OAT SEED LAB: A MODEL SCIENTIFIC EXPERIMENT

SYNOPSIS

Oat seeds are "planted" in a particular environmental context, in the first week of the course, during an intensive introduction to the Nature of Science. Concurrent with that introduction, students record their daily measurements, process those data (graphically and statistically), and prepare a formal report, using sample reports as a model. Introduces the use of a simple statistical tool to measure significant differences.

PRINCIPAL CONCEPT

Processes in science include critical and quantitative observations limited to single variables whenever possible.

ASSOCIATED CONCEPTS

1. Experimental studies must use controls to assure that the effect of a single variable is being measured
2. Biological phenomena typically vary in their expression, requiring statistical analysis for clear interpretation.
3. **Hypotheses** provide generalized expectations or understanding based on logic and previous experience, while **predictions** based on hypotheses point to specific outcomes.
4. Experiment must be a fair test or the hypothesis: results could go either way, but must match or not match the predictions based on the hypothesis, thereby supporting or weakening the hypothesis.
5. Scientific reports must be clear and detailed enough to enable accurate repetition by others.

ASSESSABLE OBJECTIVES (Students will...)

1. Distinguish good and bad examples of controls, hypotheses, predictions, and scientific reports.
2. Recognize an experiment that actually does a fair test of a hypothesis and one that does not.
3. Analyze a graph of data for what it tells us vs what it does not tell us.
4. Analyze what the statistical t-Test tells us, and what it does not tell us.
5. Recognize the appropriate interpretation of different t-values at different levels of confidence.
6. Distinguish "significantly different" from "not significantly different."

MATERIALS

(See **Teacher Notes** for details)

1. Fresh oat seeds (*Avena sativa*), plastic vials, masking tape, marking pens, forceps, paper towels
2. Blocks of wood (or suitable multiple vial holders)
3. Prepared test solution (e.g., a plant food solution, or a 1% salt solution), and tap water
4. Metric rulers
5. **Statistical Significance: T-Test Excel spreadsheet** (for data input and t-Test calculation) on Computer

TIME

About 30 minutes to set up, and 5-10 minutes a day to measure when shoots appear - for about 5 days.

STUDENT HANDOUTS

Oat Seed Lab: Instructions (3 pages)
Results (two Data Tables - 1 page)
Statistical Significance - t-Test: Information and Sample (3 pages)
Statistical Analysis: Data Sheet
Sample Research Report (Including Discussion Format and 2 Sample Discussions (4 pages)

TEACHING STRATEGIES & PREPARATION

See **Oat Seed Lab: Teacher Notes** for details. This longitudinal experiment is intended to be a guided model of a simple investigative study, providing detailed instructions with sample charts, statistical analysis, and examples of final reports. This should serve as an example for any future investigative studies that could be

undertaken by the class or individual students. Set up in the first week of school, it also serves as a vivid experience of a biological process (germination and growth) that many students may have never had, providing a point of reference in later class work in Biology or Life Science. With growth measurements taking only several minutes each day, other lab activities can be done concurrently, labs that illustrate other key components of the Nature of Science that can be selected from the Nature of Science index on this site.

PROCEDURES

1. Optional, day before or day of lab, intro use of metric ruler to measure in mm and cm. See Meaningful Metrics with Dramatic Demos at http://www.indiana.edu/~ensiweb/connections/metrics.con.html
2. On the first Wednesday or Thursday of the semester, have materials 1-4 available to all students. Introduce the rationale for doing this study (read from the **Problem** and **Background** in the **Sample Report**). Demonstrate and describe procedures as described in **Teacher Notes**. Students prepare the vials, plant the seeds, add fluids, and place them in the wood blocks.
3. Friday: have students add more water and test solution (each to level just below lower ends of seeds). Hand out the **Instructions Packet** to read for homework, insert in notebook, and bring each day.
4. First day of measurements (Monday following planting): provide metric ruler and **Results sheet** (with data tables) for each student. Demonstrate how, where to measure, and where to record.
5. Students are to measure each numbered shoot (cotyledon) in mm and record in data tables. Each student should measure and record all shoots that have started growing above the vial's edge, in **both vials**. If a team is absent, a neighbor team must measure those vials. Add water or solution (appropriate for each vial) to maintain proper level. Replace in wood block. Last person in row to return vial to block places block back in assigned spot on windowsill or other lighted area. If time is short, students could just measure their own vial, then copy each other's data for the other vial.
6. Repeat step 5 each day of the week at the beginning of the period (should take only 5-10 minutes).
7. After the next weekend, you may continue measuring for a few days, unless lots of seedlings are so long that they are bending and breaking. When that happens, students make final measurements, and **clean up** the vials: pour out the fluids, pull out the wet towel with the seedlings and discard into wastebasket. Rinse the vials with water, and place upside down to drain and dry in wire baskets.
8. Hand out **graph paper**, and have students prepare their **Summary Tables** and make their **Graphs**.
9. Assign the **Statistical Significance pages** to read for homework.
10. Provide computers with Excel spreadsheet for students to input their last day's data and get their t-Test results. Hand out **Sample Research Report** packet to read for homework. This provides instructions and models for the formal report that each student must prepare, using their team data and the collective results obtained by the other teams. This can be expedited by asking one person from each team to raise hand when you ask for "who got... significantly *faster* growth of experimental seeds," "significantly *slower* growth of experimental seeds," or "*no significant difference* of growth in the two vials." Place the tally results on the board or overhead for each student to record the numbers of teams reporting each kind of result obtained in the class. These data must be included in the report as being from a larger, and therefore more reliable, sample size. All data taken together (team data and class data) must contribute to the discussion and statement of conclusion.

ASSESSMENT: See Assessable Objectives for focus of assessment.

EXTENSIONS & VARIATIONS: See **Alternative Studies** in the Teacher Notes, and see the **Recommendations** at the end of first **Sample Discussion** page. Encourage students to continue (individually or in pairs) with one of the seed-growing recommendations, or even something different, as the course continues, using the materials provided in this model. This could be required, or done for extra credit.

ATTRIBUTIONS: Created by: Larry Flammer, 1966
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