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Exemplary Science: Best Practices in Professional Development

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Knowing and Teaching Science: Just Do It

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Setting

About five years ago, an unusual course—Knowing and Teaching Science: Just Do It—was launched at the University of Tennessee, Knoxville. This state university, founded in 1794, is located in Knox County at the southeastern border of the state. About 28,000 students are enrolled in various programs. “Just Do It” is the product of an atypical partnership between two departments in two different colleges in the university—the Department of Theory and Practice in Teacher Education within the College of Education, Health, and Human Sciences and the Department of Botany within the College of Arts and Sciences. Together, they work to make “Just Do It” a success.

Background

Dr. Leslie G. Hickok, professor of botany/genetics, collaborated with Dr. Claudia T. Melear, associate professor of science education, to design a course in which the emphasis is on long-term scientific inquiry. The result, “Just Do It,” is a graduate-level botany course focusing on research. Professors team up with doctoral students to teach the semester-long course. Any student with at least eight semester hours of college-level science credits is eligible to enroll. However, “Just Do It” was designed especially with preservice secondary science teachers in mind. Consistent with recommendations from the Holmes Group (1995), students must hold or complete a bachelor’s degree in science before beginning their fifth-year teaching internship. According to state licensure stan-

dards, they must further engage in a long-term, open-ended inquiry activity. Because so few students have firsthand, quality experience in scientific research before graduate school (Lave and Wenger 1991; Roth 1995), the preservice teachers are directed by Dr. Melear toward the “Just Do It” course. It is the main means for students to rectify their deficits in scientific experimental design. The course is taught entirely within the botany department, in a laboratory classroom. Students have ready access to basic equipment and supplies for their research projects and may use other equipment within the department as necessary. Careful scheduling of lab facilities usually allows “Just Do It” students to have free access to their classroom at any time, including weekends.

Goals of Science Education and *More Emphasis* Conditions of the National Science Education Standards

The “Just Do It” course was designed to address the four primary goals of science education as listed in the National Science Education Standards (NSES) (NRC 1996):

The goals for school science that underlie the National Science Education Standards are to educate students who are able to

- *experience the richness and excitement of knowing about and understanding the natural world;*
- *use appropriate scientific processes and principles in making personal decisions;*
- *engage intelligently in public discourse and debate about matters of scientific and technological concern; and*
- *increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers.* (p. 13)

“Just Do It” is also designed to prepare science teachers to place more emphasis on particular National Science Education Standards (NRC 1996). The course addresses the *More Emphasis* conditions of the Teaching, Assessment, and Content and Inquiry Standards.

Teaching Standards

At least six of the NSES science teaching *More Emphasis* conditions have been met in “Just Do It.” (See p. 219 for the science teaching *More Emphasis* conditions.) Students grow in knowledge and understanding of the world due to more emphasis being placed on scientific inquiry and the process skills of science. Students actively use these skills in their work. They constitute a cooperative, respectful community of learners in which scientific discussion among students and teachers is the norm. Continuous assessment fosters and enhances all these processes. Finally, because teachers from different departments work together to enhance the content of the course, students understand that shared responsibility and cooperation extend beyond the classroom.

Assessment Standards

No fewer than five NSES assessment *More Emphasis* conditions have been satisfied in the course. (See p. 221 for the assessment *More Emphasis* conditions.) Students become scientifically literate

and able to engage in meaningful dialogue because assessment in “Just Do It” is continuous. Students are given multiple opportunities to critique their own work and the work of others. The primary emphasis is on encouraging the ability to reason and to understand both content knowledge and scientific skills. The goal is for students to achieve a deep and well-structured understanding in a few of these areas.

Content and Inquiry Standards

Content and inquiry standards (see p. 222 for the content and inquiry *More Emphasis* conditions) are the central focus in “Just Do It.” The four goals of science education (NRC 1996, p. 13) are nourished as a result. Students engage in multiple long-term inquiry activities to answer scientific questions, mostly of their own design. They learn subject matter but they also study the nature of science, hone scientific process skills, and use a variety of investigative and learning strategies within the context of actual scientific investigations. Students communicate results of their experiments to instructors and to each other. Results are used to formulate sound scientific explanations and arguments, to design further investigations, and to revise previous ideas. In short, students are actively immersed in real science.

Unique Features of “Just Do It”

Teaching, Content, and Inquiry Activities

The first major portion of the “Just Do It” course centers on learning to design experiments with a professional scientist (Melear et al. 2000). The goal is to provide students with opportunities to engage in long-term inquiry activities that closely resemble those encountered in actual scientific practice. These activities include engaging in extended inquiry activities; developing process and inquiry skills and strategies; communicating scientific evidence, arguments, and conclusions; and working in groups to evaluate and synthesize experimental data. Similar experiences have been shown to improve high school students’ inquiry process skills (Bell et al. 2003).

On the first day of class, “Just Do It” students are given 10-mg samples of spores from an organism known as C-Fern, a cultivated variety of the tropical fern *Ceratopteris richardii*. Wild-type organisms, as well as a variety of others with all sorts of genetic variations, are readily available from biological supply companies (e.g., Carolina Biological). A website is available to assist teachers with use of C-Fern in their classrooms (<http://cfern.bio.utk.edu>). The organism is very easily cultured and requires nominal care. Details from the life cycle are easily observed with minimal magnification. C-Fern completes its life cycle, under ideal conditions, in as few as 90 days (Hickok et al. 1998).

In addition to the C-Fern, students are supplied with nutrient agar, culture containers, and other basic supplies. They are given few guidelines for the activity; they are asked simply to “find out something about the organism.” They mostly use common materials and supplies within the lab, such as light microscopes, dissection scopes, petri dishes, and growth lights. However, students are told to consider their supplies and materials unlimited, unless instructed otherwise. From these rudimentary beginnings, students embark on an eight-week-long series of individual and group experiments during which they mostly pose and answer their own questions.

For example, students may elect to study the life cycle of the fern. They may design investigations to explore reasons for the presence of the two different growth forms of the plant (male and hermaphroditic gametophytes) or they can study the effect of temperature, growth density, or other environmental variables on the life cycle of C-Fern. Some students, depending on their research questions, may be covertly given genetic mutants of C-Fern, such as salt-tolerant varieties, to enrich their research activities.

During the course of their investigations, students learn a variety of science content. In a typical class, students and instructors consider evidence from the C-Fern inquiry activities as they build knowledge about, for example, life cycles of organisms, growth requirements of ferns, genetic variation and transmission, and pheromones. The important point to remember is that the students' own experimental evidence must be used to make and support claims and conclusions.

Through their work with Dr. Hickok and their collaboration with one another, students also learn many process skills and techniques. A research scientist places a great deal of emphasis on how traditional scientific paradigms (Guba 1995) deal with evaluation of evidence and scientific claims. In "Just Do It," students are taught, within the contexts of their investigations, about sample size, replication of findings, what counts as evidence, good and bad scientific practices, and so forth. Specific laboratory skills are acquired as the need arises. Students learn how to properly use a microscope and prepare slides, how to prepare laboratory solutions, how to sterilize spores and equipment, and how to prepare culture media. A case in point is the procedure for sterilizing C-Fern spores. Students are initially given nonsterilized spores that will almost invariably produce cultures rampant with mold contamination. As students discover the presence of both mold and fern gametophytes in their culture dishes, they are led by the instructor to consider their results (Which organism is the unknown? Are you sure that is mold? How do you know that? How could you provide evidence that it is contamination?). Then, a few students are taught to sterilize spores with a bleach solution and to teach others to do so.

About midway through the course, the focus begins to shift slightly. Students use their growing competence in designing and carrying out scientific investigations to consider the role of inquiry in their future careers as teachers. The science educator, Dr. Melear, provides students with new choices of research organisms. She asks students to begin inquiry activities with these organisms and to use their experiences to design inquiry-based lessons appropriate for high school students. In most cases, simplicity of materials is the key. As a rule, the organisms that are selected for use have short life cycles and quick germination times and are easily maintained and/or require little in the way of expensive care. Students are often given a supply of cups and other containers, potting soil and seeds of various types (ryegrass, wheat, clover, sunflower, and many others) and asked to go to work. Materials of these sorts are widely available from biological supply companies, garden centers, and shopping centers. Students may use these supplies to study environmental effects on the growth, germination, and reproduction of plants; to compare the growth of various plant species under varying treatments; or to explore other areas of interest to them. Class instructors often supplement these inquiry opportunities with other organisms. Mealworm (*Tenebrio molitor*) larvae, isopod cultures, earthworms, and other types of organisms may be made available. In some cases, students supply their own organisms if they have particular interests they would like to explore. In short, students are free to choose their research

organisms, research questions, and methods. Once again, they learn content, skills, techniques, and methods collaboratively and within the context of their research.

Assessment Methods

Assessment is designed to match the students' "Just Do It" experiences and to be typical of assessments encountered by professional scientists. There is a shift from summative (end of activity) paper-and-pencil tests toward formative (ongoing and guidance-providing) assessments. Two categories of evaluation, described by Enger and Yager (1998), are central to the "Just Do It" assessment philosophy. First is authentic assessment, in which the assessment activity is tied to the learning activity and may be performed by actual practitioners. Second is performance assessment, in which the assessment activity requires that the student transact some skill or task related to his or her learning. As a general example, students who have completed an inquiry activity concerning sound may be asked to build and demonstrate a musical instrument as an authentic and performance-based assessment. Throughout the course, numerous authentic and performance-based assessments are used to provide a clearer picture of student achievement and progress. Because the goal of "Just Do It" is to help students become adept at inquiry, with process skills, and in scientific reasoning, the assessments are selected with these outcomes in mind.

Students are almost constantly involved in the critical evaluation of scientific research during the course. This begins, of course, with the instructors' insistence that students present evidence from their own experiments to back up their claims and conclusions. This quickly spreads to self- and peer evaluation of the evidence. Formal and informal discussions about the students' ongoing research make up much of the formative assessment. A typical exchange between students and one of the course instructors, Dr. Hickok, is represented below. It is noteworthy that students are encouraged to develop their own terminology as they discover aspects of the C-Fern life cycle (Lunsford 2002/2003). (All student names are pseudonyms.)

Alice: We've found there are two growth forms, the rice [male gametophyte] and the cornflake [hermaphroditic gametophyte].

Dr. Hickok: A genetic difference? Has anybody proven that?

Alice: You'd see a developmental difference if it was. We didn't.

Sara: It seems to be environmental, the difference.

Greg: How many did you do?

Alice: We used 18 spores.

Dr. Hickok: Do you think that's enough?

Greg: Well, according to our results it would be. It was consistent.

Dr. Hickok (turning to another group): What was the sample size and treatment in Alice's group?

Richard: Their treatment was 1 spore in a dish of agar by itself. They had 18 individual dishes. Ours was 10 spores in 6 dishes. We put sterilized spores in each dish.

No grades are assigned to these informal but critical discussions of evidence. More formal types of evaluation, summative and graded, also are used. As the students come to a better understanding of the nature of science, they are asked to seek out and critique a scientific research

paper that is of interest to them. Other students join the discussion as the evidence, methodology, and claims from the paper are considered with the critical eye of science. Students also

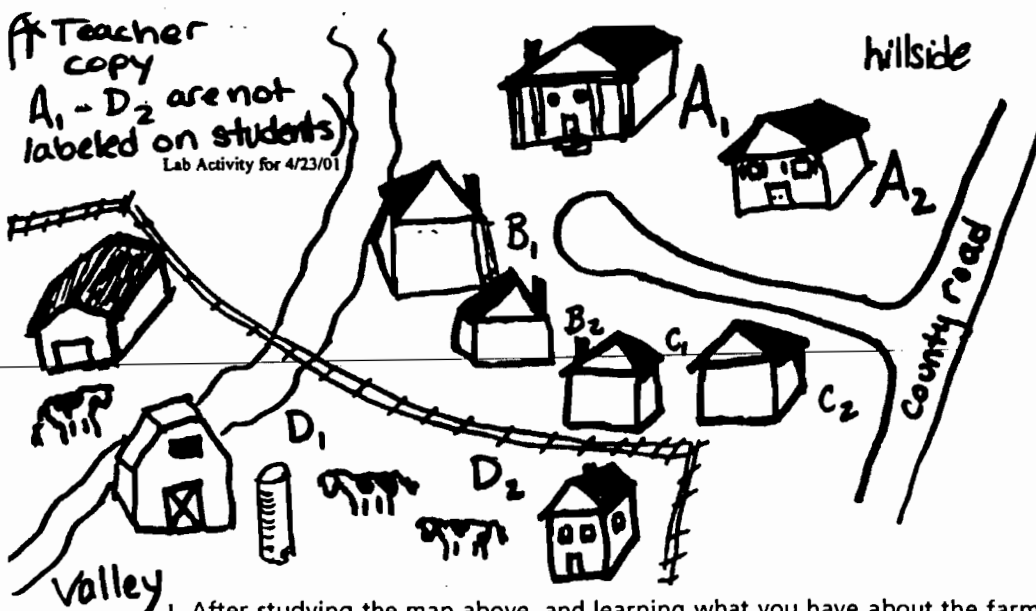
Figure 1. Rubric for Evaluating Written and Oral C-Fern Reports

| Components of Report | Points | | | |
|--|---|---|---|---|
| | 4 | 3 | 2 | 1 |
| Introduction— <i>justification and background</i> | Clearly presents the basis and rationale of the experiment, along with any background material that is appropriate. | Only partially presents the basis and rationale of the experiment. | | Does not present the basis and rationale of the experiment. |
| Materials and Methods— <i>experimental design</i> | All variables are properly identified and dealt with. The experimental design is adequate; it includes data to be collected, controls, techniques used, and an adequate number of replicates. | Only some of the variables and design issues are correctly identified and dealt with. | | None of the variables and design issues are properly identified and dealt with. |
| Results— <i>presentation of data</i> | Complete and adequate. Tabular and/or graphic representation of data where appropriate. | Only partially adequate; graphic and/or tabular data are not clearly represented. Some components are omitted or improperly identified and/or presented. | | Description of results is totally inadequate. |
| Discussion— <i>analysis and interpretation of outcomes</i> | Appropriate interpretation and discussion of the outcomes of the experiment. Possible implications/further experiments are proposed. | An adequate interpretation of the data is presented, but it is not related to possible implications or additional experiments are not suggested. . . OR vice versa. | | The data and implications are not adequately discussed. |
| Oral— <i>overall verbal and visual presentation</i> | Excellent use of visuals and clear, well-rehearsed, and enthusiastic presentation. | Presentation adequate, but there is considerable room for improvement of verbal and/or visual portions. | | Unorganized verbal presentation with ineffective use of visuals. |
| Written— <i>grammar and language use</i> | Grammar/language use is very adequate. | Grammar/language use is inconsistent or somewhat inadequate. | | Grammar/language use is generally poor. |

present, orally and in writing, formal accounts of their research with C-Fern. A rubric is used by the instructor to help quantify various components of written and oral scientific presentations (Figure 1). The presentations allow students to publicly communicate, evaluate, and synthesize their scientific findings and knowledge, and often lead to further investigations. Students are allowed to revise their written papers as many times as they wish.

Formative assessment, of the types described above, also continues as the students engage in their second round of inquiry activities, using other organisms. Summative assessment of this activity requires that all student groups present to their peers an inquiry-based science lesson, suitable to high school students and based on their lab work. Students must use the 5E learning cycle (Trowbridge and Bybee 1995) as they design and carry out their inquiry lessons. During these lesson presentations, students may involve other members of the class by asking them to prepare laboratory solutions, evaluate data from an experiment, graph class data, or make recommendations as to how inquiry results may be applied to real life. In one case, for example, students grew ryegrass (*Lolium multiflorum*) in varying concentrations of urea to simulate runoff from fertilizer. They presented the plants to the class, along with the map shown in Figure 2. Students were asked to correlate the ryegrass samples with growth locations on the hypothetical map. This led to discussions of land use within the context of the students' evidence.

Figure 2. Alice and Veronica's Lesson Presentation Map



1. After studying the map above, and learning what you have about the farm and the newly developed subdivision, within your group, discuss the potential cause of the problems.

Another major component of assessment in the course involves the notion of scientific inscriptions. Inscriptions are written, electronically produced, hand-drawn, or otherwise preserved representations of scientific knowledge and thought (Latour and Woolgar 1979; Roth and McGinn

Figure 3. Rubric for Evaluating Student Inscription Notebooks

Evaluation Sheet
Laboratory-Inscription Notebook

Your laboratory-inscription notebook will account for 10% of your total course grade. Listed below are the criteria upon which your notebook will be evaluated. Your completed notebook will be due _____. At that time, please hand in all carbon copies to me, along with this sheet. I would like to look over your notebook periodically, at least two or three times, throughout the course as well. I encourage you to frequently exchange and share your carbon copies within and between your lab groups too. Be sure to get all of your own carbon copies back, and organized into a completed notebook, before the due date. Please feel free to ask me any questions concerning this assignment that you have. You may ask me in person or by e-mail.

| Criteria | Absent | Poor | Fair | Adequate | Good | Excellent |
|---|---------------|-------------|-------------|-----------------|-------------|------------------|
| <i>Total number of Inscriptions</i> (50 inscriptions = adequate) | 0 | 2 | 4 | 6 | 8 | 10 |
| <i>Neatness and Clarity</i> (e.g., labeling of figures, listing names of partners, dates, references to other pages, units of measurement) | 0 | 2 | 4 | 6 | 8 | 10 |
| <i>Transformation Cascades</i> Combining simpler and less abstract inscriptions (e.g., lists, Vee diagrams, sentences, drawings, photographs, maps, tables) into more complex and abstract ones (e.g., concept maps, graphs, composite drawings, equations) (8 cascades = adequate) | 0 | 6 | 12 | 18 | 24 | 30 |
| <i>Social Use of Inscriptions</i> Share ideas, data, methods. Document meetings within and between groups. Use others' ideas in your own inscriptions. (8 uses = adequate) | 0 | 6 | 12 | 18 | 24 | 30 |
| <i>General Improvement Over Time</i> (e.g., choice of material for inscriptions, better quality, increasing incidence of social use, and transformation of inscriptions) | 0 | 4 | 8 | 12 | 16 | 20 |
| Total Points (100 points max) | | | | | | _____ |

1998). They may take the form of lists, photographs, graphs, tables, charts, and maps, for example. Early in the course, students are given minimal instructions about the various types of scientific inscriptions and their uses in professional science. They are required to maintain a notebook of inscriptions in order to document their observations, methods, results, and conclusions throughout their inquiry experiences. The laboratory notebooks are constructed to allow students to make at least one carbon copy of each handwritten inscription they generate. They may then easily share their inscriptions with others in the learning community, fostering the collaborative nature of the class and helping students and instructors to monitor progress in scientific reasoning. The students use their inscriptions to display, summarize, and evaluate their evidence; to consider future experiments; and to argue their claims in class discussions, presentations, and written papers. Students are graded on the total numbers of inscriptions, on the social generation and sharing of inscriptions, and on transforming (Roth and McGinn 1998) basic, concrete inscriptions (such as written statements, tallies, and basic diagrams) into more complex, abstract inscriptions (tables, graphs, equations, complex diagrams) as the course progresses. The rubric used to evaluate student-generated inscriptions is shown in Figure 3.

Students also maintain a reflective journal in which they make at least weekly entries about affective experiences in the course. They are asked to consider if/how their thinking changes regarding the nature of science, science process skills, abilities to work with a group, and so forth. They are often given writing prompts such as, “How much do you understand about what you are supposed to be doing?” and “Is this course similar/dissimilar to previous science courses?” The reflective journal helps students monitor their understanding of science and of process skills. Entries are regularly shared with an individual (usually a science education graduate student) who provides feedback and suggestions. The science instructor does not have access to the reflective journals until after the class has ended.

A summary of the assessments used in “Just Do It” is presented in Figure 4. Figure 5 presents a summary of some of the students’ thoughts on how they were assessed. Data were derived from reflective journal entries and from interviews (Lunsford 2002/2003).

Figure 4. Summary of Assessment Methods Used in “Just Do It”

Summative Assessment

(assigned a numerical point value)

- Presenting summaries of scientific research papers
- Keeping a reflective journal (also used as formative assessment during the course)
- Giving a written and oral presentation on C-Fern
- Maintaining a Laboratory-Inscription Notebook (also used as formative assessment during the course)
- Designing and presenting an inquiry-based science lesson

Formative Assessment

(not assigned a numerical point value)

- Defending methods and conclusions to course instructors

Figure 5. Summary of Affective Comments Relating to Assessment

- "Having to defend your work to a fellow scientist is not a personal attack on you. It feels natural with practice. Also you should look at your own work and the work of others more critically."
- "I think the assessment really reflects my work."
- "There were no tests like in my other classes."
- "What we did was more valid than a test would have been."
- "The laboratory-inscription notebook was very valid. It was hard to know what to record at first and I was worried about having enough inscriptions. As time went on, it became more natural to record inscriptions."
- "I liked the rubrics."

Evidence for "Just Do It" Effectiveness

Figure 6 provides a general summary of the sorts of things students learn during their "Just Do It" experience. Some examples of, and evidence for, student learning in the course have already been presented. To review, students use actual laboratory experiences to gain an understanding of basic laboratory skills such as the preparation of reagents. During the course of their observations and investigations, they study topics such as metamorphosis, plant reproduction, and plant growth requirements. The course focuses on science as inquiry, unifying concepts and process skills, the nature of science, and science in personal and social perspectives. Since the course uses living organisms for inquiry purposes, it naturally provides opportunities for students to study a variety of content from the life sciences; other content standards, such as Earth and space science, science and technology, and physical science, are often studied in the context of inquiry as well. For example, past "Just Do It" students have considered soil profiles, light, weather patterns, chemical reactions, and biogeochemical cycles in conjunction with their inquiries. Students routinely use computer technology to assist them with the production of graphs and other inscriptions. Also, the class frequently maintains an internet website, allowing for discussions and the posting of results discussion. Some lines of evidence for the effectiveness of the course are quite surprising, considering that students in the course almost invariably hold a degree in science. Many of these graduate students are unable to correctly use a microscope when they enter "Just Do It" (Melear et al. 2000). In another surprising case, one student reported that he thought "bugs" might have been inexplicably falling into his mealworm culture. This good student could have recited a brilliant definition of *metamorphosis* on entering the course. However, he and others made great strides in correcting their misconceptions by the end of the class (Lunsford 2002/2003).

Morgan: I learned some valuable information about my mealworms. For the longest time, I have thought that my worms have been drying out and dying. This was so wrong. They shed their exoskeleton in order to grow. I had never considered that to be what was going on.

Other students built inscriptions concerning their observations of their mealworm cultures. They correctly worked out the life cycle by way of collaboration and sharing of evidence. Phillip

Figure 6. Summary of Student Learning in “Just Do It”**Content (Partial List)**

- C-Fern life cycle
- Alternation of generations
- Pheromone signals in development
- Plant growth requirements
- Preparation of laboratory solutions
- Preparation of wet mounts with stains
- Use of microscope
- Metamorphosis
- Biogeochemical cycles
- Effect of chemicals on plant growth
- Effect of soils on plant growth
- Effect of other environmental variables on plant growth
- Sterile technique
- Genetic transmission of traits
- Careers in biology
- [Many others depending on student inquiry projects]

Scientific Skills

- Posing good scientific questions
- Designing and carrying out an experiment
- Interpreting evidence in science
- Importance of replication, control, and operational definitions
- Communicating scientific evidence
 - Preparation and use of inscriptions
 - Writing a scientific research report
 - Oral presentations of evidence
- How to do a literature review
- Recognizing good and bad scientific practices

Pedagogical Skills

- Preparing inquiry lessons
- How to teach by way of inquiry
- Using group work and cooperative learning
- Teaching techniques in lieu of lecturing

made a discovery that tied all the evidence together and ended the mystery: “Pupae are starting to emerge. They look like little white beetles” (Lunsford 2002/2003). Contrary to results reported by researchers such as Barnett et al. (2001), “Just Do It” students routinely used their own inscriptions to argue the efficacy of their results and to share their findings during formal and informal presentations. They made, used, and understood inscriptions that were a mirror of their research. Some inscriptions, such as graphs, were abstract representations of the students’ experimental data but were used in ways that linked them with the students’ work.

One of the most obvious lines of evidence for the effectiveness of “Just Do It” lies in the students’ improved ability to design, carry out, and interpret sophisticated experiments with the passage of time in the course. By the end of the typical “Just Do It” experience, students are able to design experiments that use evidence to demonstrate such things as various aspects of plant life cycles, transmission of genetic traits, chemical developmental signals, and the effects of varying environmental conditions on plant growth (Hickok et al. 1998; Lunsford 2002/2003).

Students typically enter the course with the ability to verbalize well-articulated notions of experimentation, sample size, control, and replication. However, despite their extensive academic backgrounds in science, they almost invariably fail in their initial attempts to actually “do it.” In other words, the students can talk about doing an experiment, but initially lack the ability to do so. In a recent analysis of “Just Do It” students, Lunsford (2002/2003) found that the students’ ability to design and carry out sound and successful experiments increased during the course. Multiple experiments were evaluated from 10 students, organized into four cooperative work groups. In the first experiments, only one group had a control and none had a well-designed research question. Most students left operational definitions and details on methods open to the imagination. By the end of the class, however, students had improved these abilities dramatically. Students’ final experiments all included replicated controls and focused on a single,

well-stated research question. The students included detailed operational definitions that would allow for easy replication of their procedures by other researchers. They also used multiple replicates in their experimental groups.

The students attributed this dramatic shift in their ability to engage in inquiry to several factors. They all agreed that their experience with Dr. Hickok was a primary factor. Further, they stated that the ability to actually do real science helped as well. They also identified the collaborative nature of the class and their production and use of scientific inscriptions as benefits toward their gaining competence in inquiry. Many students related that they began to “think like a scientist.” Some additional student comments are shown below (Lunsford 2002/2003).

- Alice:* [Dr. Hickok] was able to direct us throughout the experiment. He knew the right questions to ask. He would direct us [but] really forced us to do it on our own.
- Veronica:* You don't get answers to your questions, you get questions to your questions. We are so used to...having the cookbook recipe of an experiment and not having to actually think on our own.
- Sara:* The journal club presentation was a great idea because we got to see exactly what a real scientific paper is and what research should look like.

One other critical measure of the success of “Just Do It” remains to be thoroughly evaluated; it will be the subject of future research by the authors and others. A primary goal of the course is to prepare preservice science teachers to teach their own students by inquiry. Since the course is relatively new, detailed data on this measure of success are scant. “Just Do It” students clearly learn inquiry techniques and skills. However, the question regarding their ability to transfer these skills to their own classrooms remains completely unanswered at this time. Brown (2002) has completed the only longitudinal study of the effects of “Just Do It.” She evaluated eight students who took the course in the first three cohorts. These individuals, now teachers, had one to three years of teaching experience at the time of her study. Two instruments are pertinent: the Salish I Research Project's Secondary Teaching Analysis Matrix (STAM) (Simmons et al. 1999) and the Teacher Pedagogical Philosophy Interview (TPPI) (Richardson and Simmons 1994). Simmons et al. (1999) document the three-year national study of science teacher preparation programs (Salish I Research Collaborative [1997] and Salish I Research Project Supplement [1997]). Using the STAM, an instrument that measures actual classroom behavior of teachers with a schema drawn from both teacher-centered *conceptual* inquiry and the TPPI, Simmons et al. (1999) reported a stark contrast between new teachers' ($N = 60$) student-centered beliefs and their teacher-centered actions. The teachers espoused their belief in inquiry, student-centered teaching, but their behaviors did not support their beliefs. Even though some reported a traditional research experience in the laboratory of a scientist, prior to the study, Salish I teachers had no comparable research experience like that in the “Just Do It” course.

Brown (2002) found that “Just Do It” teachers, while also showing mostly teacher-centered teaching behaviors, were aware that they were teaching in this *conceptual* rather than inquiry-oriented manner. We believe that it is too early in the teaching careers of these participants to accurately measure what effects their preservice preparation (i.e., the “Just Do It” experience)

Figure 7. Ways in Which “Just Do It” Meets NSES Science Teaching, Assessment, and Content and Inquiry *More Emphasis* Conditions

Science Teaching

- Course consists of long-term inquiry with living organisms.
- Students present and debate the results of their own experiments.
- Assessment occurs throughout the course.
- Group work is emphasized.
- Scientists and science educators designed the course.
- Research questions come mostly from students’ interests and needs.

Assessment

- Students assess their own work and that of peers.
- Evidence from inquiry activities is used to back up claims and conclusions.
- Emphasis is on process skills of science.
- Content learned relates to inquiry activities.
- Inscriptions are based on inquiry activities.
- Both formative and summative assessments are used.

Content and Inquiry

- Most class time is devoted to student-generated experiments.
- Students use and contribute to a course website.
- Emphasis is on life science with opportunities to explore other content areas within the inquiries.
- Students communicate, synthesize, and defend their findings.
- New questions are generated from the students’ own work.

might have on teaching by inquiry. The fact that these new teachers are more aware of the match between their teaching philosophy and their teaching behavior is an indication that, if they choose to move toward more inquiry-based instruction, they have the skills to do so. That is, they have the self-awareness necessary for deliberate behavioral change.

Summary

Knowing and Teaching Science: Just Do It is a unique and effective learning experience in teacher preparation. The semester-long course provides students with the firsthand, detailed, long-term exposure to scientific inquiry that is so often lacking in their other science courses. By “just doing it,” students become adept at planning and carrying out scientific investigations. They learn scientific content and are assessed by methods that are more closely in line with the work of an actual scientist. Students learn about alternative ways to teach and assess their own future students. A summary of the ways in which “Just Do It” helps to make the NSES *More Emphasis* visions come to life is offered in Figure 7.

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