Use of a question and answer study guide in an introductory soil science course

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ABSTRACT

The traditional study methods of reading and re-reading textbook and lecture notes may be improved upon by the use of a question-and-answer study guide that more actively engages the student in the studying process. Such a study guide was developed for a college junior-level introductory soil science course. This study guide consists of a series of questions on each of the major concepts in the course. The questions lead the student in a logical sequence from the simple to the more complex aspects of each subject. Answers are provided at the end of each chapter. Various question formats are used including numerical, graphic, and verbal. Though its use was voluntary and optional the study guide was purchased by 85 to 95% of the students enrolled in the course. A questionnaire, distributed near the end of each of five semesters, was filled in by a total of 529 students. Their responses indicated that 92% of them worked in the study guide for at least 1 h/week. Over 75% of the respondents agreed or strongly agreed that the study guide helped them learn the course material and prepare for exams, though only 16% felt it helped them more than reading the textbook, attending lectures, and studying their notes. Nearly all the respondents thought that the answer keys at the end of each chapter contributed to the study guide’s effectiveness.

When the study guide was used without answer keys for one semester, it caused a great deal of insecurity among the students and inconvenience for the instructor. More than 80% of the respondents would like to see other instructors provide similar study guides.

Additional index words: Teaching, Workbook, Learning tool.

TRADITIONAL study methods may not be adequate to allow students to gain a good understanding of the plethora of new concepts presented in an introductory level survey-type course. Students have often described to me the frustration of devoting long hours to studying, yet still feeling they did not comprehend many of the concepts. My experience with Introductory Soil Science, first as a student, and subsequently as a graduate teaching assistant and as an assistant professor, lead me to believe that for many students, reading and re-reading the textbook and lecture notes resulted in a great deal of studying but not necessarily much learning. What seemed to be needed was a more active approach to studying. A question-and-answer study guide was developed to fill this need. Anderson and Biddle (1975) present evidence that reading comprehension is improved if students answer questions on the material as they progress. A study technique was developed in which students frame and answer a question about each paragraph they read. Groups which used this technique had significantly higher scores on comprehension tests as compared to groups which merely read the same passages (Anderson, 1978; Andre and Anderson, 1979). Ellis et al. (1982) found that learning was enhanced by giving students guidelines as to the main concepts on which to focus prior to reading an assignment. They also found that giving students adjunct questions to answer after reading a text was an even more effective method of increasing learning. The use of adjunct questions significantly improved the students’ responses both on test questions involving the same concepts as the adjunct questions and on test questions involving incidental concepts or information covered by the text, but not dealt with in the adjunct questions. Answering the adjunct questions had caused the students to actively think about the passages they had read and catalogue the information in their minds.

Szafran (1981) used a question pool study guide in one of two sections of his large introductory sociology course. His study guide, consisting of 150 multiple choice questions, was given to the experimental group several days before the exam along with the information that the exam itself would consist of 33 of the same questions (but with the order of answer choices scrambled). He found that the experimental group performed better on the exam and reported a lower level of test anxiety than the control group. Szafran made the following arguments in favor of using a question-pool study guide.

1. The questions clarify to the student what ideas are important to know.
2. Answering specific questions actively engages the student’s interest.
3. In searching readings and notes for answers, other information not directly asked about is reviewed as well.

If the study guide includes diagrams and tables used in lectures, it should also assist students in note-taking, avoiding inaccuracies and allowing students to concentrate more on what is being said in lecture. In this last way a question and answer study guide could provide some of the benefits that Vietor (1979) reported from the use of printed lecture notes.

The purposes of the present study were 1) to provide students in an introductory soil science course with a question and answer study guide to enhance their learning and 2) to determine from student evaluations how

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the students used the study guide and how effective they perceived it to be.

**MATERIALS AND METHODS**

A question-and-answer study guide was prepared for the junior-level introductory soil science course (AGRO 302) at the University of Maryland. In its final form, this study guide consisted of over 1000 questions organized into 12 chapters (Table 1). The questions deal with most of the basic topics covered by introductory soil science textbooks (Brady, 1974; Donahue et al., 1978; Foth, 1978; Hausenbuehler, 1978; Thompson and Troeh, 1978). In order to provide flexibility in teaching, the study guide includes 5 to 10% more subject matter than is covered in the course in any one semester. Students are told which questions deal with topics that they will not be held responsible for on that semester's exams.

The questions in each chapter are not arranged in random order as would be appropriate for questions on an exam used as an evaluation tool (Weil and Kroontje, 1976). Rather, the questions are grouped by specific topic and are designed to lead the student in a logical sequence from the simple to the complex aspects of a topic as well as from topic to topic. In this manner, answering the first question in a sequence prepares the student to comprehend the next question, and so on. Each chapter is designed to be used independently of the others. Many questions do, however, require that a student integrate concepts from several chapters. In these cases cross-references are made between chapters. This allows the chapters to be used in a variety of sequences. During this study several different sequences were used in different semesters. Also, two different course textbooks (Brady, 1974, and Donahue et al., 1977) were used during different semesters.

In the final version of the study guide, complete answers to all the questions in a chapter are given at the end of that chapter. In the version used during the first semester of this study, answers to the questions were not given. According to the type of answer called for, at least eight different question types are used in the study guide (see Fig. 1). The questions on the course exam also included the graphical, numerical, and verbal types, but unlike in the study guide, all exam questions were in a multiple choice format, requiring the students to choose the most appropriate of an array of possible responses. None of the questions from the study guide was used on course exams without considerable modification. The lecture portion of the course (three semester credit h) included two to three 1-h exams and one 2-h comprehensive final exam. The laboratory portion of the course (1 semester h) was not covered by the study guide.

The study guide was used as an optional learning aid for six semesters from Fall, 1979, through Fall, 1982. Work in the study guide was never assigned, none was graded, and the purchase of the study guide was never required, only recommended. During the Fall, 1979, and Spring, 1980 semesters, only the first 9 or 10 chapters of the study guide had been completed, respectively, and these were distributed as series of handouts free of charge. During the following four semesters the entire study guide was sold as a softcover book. To determine how many of the students enrolled in the course actually purchased the study guide, a question to this effect was asked on the final exam for two consecutive semesters.

As a means of student evaluation of the study guide, a questionnaire (see Table 2) was distributed in class near the end of each semester (except Fall, 1981). The respondents remained anonymous, the only personal information asked being their grade point average. The responses were punched onto cards and analyzed using SAS programs (Helwig and Council, 1979). Associations between responses to pairs of questions were tested using chi square statistics. This paper reports the responses of 529 students enrolled during five semesters.

**RESULTS AND DISCUSSION**

According to student responses to a question on the final exam, the study guide was purchased by between 86 and 88% of the students enrolled in the course during the spring and fall semesters of 1982. My own observation was that most students brought a copy with them to class. Soon after I began using the study guide, I noticed that it became the focus for most of the tutoring encounters with students. For example, instead of coming to me with a vague request for help in understanding soil water potential, they now come to ask about the reasoning behind a specific problem in the study guide. This specificity has greatly enhanced the effectiveness and efficiency of one-on-one instructor-student interactions. The study guide also replaced the previous practice of circulating copies of old exams to allow students to practice test-taking. Thus, I could maintain security on my exams and use certain particularly effective exam questions in successive semesters. Given the time and effort required to write new multiple-choice items to test higher order learning outcomes (Weil and Kroontje, 1976), for me as an instructor, this change represented a substantial benefit of using the study guide. Student reactions to the study guide were also enthusiastic. The most common comment was, "I don't know how I'd get through this course without it."

The questionnaire used in this study generally confirmed that the students responded positively to the use of the study guide. The responses reported in this paper may or may not represent a slightly biased sample since the questionnaire was filled out during class time. Students who habitually failed to attend lectures would not be represented. The number of respondents was 73% of the number of students enrolled in the course.

Item 12 of Table 2 indicates that the great majority of respondents are pleased with the policy of making the use of the study guide voluntary and optional. A few students commented that requiring selected problems to be handed in for grading purposes would have helped motivate them to use the study guide more regularly and thus do better on exams. Most (92%) of the respondents...

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**Table 1.** Heads and numbers of questions for each chapter of the study guide.

<table>
<thead>
<tr>
<th>Chapter titles</th>
<th>No. of questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Soil as a Natural Body</td>
<td>39</td>
</tr>
<tr>
<td>2. Soil as Medium for Plant Growth</td>
<td>53</td>
</tr>
<tr>
<td>3. Soil Mineralogy</td>
<td>88</td>
</tr>
<tr>
<td>4. Factors and Processes of Soil Formation</td>
<td>73</td>
</tr>
<tr>
<td>5. Soil Classification</td>
<td>38</td>
</tr>
<tr>
<td>6. The Architecture of Soils</td>
<td>103</td>
</tr>
<tr>
<td>7. Water in the Soil</td>
<td>119</td>
</tr>
<tr>
<td>8. Soil Air and Temperature</td>
<td>73</td>
</tr>
<tr>
<td>9. Soil Biology and Organic Matter</td>
<td>108</td>
</tr>
<tr>
<td>10. The Chemical Nature of the Soil</td>
<td>102</td>
</tr>
<tr>
<td>11. Soil Fertility and Fertilizers</td>
<td>148</td>
</tr>
<tr>
<td>12. Soil Erosion and Conservation</td>
<td>86</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1030</strong></td>
</tr>
</tbody>
</table>
The bulk density of a mineral soil could reasonably be expected to be \( \text{g/cm}^3 \). (Choose one or more).

- a. 1.10
- b. 1.52
- c. 2.55
- d. 0.45
- e. 3.00

How much dry soil is there in 50 g of soil at 30% moisture (by weight)?

In the figure below, which drainage pipe is correctly installed?

The figure below depicts the potassium cycle in soils. Name the processes and forms of potassium represented by the arrows (1-S) and compartments (A-H), respectively.

Draw a diagram in each of the blank spaces in the figure below to show the appropriate arrangement of silica tetrahedra. Beneath each of the 4 diagrams name a mineral having that type of tetrahedra arrangement.

<table>
<thead>
<tr>
<th>individual tetrahedra</th>
<th>single chains</th>
<th>double chains</th>
<th>sheets or layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nesosilicates</td>
<td>Inosilicates</td>
<td>Phyllosilicates</td>
<td></td>
</tr>
<tr>
<td>![Diagram of individual tetrahedra]</td>
<td>![Diagram of single chains]</td>
<td>![Diagram of double chains]</td>
<td>![Diagram of sheets or layers]</td>
</tr>
</tbody>
</table>

Virtually all fungi and actinomycetes are

- a. heterotroph
- b. autotrophs
- c. aerobes
- d. facultative anaerobes.

Name 3 materials that can be used to lower soil pH in order to grow acid-loving plants.

1. 
2. 
3. 

Describe and explain the relationship between soil texture and the amount of lime required to achieve a desired change in pH.

Fig. 1. A classification of the types of questions used in the study guide, including an example of each type.
Among those who had answered different percentages of the study guide questions, nearly 40% of the respondents worked in the study guide for 3 h/week or more (Table 2, item 2). Another indication of the extent to which students used the study guide is the proportion of questions answered. More than 1/3 of the respondents answered 90% or more of the questions. Approximately 7% of the respondents did not use to a significant extent (Table 2, item 7).

Since there was no control group in this study it was not possible to determine if the use of the study guide affected student performance on exams. However, there were significant differences (probability of a greater chi square = 0.005) in the distribution of exam grades among those who had answered different percentages of the study guide questions. Of the students who had answered 0 to 30% of the study guide questions, 12% received a grade of A on the first exam. Of those who had answered 30 to 70%, 16% received a grade of A, and of those who had answered 70 to 100%, 23% received a grade of A. This finding could be the result of enhanced learning by use of the study guide or it could mean that the more studious students tended to use the study guide more extensively. However, the later interpretation does not agree with the fact that there was no difference (probability of a greater chi square = 0.646) in the distribution of cumulative grade point averages among those students who worked different proportions of the study guide questions.

Initially, I had expected that students would work together on the study guide in small informal groups. Working with friends was suggested in the preface to the study guide as it was hoped that students would learn from one another. Item 11 in Table 2 shows, however, that only 11% of the respondents actually studied in groups, perhaps because the University of Maryland has a high proportion of commuting and working students and it is difficult for them to meet outside the class.

A list of answers at the end of each chapter seems to be of critical value to the study guide learning tool. During the first semester of use no answers were included for all questions in the study guide as it was hoped that students would learn from one another. Item 11 in Table 2 shows, however, that only 11% of the respondents actually studied in groups, perhaps because the University of Maryland has a high proportion of commuting and working students and it is difficult for them to meet outside the class.

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Different students used the study guide and its answers in different ways (Table 2, item 10). Approximately 60% of the respondents wrote out their answers, either before (37.7%) or after (22.6%) checking the answers given at the end of the chapter. I have observed many copies of the study guide with neatly written answers filling all the spaces by the end of the semester. The remaining respondents merely formulated their answers mentally without usually writing them down. A total of 39% of the respondents usually looked up the given answer before attempting to formulate their own answer to a question. The proportion of students using each approach was the same for students with different grade point averages (Table 3). Neither was there any relationship between approach used and performance on the course exams (data not shown).

Questionnaire items 3 and 6 (Table 2) served as an internal check for consistency on the questionnaire, since learning the course material and becoming better prepared for exams should be very closely related outcomes. The responses to these two questions were, in fact, nearly identical. More than 75% of the respondents either agreed or strongly agree that the study guide was helpful to them in both ways.

Of the four types of study guide questions listed in questionnaire item 8 (Table 2) the greatest percentage of the respondents (38.8%) found the illustrated and graphical type to be the most useful. In response to early questionnaire results the use of illustrations was emphasized in the study guide. The latest edition contains some 168 illustration or graphical items. Few respondents (5.7%) found the numerical calculations to be the most useful type of question. This result is difficult to explain because numerical calculations were emphasized on the course exams and were the type of exam questions on which the classes did most poorly.

The responses to questionnaire item #4 (Table 2) indicate that the majority of respondents (54%) felt that attending lectures was the activity that helped them most in learning about soil science. Working on the study guide ranked about the same as reading the textbook and studying lecture notes in effectiveness as a learning activity. As might be expected, those students who used the study guide more thoroughly were more likely to strongly agree that it helped them in learning the course material (Table 4). Perhaps the best general indication of the value of the study guide to the students is their response to item 13 (Table 2). Apparently more than 80% of the respondents would like to see other instructors use similar study guides, though there was a significant difference in the response to this item between those who did and did not agree that the study guide had helped them learn the course material (Table 5).

**CONCLUSION**

The study guide made the teaching process more efficient for the instructor by focusing tutorial interactions on specific questions, eliminating the need to circulate copies of old exams, and allowing more material to be covered in lectures. It was used extensively on a voluntary basis by most students and the majority of students agreed that it helped them learn the material and prepare for exams.

**ACKNOWLEDGMENT**

The idea for the study guide originated when I was a teaching assistant for Professor Wybe Kroontje at Virginia Tech. He encouraged me to develop the study guide and we have, over the years, collaborated on our respective versions of this teaching tool. A jointly authored study guide has recently been published (Weil and Kroontje, 1984).

**REFERENCES**