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FISH BRIEFS AND BUCKETS OF FISH: CONFORMING ICHTHYOLOGY TO NEEDS OF STUDENTS WITH NATURAL RESOURCE CAREER PATHS

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ABSTRACT: Traditional ichthyology courses often focus on objectives related to fish evolution and skills required for museum work. Students in natural resource disciplines often perceive these objectives and skills as having little relevance to their future careers. In some ichthyology courses, memorization of fish taxonomy and phylogeny may outweigh emphasis on the development of critical thinking skills. Guided by objectives to develop critical thinking and information gathering skills, we have developed two instructional methods that incorporate the practical needs of students in natural resource disciplines without sacrificing important subjects in the ichthyology course offered at Michigan State University. The first method consists of a requirement to write two brief papers (500 words or less) that address a specific question of interest to the student. The objectives for this assignment are to develop professional skills involving information retrieval and interpretation and to write a concise, but thorough product. Students are given specific requirements for format and information quality, and are provided assistance in focusing the question so that it is answerable in a brief format. First drafts go through a peer review process to check on aspects of clarity, conciseness, and completeness and students may incorporate the comments and revisions in the final draft. In the second exercise, Buckets of Fish, students are presented with specimens from the Great Lakes fauna (100 species) and are assigned to learn to identify these species with identification keys provided by the instructor. They have four laboratory periods to study specimens and then four examination periods to demonstrate their proficiency in identifying a collection of these species. In the examinations, students work in two-person teams and have one laboratory period to identify a collection of fish specimens in a jar of unknowns. This exercise is meant to simulate the experience of bringing a sample of fish back from the field and then identifying the fish in the sample. Student proficiency in identification increases through the examination series. In both of the instructional methods, the relevance and focus of the assignment generated greater student interest in learning information basic to an ichthyology course, and developed critical thinking and technical skills needed for students directed towards research or natural resource management career paths.

INTRODUCTION

Natural resource professionals require a solid foundation in the biology and ecology of the organisms that form the basis of renewable resource use and management. Most fisheries and wildlife curricula require students to complete at least one advanced course in the study of a group of vertebrates. Traditional ichthyology, ornithology, mammalogy or herpetology courses focus on the anatomy, physiology, behavior, systematics, distribution and evolution of the targeted vertebrate group. Laboratory exercises typically emphasize skills required for museum work at the expense of field skills (*cf.* Caillet et al. 1986). Detailed morphometrics and meristics exercises, and quizzes over taxonomy and species recognition can be tedious and repetitious, and students in natural resource disciplines often perceive these skills as having little relevance to their future careers. Similarly, emphasis in lecture on memorizing phylogeny and the finer points of biogeography may outweigh an emphasis on the development of

information gathering and critical thinking skills which are needed for careers in natural resource research or management.

In response to repeated requests from natural resource students to make ichthyology more relevant to their interests and career aspirations, we have incorporated several new techniques in the ichthyology course offered at Michigan State University. These adjustments were intended to meet the objectives of challenging students to develop skills that they want to develop, and to do so in a way that is appealing to the students, and does not sacrifice the content needed in a course on the biology of fishes.

In particular, we were interested in techniques that would develop information gathering and critical thinking skills in connection with the lecture portion of the course, and fish identification skills in the laboratory portion. These are in contrast to exercises that we used previously that emphasized

memorization of information dispensed in lectures and memorization of distinguishing traits of fish species, along with their common and scientific names and their habitat requirements. We were guided in part by research that demonstrates that testing formats which emphasize understanding and self-motivation rather than memorization of details lead to better retention of learned information (Marton and Saljo 1976).

INSTRUCTION AND ASSESSMENT METHODS

Ichthyology (Fisheries and Wildlife 471) is a four credit semester course at Michigan State University. The class meets for three 50 minute lecture/discussion periods and one 170 minute laboratory period each week. As a 400-level course, it draws junior and senior level undergraduates and some graduate students. Most students are pursuing majors in Fisheries and Wildlife or Zoology.

Fish Briefs

The exercise that was intended to develop information gathering and critical thinking skills is called "Fish Briefs" in the course syllabus, and consists of a requirement to write two brief papers (500 words or less) that address a specific question of interest to the student. This is designed to simulate a work-related situation in which a citizen calls the local fish and game agency office and asks a specific question about fish. The circumstances might be a junior high school student who is pursuing a potential science fair project, an adult who is trying to settle a debate with a fishing buddy, or a television viewer who believes that some nature program has just transgressed the truth of nature.

Students are given a list of over 100 questions from which they may select their choice for the assignment. They may also pursue a question of their own interest, providing the instructor gives prior approval based on its relevance and conciseness. The questions are divided into two categories: organismic or evolutionary/ecological, and are wide ranging in topic (Table 1). Each student is required to submit one brief on a question from each category. The two briefs account for 17% of the course grade.

Table 1. Examples of questions for Fish Briefs exercise.

Organismic Questions:

- How do scales influence the swimming efficiency of fish?
- What is the function of the axillary process in herrings and salmonids?
- Which is the more hydrodynamically efficient form of ventilation, ram or buccal ventilation?

Evolutionary/ecological Questions:

- Do bluegills select prey on the basis of actual prey size or apparent prey size?
 - Why is parental care exhibited by males in more species than by females?
 - What has caused the rapid extinction of so many cichlid species in Lake Victoria, Africa?
-

Students are given instructions in how to research questions such as these by use of primary and secondary scientific literature. Each brief must cite a minimum of four references, two of which must be primary sources. In addition, the briefs are evaluated on the basis of accuracy in representing the literature, completeness in addressing the answers likely to be found in the literature, and conciseness (no more than 500 words). Format, sentence and paragraph structure, and grammar are considered in the grading, but are weighted less than the other four criteria.

Students participate in a peer review process before submitting their brief for evaluation. They use a review form to structure the process, after the instructor describes the process, rules of conduct, and criteria for guiding the review (Table 2). Reviewers are required to summarize their review with three constructive recommendations, and authors are required to respond to these recommendations in a form that accompanies their final draft. They may incorporate the comments and revisions from the peer review into their final draft, or may decline to incorporate them, but they must explain their reasons in the event that they decline to follow their reviewer's advice.

Table 2. Framework provided for students using the peer review process to preview Fish Briefs.

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- A. Purpose of the Review Process
 - To provide second view on and improve structure & organization content assessing : completeness, conciseness, accuracy, authoritativeness, analysis, and logic.
 - B. Rules of Conduct
 - 1. Provide constructive criticism, respect the author's work, and assume credibility
 - 2. Ask questions rather than giving answers
 - 3. Suggest alternatives
 - 4. Provide at least 3 recommendations for improvement
 - 5. Do not plagiarize
 - C. Protocol for Review
 - 1. Use groups of 3 for review and proceed in a round-robin fashion
 - 2. Read paper thoroughly first, then go back and review
 - 3. Present review to both the author and third person in the group
 - 4. Complete all 3 presentations for the group

5. Write down the 3 recommendation on review and return to author

D. Protocol for the Author's Final Draft

1. Consider and address various comments of the reviewer
2. Make necessary changes, including additional literature review if necessary
3. Address the 3 recommendations on the provided review form
4. Turn in the final draft and the review form but not the rough draft

Our evaluation of the Fish Briefs exercise consists of observations from 8 years of using this exercise, along with comments from student evaluation forms completed at the end of each term.

Buckets of Fish

The Buckets of Fish exercise is designed to develop fish identification skills in a setting that simulates a common task for a fisheries biologist in the field: identifying all of the fish in a sample taken from a lake or stream. Students prepare for the exercise in a series of four laboratory sessions. The purpose of these sessions is to introduce students to the diversity of the Michigan fish fauna, and to give them practice with the identification tools that they will use in their quizzes. Students also have practice quizzes to use in testing their skills during the period. The practice quizzes are small collections of 12 – 16 fish that represent a variety 5 – 8 species. They can receive answer keys to the practice quizzes after completing the quiz. After the four survey laboratory sessions, students have a quiz in laboratory period in each of the next four weeks. Students work in two-person teams on the quizzes, and teams remain fixed for the four quiz series. For the quiz, each team is given a bucket of preserved fish specimens, and is assigned the task of identifying all 30 fish in the bucket. The number of species in the bucket ranges from 10 to 17. Teammates must work together, but they have the option of turning in separate and disagreeing answer sheets. Students are allowed to use their notes and keys, as well as any other reference book in the laboratory classroom. The answer sheet must consist of the scientific name (spelled correctly) of each species and the number of fish representing that species in the bucket. Family names are required for each species as well. Each fish in the bucket is worth 1 point, but to earn that point, the family name and species name must be completed.

To evaluate the Buckets of Fish exercise, we present data on responses to questions on a standardized University student evaluation form and on student performance on quizzes. In both cases, we compare results from years when quizzes required students to memorize fish identity and nomenclature (1992-1994) with years when the Buckets of Fish quizzes were applied (1995-1997). In addition, we tested for increased competency with experience by comparing mean quiz scores for

the class from the first to the second and last quizzes of the series in each year.

RESULTS

Fish Briefs

The Fish Briefs exercise has been an effective means of developing students' information-gathering skills, critical thinking skills, and their writing skills. The information-gathering aspect has been particularly dynamic over the past eight years. Each year, the guide to finding information in the literature has required revision in order to accommodate new technological tools for finding information in scientific literature. From 1989 to 1997, the guide has changed from being strictly a guide to use of card catalogs and published abstracting services to a guide for use of CD-ROM, World Wide Web-based searches and other technological aides.

Critical thinking is required of students to evaluate which materials are pertinent to answering the question, and to discern between alternate explanations. They feel compelled by the context of the assignment to have a single answer to the constituent's question, yet they dare not overlook the multiplicity of explanations available for fear of being graded down on completeness. The peer review process and feedback from the instructor help to further develop the students' abilities to evaluate alternate answers to a question.

By far, the greatest challenge to the instructor in this assignment is the need to grade and provide useful feedback to students in a timely manner. In particular, students seek feedback quickly so they can incorporate instructor suggestions in their second brief assignment, which is due four weeks after the first brief. Students address this in their comments on course evaluations at the end of the semester, and frequently state that they would have learned even more from the assignments with faster return of their graded assignments.

Aside from the timeliness of feedback, most student comments on the Fish Briefs are positive. Comments collected from 113 students from 1992-1996 regarding the fish brief assignment ranged from a single critical comment:

"...this is a 400 level course, by now we know how to use the library, find journals, etc....."

to dozens of positive comments, such as:

"The fish briefs are good and two is a good number."

"The fish briefs were work, but really a good way to learn to use the library resources... Having to research subject matters is a good way to learn...most of that information will stick."

“Fish briefs were very good learning exercises”

“The library assignments (fish briefs) helped me a lot with learning the library, although at times it was a pain”

“Fish briefs greatly advanced knowledge of research techniques”

Buckets of Fish

Student performance on fish identification quizzes improved after adoption of the Buckets of Fish model. Quiz scores from the years 1992-1994 (pre-Buckets), standardized to a 100 point scale, were significantly lower (82.43) than in the years 1995 – 1997 (Buckets), 88.61 ($t = -2.708$, d.f. = 27, $p < 0.01$). The variance of scores for the pre-Buckets years was nearly twice that of the Bucket years (49.55 vs. 29.43), largely due to the fact that most teams submitted one set of answers for the team, rather than splitting their answers apart. Furthermore, students showed definite improvement with experience in the Buckets of Fish model, but not in the previous model. The mean difference between the first and last quiz score in the series was 0.53 in the pre-Buckets period, but increased to 6.52 in the Buckets period. Much of the improvement during the Buckets period was between the first and second quiz, when scores increased by 4.11 points.

Another indication that student performance improved with experience in the Buckets period is the decrease in the time needed to complete the quiz from the first to the last quiz of the series. We only collected time data on quizzes in 1997. The mean time to complete the first quiz was 134.1 minutes and for the last quiz the mean had dropped to 101.1 ($t = 2.653$, d.f. = 24, $p < 0.01$).

Student comments about laboratory quizzes were much more positive in the Buckets period than in the pre-Buckets period. Students clearly disliked the pre-Buckets quiz format, and indicated in a few representative comments from course evaluation forms:

“I thought the lab quizzes were not very helpful in learning about fishes. The material was forgotten 5 minutes after the quiz, and they were hard. I did learn general families and genera, but I doubt I’ll remember many species”

“I did learn a lot about identifying Michigan fish, but I find that I have trouble remembering fish from the 1st few weeks of class. I guess studying for a quiz every week did not encourage me to put the information into long term memory”

“The only comment that I have is that there was too much emphasis put on memorizing the huge Michigan Fish fauna. I think the lab could do with less memorization of these fish.”

“The way lab is currently run, emphasis is placed on short term memorization of species names. I myself serve as an example of this- I would estimate that I remember less than 20% of the fish that we were required to memorize. ...students should be taught how to key out the fish with priority placed on the recognizing the physiological structures necessary in their identification. Instead, we were encouraged to blindly memorize the minimum amount of information necessary to pass the quizzes.”

Comments regarding the Buckets of Fish Exercise in 1995 and 1996 included two critical comments:

“Lab quiz format needs review. Not sure much is learned other than how to key out fish. Not practical for field. Total memorization is not essential but need to learn/memorize a little more”

“I think the lab would have been better if the fish quizzes weren’t open book. I would have studied the fish more if I had had to know them”.

By far, the comments regarding the Buckets of Fish method were more positive than negative:

“Lab was well done, wish there was more time for descriptions (overview of species). The quizzes were a great learning experience. My grade increased each time indicating that I was learning to key them more accurately. “

“I liked the way quizzes were set up. Avoided memorization of family and species...Important to me because was not required in my degree program”

“..thought the buckets-o-fish were a great way to learn. They could have been more challenging, maybe a time limit. Out in the field, you really don’t take that much time to key out fish. Forcing us to learn family, genus and maybe some species would have helped me”

“I think the fish jar quizzes are an excellent idea. I learned many, many more fish than I had known coming in...”

“I think the lab approach was very successful. It seemed to be more fair to everyone, and more practical. I can now ID most fish quickly by just looking at them. That came about through repetition and using the key. Just memorizing scientific names would not have accomplished this. The lab was a realistic presentation of the species of our region. I feel my knowledge had multiplied exponentially. Whether or not I could stand aboard a ship and call out catch identifications with confidence I do not know. But, even if I could, I’m sure that memorizing this information, it would leave me in a matter of weeks/hours.”

In spite of these perceptions of improvement, the overall evaluations of the course did not improve from the pre-Buckets

period to the Buckets period. We evaluated responses to two standard questions on the student evaluation form, "This course increased my knowledge in this subject" and "This course deserves an overall rating of ___?" For each question, students could mark one category from a range of five that extended from "superior" to "below average". Students only used the top three categories across the years 1992 – 1996 (1997 data are not available at time of publication), and the majority of responses were in the "superior" category. The distribution of responses among the three categories did not differ among years for the first ($X^2 = 3.93$, d.f. = 8, $p > 0.10$) or second question ($X^2 = 9.27$, d.f. = 8, $p > 0.10$).

DISCUSSION AND CONCLUSIONS

The Fish Briefs exercises met the objectives of developing information-gathering, critical thinking and writing skills. Students reported that it takes much less time to gather information for their second brief assignment than for their first. In addition, advances in information technology have made the process more focussed on identifying the issues related to the question and less focussed on the techniques of finding articles and books that address the issues.

Kurfiss (1988) argued that "learning by doing" in structured and guided exercises enhance the ability of students to develop critical thinking skills in science-based courses. The Fish Briefs exercise is moderately structured, but allows for individuals to pursue topics that they find interesting. Further, by having a structured set of criteria for evaluation, students are motivated to review their and peer briefs in ways that require higher levels objectives associated with critical thinking, including analysis, synthesis and evaluation (Bloom 1956).

The groups used for peer review were formal groups (Johnson et al. 1991) created for the short-term goal of reviewing group members' Fish Briefs. New groups were constituted for review of the second Fish Brief in a semester. The cooperative efforts required in these groups further refined students skills in critical thinking and writing, and these benefits accrue to all three students involved in the review triad.

Grading of the Fish Briefs was expedited by use of structured criteria for evaluation. Even with this, it is difficult to get feedback to students as quickly as they would like to have it. Providing generic feedback to the class with anonymous examples excerpted from student papers in previous years helps to address students' immediate concerns and allows for the more lengthy process of reviewing and evaluating individual briefs.

One other aspect of the Fish Briefs exercise suggests that students value this approach to learning. The list of questions for Fish Briefs is appended with new ones each year, but old questions remain on the list. As a result, students may write

on a question that another student wrote on in previous years or even earlier in the same semester. Yet, we have not documented a single case of plagiarism over the eight years in which we have used this exercise.

The Buckets of Fish technique provided the students with an opportunity to develop and practice tedious but necessary skills in a simulation that gave the experience relevance. McKeachie (1994) argues that simulation can be powerful a tool in learning because it involves students as active participants in the learning process. Student achievement is higher in the Buckets setting than in the previously used setting, and their performance clearly improves with experience. As with Fish Briefs, this exercise uses small groups (dyads) to foster collaboration among learners. The number of fish and the number of potential species for the quiz (104) are great enough that it would be difficult for either individual in the dyad to complete the quiz in the allotted time (170 minutes). By consulting and collaborating together, team members can expedite the work required and can check each other for accuracy in assigning fish to species and checking spelling of names and families.

We have found that the Buckets quizzes exert a greater demand on the collection of fish specimens used for teaching. We need more specimens, and need to replace specimens more frequently than under the previous system. Students handle the specimens more and examine them more carefully, resulting in dried fins, loss of scales, and deterioration of mouth parts, all key traits used in identifying fish. In short, students wear out the fish more rapidly because they use them in the way they should be using them to learn the skills needed for identifying fish.

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