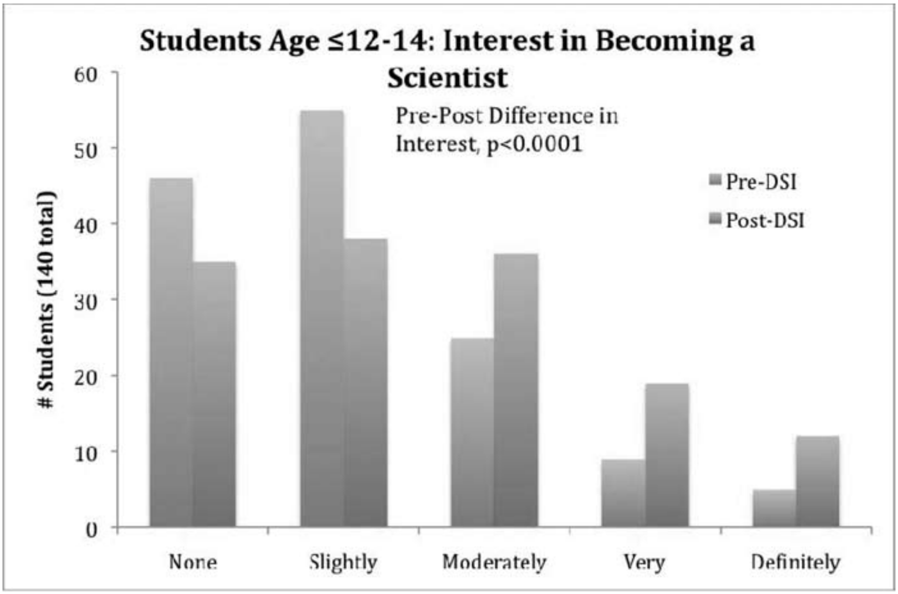
In earlier studies, one of us (LJK) developed a computer-based approach designed to help people learn through use of quizzes that provide explanatory feedback in response to each selected answer. The approach permits a student to examine each answer and go back to view earlier answers. The questions are also drawn from a database with alternative answers and this allows a student to look at hundreds of questions and never see the exact same set of possible answers. When offered as a supplement to lectures, students spent hours studying these formative feedback questions. He discovered that these feedback learning questions led to a marked improvement in biology and mathematics classes, including elimination of the achievement gap (Lu, 1993; Kleinsmith, 1994; Lu, 1997). The quizzes included on our library pages incorporate these principles, giving students guided feedback on wrong and right answers. We were delighted to learn that our students behaved in a similar fashion with *DSI*. We were surprised to note that nine percent did 50 or ▶

more quizzes over the course of playing 5 cases and one student completed 495 quizzes — this with each quiz consisting of three different questions.

Intrigued by this result, we looked more into the characteristics of these 31 students. They did not differ by age, gender, race, or ethnicity from our larger group. Yet they completed 18% more cases than the average (4.8 cases vs. 4.0 for all others), took 36.8% more important notes, did 330% more quizzes, and looked at 90% more library books per case (26.5/case vs. 13.9 for the rest) including 56.8% more unique library books (12.1 vs. 7.7). They obtained an average per case quiz score indistinguishable from the rest (63.3% correct on first answer vs. 64.2% for all 357 students). While only 11% of all students said that their usual grade was C or below, this was the designation for 20% of this group. Importantly, with respect to learning about drugs of abuse, their percent gain in knowledge was 37% higher than the average for all. It appears that students who did a surprisingly large number of quizzes were not only trying hard to learn and improve, they succeeded. Thus, it would appear that the game offered opportunities for students to become highly engaged and go beyond basic requirements: collecting evidence, taking and organizing notes, inquiring of library books, developing hypotheses, and ruling out alternatives.



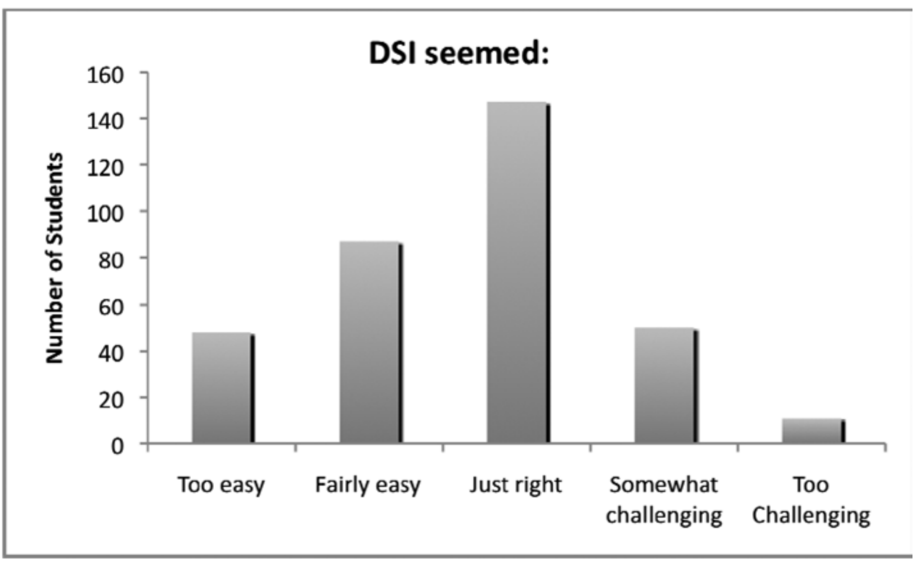
We asked all students: *Are you interested in becoming a scientist or working with scientists?* and we offered options of *not at all interested, slightly interested, moderately interested, very interested,* and *definitely interested.* Before playing DSI, 74% of the students answering the question said they were not at all interested or only slightly interested. Playing the game led to a striking increase in interest with this earlier group dropping to 50% and the others choosing moderately interested (28%), very interested (12%) and definitely interested (10%). These results suggest that DSI could serve well as an introduction to many science courses.



Additionally, 67% of these students agreed or strongly agreed that DSI *increased my concern about the hazards of using drugs*. Thus, while we had some concern that teaching students accurate information about drugs of abuse might lead them to believe that they were not as hazardous as they had perceived from earlier information, the reverse appears to be the case.

Did Students Like Playing DSI?

We were gratified by how much students seemed to like the game. More felt it was too easy than too challenging, but most thought it was just right. We asked if they trusted the information, and 85% answered *strongly agree* or *agree*. ▶



The real value of the game came through student comments. Here are a sampling: *Overall this is a great game that many students can use to learn about the hazards/dangers of drugs. I really enjoyed it and I am planing* [sic] *to do it in my free time.!!!!!!!! its awesome " I liked that it really did make you think and do research i liked that it didn't just give you answers. you had to look for clues to solve cases which lead to you actually learning about the drugs. i wish i could play more cases instead of just five! Plus you should make it so that we have to read alot* [sic] *in the library. It was fun finding evidence against drugs and for drugs It was AMAZING!!! i love this game!!! I liked finding the evidence. It was fun and satisfying identifying the correct drug as well as eliminating drugs that wern't* [sic] *used.*

What Do Teachers Think?

Teachers also viewed DSI positively. All of the six teachers who completed a post-DSI survey *agreed* or *strongly agreed* that *DSI required little of my time*, that *DSI makes efficient use of class time* and that *DSI can help students to think critically*. When we asked about how the approach might be extended to other topics, they suggested: *This would be excellent with historical cases such as JFK assassination or unsolved historical questions. I think you could use it with science on rock identification; parts of the body, or any topic*. When asked about how DSI compared with other ways they have taught drug education, they commented: *This is much more engaging than videos and handouts. It is hands on and it gives them a chance to find out the information for themselves. Drug education is generally taught through lecture or reading format. This was a very interactive, fun way to teach it.* When we asked what they liked about DSI they offered: *It was very student based, not teacher directed. That the kids love it because of the technology. It had in depth knowledge about a wide variety of drugs. Also, I liked how it had drugs grouped instead of just individual. Often, students only know drugs by name, not what they do. I liked how if students read and tried to follow each case, they had an easier time getting the correct answer than if they just clicked randomly. I made the students think and interact with the program to find out information on their own.*

Next: Version Four

Teachers and students also identified problems. Some related to local firewall restrictions interfering with a chat system we included to facilitate cooperative learning, some to lack of clarity in the scoring system, and some with saved notes. We have now made adjustments and modifications to address all concerns. The resulting changes will make it easier to use and even more adaptable to the varied needs of students in middle and early high school. We will release Version Four of DSI in September, 2010. The game will be offered free for the coming year to all schools which are willing to participate in the evaluation (currently embedded as part of the game). During this evaluation, we want to learn more about the increased interest in science and obtain more information about the perceived hazards of drug use. We also hope to tease out information to learn what aspects of the game have the greatest effect on learning

By using the game with all students in one grade in a school district, we may also learn if the increased belief that drug use is dangerous leads to an overall reduction in drug abuse when measured by the district. (We do not ask about drug use, and all participants are anonymous).

Summary

We've explored the potential of using the scientific approach to teach science by way of a web-based video game. The game involves a set of five cases in which young people get into trouble through use of some abused drug. The challenge presented to game players is to use principles of scientific discovery to determine the causative drug. These involve evidence collection, library inquiry, formative feedback quizzes on library pages, note-taking, note organization, and linking of evidence with library notes. Note-linking follows hypothesis generation and is designed to assist the student in learning the importance of ruling out alternative explanations as to identification of the culprit drug. In the process, students must use critical thinking and evidence-based reasoning, all essential aspects of science. We have been pleased that an evaluation of 357 students, ages 12-17, provided clear evidence that students engaged with the game, thought it was fun, learned, gained an increased interest in science, and finished with an increased concern for the hazards of drug use. Teachers agreed with these conclusions and felt it took little of their time. During the 2010-2011 academic year, the game is being made available free of any charge to middle schools and high schools willing to assist in a continuing evaluation.

A teacher? Want to try the game? Go to http://dsihome.org for more information.

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