Solving Problems Transformationally

I. The Standards and Big Ideas

Common Core State Standards: Literacy in Science & Technical Subjects
RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table)
RST.6-8.8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
RST.6-8.9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Next Gen Science Standards (from second public draft*)
Science and engineering practices that should be developed by students in grades K–12:
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in Argument from evidence
8. Obtaining, evaluating, and communicating information


Big Idea One: While certain components of scientific investigation are indispensable, science does not always play out in a step-by-step fashion in real life. Instead, the term inquiry method describes the more organic approach scientists take when conducting research. Therefore, what has been taught in schools over the years as the "scientific method" is not a true representation of real-world scientific investigations.

Big Idea Two: A strong grounding in science education includes grounding in three behaviors:
• Scientific Inquiry (investigable questions, collecting data, evaluating data, and communicating evaluation)
• Scientific Argumentation (generates scientific knowledge and its validation)
• Scientific Knowledge (based on observation and inference)
II. The Context (*Mystery of Taiga River: A Science Process & Inquiry Unit*)

*Mystery of Taiga River*, as all Atlantis Remixed narrative games, serves as an illustrative model of our theory of Transformational Play, where the goal is for students to view academic content as tools for solving problems, not as random information they must learn to get through school. As a design theory the goal is to build curriculum that positions PERSON with intentionality, CONTENT with legitimacy, and CONTEXT with consequentiality.

The world of *Mystery of Taiga River* is a 3D virtual space where players are intentionally positioned as agents of change whose purpose is to help a national park suffering from a decline in the native fish population of the river... a problem threatening the park’s very existence. Players soon learn that an application of science inquiry and systems thinking, coupled with understanding of water quality indicators, are all necessary to resolve the game’s narrative conflict.

As the game progresses, players experience how their choices and use of science processes and inquiry dramatically change Taiga National Park, stakeholders in its welfare, and even the students themselves.

III. The Task (Helping Ranger Bartle Decide on the Best Course of Action)

Students find that they have a chance to serve as change agents in *Mystery of Taiga River*, when they are thrust into the role of **water quality specialist**.

In their first activity in the game players are immediately immersed in scientific inquiry as they investigate a hypothesis that acid rain might be the reason for the fish population decline. They gather data, interview employees of the park, and test a water sample from Taiga River for pH levels to explore whether there is sufficient evidence to support that hypothesis. Players soon learn that the evidence does not support the acid rain hypothesis... The mystery has not yet been solved.

They are given tools, both in-game and hard-copy, which will guide them along the way. But ultimately the game experience is in their hands, and each student’s path in *Mystery of Taiga River* is a unique one.

The Remixer Device (left), strapped to the avatar’s wrist, provides hints about where to go next. The hard-copy Field Notebook (right) is created in class and taken to the computer lab each day.
And what is that mystery? Students learn that something has affected the unique Taiga Fish; the population has dropped drastically, which in turn is affecting the rest of the river habitat. Once they rule out acid rain from nearby factories, they have three other hypotheses to investigate: overfishing by the K-Fly Fishing Company, which holds a fishing tournament during spawning season; turbidity from Build Rite Lumber, whose logging practices may be a bit too close to the river; and eutrophication from Green Leaf Farms, where fertilizer and cattle waste might be a run-off problem. They hear a lot of gossip and incriminations from each of these stakeholders, but ultimately, it is the player’s use of science processes and inquiry skills that will solve this mystery!

IV. The Evidence (Gathering data, collecting information)

Students grab their in-game field notebooks and head into the park to begin their investigations of the three major stakeholders.

The evidence that players collect doesn’t have any meaning in isolation, but must be carefully matched with claims in the Chain of Reasoning embedded assessment (see sections V and VI for more about this tool), carefully coded to evaluate their arguments, as shown in a portion of the coding document below.

<table>
<thead>
<tr>
<th>Stakeholder under Investigation</th>
<th>Claim</th>
<th>Evidence</th>
<th>SCORE: Does Evidence Support Claim?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers</td>
<td>Evidence links farm to NITRATE increase</td>
<td>PHOTO: Farming near river</td>
<td>Farm Photo = 3</td>
</tr>
<tr>
<td>Farmers</td>
<td>Evidence links farm to NITRATES increase</td>
<td>Water Sample A: Nitrates data</td>
<td>Farm water nitrates = 0</td>
</tr>
<tr>
<td>Farmers</td>
<td>Evidence links farm to PHOSPHATES increase</td>
<td>Water Sample A: Phosphates data</td>
<td>Farm water phosphates = 0</td>
</tr>
<tr>
<td>Farmers</td>
<td>Evidence links farm to decrease in DO</td>
<td>Water Sample A: Dissolved Oxygen data</td>
<td>Farm water DO = 2</td>
</tr>
<tr>
<td>Farmers</td>
<td>Evidence links farm to ALGAE increase</td>
<td>Sample of algae gathered in river near farm</td>
<td>Algae sample = 3</td>
</tr>
<tr>
<td>Farmers</td>
<td>Evidence links farm to increased eutrophication</td>
<td>&quot;Green Leaf works awfully close to the river. All that manure washing into the river can’t be good!&quot;</td>
<td>Farm Quote (speculation) = 1</td>
</tr>
</tbody>
</table>

In addition to gathering data from stakeholders and documentary evidence, players also collect water samples to test at the Taiga Science Center. But providing cold data in the form of water quality levels doesn't fit the spirit if educational gaming, so ARX takes the learning of water quality indicators even further. Enter the Virtual Fish Tank! While traditional instruction such as science textbooks can do nothing more than TELL students the water temperatures that are safe for particular fish species, Mystery of Taiga River allows players to discover it for themselves.
Additional embedded assessments, like the Lenses of Lumination Goggles (right), guide students in analyzing complex texts to locate more evidence to support a particular hypothesis.

The Taiga Virtual Fish Tank allows students to play around with numbers, looking for the perfect range of water quality indicator they need to support the hypothesis they are working on. They enter a number and run a simulation, which quickly fast-forwards time one year. They examine the health of the fish population at that level, marked by color to show the results. Once they have determined the range of the indicator (such as temperature in this case) that might account for a decline in the fish populations, a CLAIM is generated, and added to their in-game notebooks (below).
V. The Argument (Matching evidence to reasons)

So now the player has gathered interview statements, documentary evidence, photographs, and data from testing water samples. A series of trusted CLAIMS have been generated that might lead to the hypothesis. What's next? Well, the next step is to assemble all of this evidence into a logical argument, in an effort to test whether this hypothesis holds true, not just in general, but specifically for the situation at Taiga National Park. And in the spirit of educational gaming, that means another in-game tool that will help students assemble these pieces into an argument: The **Chain of Reasoning Tool** (CoR).

The CoR is an interactive object that allows students to organize all of the claims into a chain, and then determine if each of those claims holds true for Taiga.

Using an algorithm based on the point value chart (a partial chart was shown on page 3), the tool provides feedback on students' chain of logic, affording the freedom to change and rearrange the evidence into the strongest argument in their effort to prove or disprove the current hypothesis (this is shown in-depth on the next page).

In addition to the evidence/claim chaining activity, students have the in-game help of Abbie, the Taiga National Park Scientist. She explains the value of strongly linked claims and evidentiary support from water tests, photos, and statements related to the park.

These scaffolds to understanding science inquiry and systems thinking are so entrenched in the game that students consider them part of the "play," which is a major feature of the theory of transformational play.
VI. The Products (Embedded and Teacher-Reviewed Assessments)

Students create a variety of products throughout *Mystery of Taiga River*. Some of those products help to scaffold instruction, such as the Chain of Reasoning Tool (described on the previous page and shown below). After players have gathered the data that Abbie suggests for testing a hypothesis, they use the drag-and-drop feature of the trope to build a chain of CLAIMS (purple), and attempt to support each with EVIDENCE from Taiga River and Park (blue). Their chains are scored according to the coding system (see page 4), and they eventually learn whether: 1) they crafted the best chain of reasoning possible from the evidence at hand, and 2) the matches either prove or disprove that the *hypothesis*, leading to a *conclusion* related to Taiga’s problem.

This example of virtual scientific inquiry is repeated four times throughout the game, testing hypotheses that point the finger at nearby factory pollution or the actions of the farmers, fishers, or loggers. When they believe they have enough evidence to blame one or more of these groups for the declining fish population, players report back to Ranger Bartle with their decisions. The ranger asks them to consider how best to regulate the actions of the culprits, and then they are allowed to see the CONSEQUENCES of those decisions (see page 8).

In Atlantis Remixed the final work is delivered through reports or challenges that teachers can review. The culminating challenge in *Mystery of Taiga River* is the players’ understanding of the problem and their explanation of the solution they devised. The report is designed to show Bartle and the Parks Council the processes they followed in this inquiry.

The example on the next page is one student’s report. Notice how the essay shows evidence that the standards have been met.
Written by a student in North Carolina

There were multiple problems with my first hypothesis, regulating only Green Leaf Farms. One problem was that it allowed the loggers to continue to increase the turbidity of the water. The loggers told me that they left a buffer zone on the river bank, but my turbidity tests proved that they were causing erosion, leading to sediment and higher turbidity. The high turbidity of the water raised the temperature of the water to harmful levels. The fish population continued to decline, even with the farmers being limited. All throughout Taiga, the water was darker and more cloudy than it was before because of the turbidity.

My new hypothesis will be to share the blame between Build Rite Lumber and Green Leaf Farms. A poster in the science center showed that the loggers were causing sediment in the river. I tested the water there and found that it is true: too much sediment (turbidity) decreases dissolved oxygen and raises the temperature, which is bad for the fish.

So, I will regulate Green Leaf, but the farmers will be able to continue farming. But the fertilizer's phosphates and nitrates will no longer be allowed to runoff into the river. That will help the fish because there will be higher levels of dissolved oxygen. A few negative impacts of blaming the loggers is that people who worked in their company will lose their jobs and the loggers could go out of business. But I am satisfied that my hypotheses and my regulations are the best for Taiga Park.
VII. The Ramifications (Students confront the consequences of their acts)

The premise upon which Atlantis Remixed is built is that students learn best when they feel they are acquiring useful tools that have direct functional value in the world. Mystery of Taiga River provides that value through a reflexive play space in which students make physical efforts to complete multiple tasks (such as talking to different characters in the space, collecting data), change the space by testing hypotheses and then implementing solutions, and ultimately reflecting on the consequences of their chosen actions.

In Mystery of Taiga River, this consequentiality occurs painlessly, through a device called a "Simulator" that was found in a hidden cavern. Using this device, players set regulations on each of the stakeholders and then visit a "virtual" future Taiga, talking to simulated copies of those stakeholders to see how the players' regulations affected the park. They may repeat this activity as many times as they like, until they have found the correct balance of regulations that not only benefit the fish population and the park, but causes as little harm as possible to the stakeholder groups as well.