Role Playing and Mind Mapping Issues on Nitrate Contamination

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ABSTRACT

Agricultural science professionals are faced with controversial issues that often reach far beyond the professional's disciplines. The need for competencies in systems approaches to problem-solving is stimulating revisions of agricultural science curricula. Mind mapping and role playing exercises described herein were designed (i) to guide students in the exploration, expression, and integration of varying viewpoints and opinions of a controversial topic (i.e., nitrate contamination of our water supply); (ii) to illustrate the importance of applying soil fertility principles to environmental and agronomic management; and (iii) to encourage students to take active leadership in their learning process. These exercises were developed for a college Soil Fertility course and for a high school student workshop during a college recruitment conference. Students assumed the roles of interest groups in the controversy over nitrate contamination. Published articles and reports, many of which were written from biased views, gave students a sense of the various perspectives on the issues. Student evaluations of the exercises suggested students enjoyed exchanging these ideas and perspectives during a small-group mind-mapping assignment and in a mock town hall meeting. They also gained an appreciation for developing science-based solutions to the nitrate contamination problem, while reconciling the varying perspectives within society. Mind maps helped students understand interrelationships and roles among government agencies, fertilizer industry, farmers, consumers, and university personnel.

Academic science professionals are faced with controversial issues that often reach far beyond the professional's disciplines. Concerns for environmental protection, public health, and long-term agricultural sustainability are affecting agronomic decisions. To solve complex problems such as those related to nitrate pollution, agricultural science graduates will be asked to interact with many segments of society, such as government agencies, environmental and consumer groups; grower organizations, agrichemical industries; and university research and extension personnel. Students need problem-solving skills to deal effectively with such complexities (Wilson and Morren, 1990).

This need for problem-solving competencies has stimulated changes in agricultural science curricula (Merritt, 1984; Merritt and Hamm, 1994). These changes include the redesign of whole curricula, course development in systems thinking, and the modification of existing courses (Merritt, 1984; Grabau, 1988; Macadam and Packham, 1989; Merritt and Hamm, 1994). Agriculture courses are typically presented in the lecture and note-taking format, in which the lecturer presents factual material for students to assimilate and assemble within their current knowledge base. This is an efficient method for disseminating facts, but it is not as effective at building student competencies in human interactions and group problem-solving. These competencies can be addressed within science-based courses by complementing technical lectures with exercises that weave scientific concepts into discussions of current, controversial topics that are relevant to students as citizens and future professionals. In doing so, students are better able to connect scientific concepts and facts to real-life situations, perhaps sustaining their interest in science and providing motivation for learning.

Small-group exercises highlight and encourage the individuality, personality, experiences, and skills of each student (Sharan and Sharan, 1976). Small group settings also empower students to take control of the learning process, giving them an opportunity to develop leadership skills and a sense of self-worth. In addition, students learn to cooperate and communicate in analyzing and organizing abstract concepts. This approach also helps to redefine the role of the instructor from lecturer to facilitator.

Role playing and mind mapping are teaching techniques that can be applied within the small-group forum. These techniques can facilitate the exploration of controversial scientific issues that often reach far beyond the professional's discipline that can be addressed within science-based courses by complementing technical lectures with exercises that weave scientific concepts into discussions of current, controversial topics (i.e., nitrate contamination of water); (ii) to illustrate the importance of scientific knowledge of soil fertility principles in addressing environmental and agronomic management; and (iii) to encourage students to take active leadership in their learning process.

METHODS

Group exercises were designed around the problem of nitrate contamination of water supplies and its implications for soil fertility management. The exercises were applied in two teaching situations at Washington State University: (i) an upper division undergraduate Soil Fertility course taught annually from 1990 through 1994; and (ii) the 1993 Agriscience Leadership Experience, a college recruitment

Abbreviations: ACE, Agriculture in Concert with the Environment.
program that introduced high school students to agricultural research and extension programs. Little student knowledge in nitrogen fertility was assumed with the implementation of these exercises.

Before each exercise, students received reading materials on nitrate contamination collected from agribusiness magazines and scientific reviews (Clark and Richardson, 1986; Williams, 1988; Hergert, 1986; Hufford, 1991; Halas Steel, 1988), newspapers (Nelson, 1989; Sorenson, 1993; Huspeni, 1993), popular magazines (Carpenter et al., 1991), extension bulletins (Hermanson and Thomason, 1993; Bierlink, 1992), and government reports (Barrett, 1986; Hoyer et al., 1987; Agricultural Research Department, 1990). Typically, articles were written from the perspective of one or more of five interest groups: (i) farmers; (ii) the fertilizer industry; (iii) government agencies; (iv) universities; and (v) the general public. Each student was assigned to assume one of these five roles. Students were instructed to focus on the perspective of their assigned group, and to come to class prepared to represent that perspective.

**Mind Mapping**

In the Soil Fertility course, students were divided into teams of five students, with each interest group represented within each team. Each team was provided a 0.9 m by 1.4 m sheet of paper and markers for constructing a mind map of their discussion, with the following objectives: (i) to develop a rich picture of major issues and associated factors, including the important perspectives of the various interest groups; (ii) to identify problems associated with the current systems that have a bearing on nitrate contamination; and (iii) to decide what kinds of solutions are required to address these issues. Examples of mind maps describing other issues (Wilson and Morren, 1990) were provided to illustrate the mind mapping concept.

A 50-min period was allotted for student interaction and mind map construction. The instructor and teaching assistants were available for consultation if advice or assistance was requested, or if discussions stalled. For the most part, however, students were allowed to interact within their teams without intervention from the instructor. Each group elected a note-taking mind mapper to record the discussion. Often, this responsibility was passed from student to student during the discussion. The students sat around a table with the mind map in the center. The notetaker constructed the mind map as the students discussed issues, problems, interactions among interest groups, and solutions. The various topics were initiated in different locations of the mind map to allow addition of details as the discussion proceeded. As students watched their mind map evolve, they offered facts, opinions, and suggestions for approaches to solutions from the perspective of their assigned interest group. The mind map provided a method for organizing a free-flowing discussion, and for illustrating key interactions, common goals, and conflicts among the interest groups. Another 50-min period was devoted to a review of the mind maps. Each group presented a summary of their maps, allowing for a review and reinforcement of major points.

A follow-up, argumentative short essay was then assigned. Students were asked to construct a 2-page editorial essay that logically supported a particular perspective discussed in the reading assignments and in the mind mapping exercise. The following examples were provided:

1. The government (should/should not) regulate nitrogen fertilizer and manure use to protect our water quality.
2. Growers’ use of nitrogen fertilizers and manures (has/has not) been the primary cause for increased nitrate levels in our drinking water.
3. The fertilizer industry (is/is not) responsible for bearing the costs of protecting our water quality from nitrate contamination.
4. There (is/is not) a need for researchers to develop alternative cropping systems that eliminate the use of synthetic nitrogen fertilizers.
5. The public (should/should not) pay for environmental protection measures that will add to growers’ production costs.

**Mock Town Hall Meeting**

A variation of the above-described exercise was devised for the 1993 Agriscience Leadership Conference. This conference was organized by the Washington State University College of Agriculture and Home Economics to recruit outstanding high school graduates to the College. Various demonstrations and workshops were offered during the 2-d conference to stimulate students’ interests in agricultural sciences, to make them aware of the opportunities in agricultural professions, and to demonstrate the role of agricultural science in society.

A workshop was devised to encourage students to interact in a mock town hall meeting. A packet of information was sent to each participant before the conference, including an introductory handout (Fig. 1) and selected reading materials from the collection described above. The meeting centered around the fabricated situation that the Pullman city well had recently been closed due to nitrate levels that exceeded USEPA limits. An actual closing of a local municipal well (Huspeni, 1993) added a sense of realism to the exercise. The workshop was subdivided into three main stages: (i) small group discussion by interest group; (ii) role-playing during a mock town hall meeting; and (iii) summary of issues during a review of an instructor-constructed mind map. Professionals from the fertilizer industry, a grower organization, the Soil Conservation Service, university faculty and the Washington State University Center for Sustaining Agriculture and Natural Resources, and a concerned citizen were invited to provide advice and insight into perspectives during the discussions within each interest group. This small group discussion lasted about 20 min. The students reviewed the perspectives and arguments of their interest group, and organized their presentation for the town hall meeting.

The mayor of Pullman, WA, presided over the mock town hall meeting to provide guidance on meeting protocol and to add authenticity to the proceedings. The mayor called the meeting to order. Each group decided on their presentation format, and each presentation was 5 to 10 min. Four students were asked to sit on the town council to provide an impartial review of the presentations, and to help summarize resolutions for solving the nitrate contamination of local
OVERVIEW
Welcome to the 1993 Agriscience Leadership Experience program on “Science for a Safe Tomorrow.” It is an exciting time to be involved with science in agriculture! Our society is facing many important issues on food and fiber production, management of natural resources, and environmental protection. People from different parts of our society usually have different opinions on how to solve these problems. You may have recently seen or heard about some highly publicized examples, such as the spotted owl and logging industry controversy. Other examples include pesticide use and food safety, and water use on the Snake and Columbia rivers and the survival of the salmon. Often times, science and agriculture are deeply involved in the controversy.

Finding solutions to these difficult issues requires that people work together to find common ground. Different interest groups will need to develop a broad understanding of all the issues surrounding a situation. Before solutions can be formulated, people will need to understand and appreciate opposing views and opinions.

Your Agriscience Leadership Experience will include a workshop on addressing these difficult issues. We will discuss the following current topic, and try to come up with some solutions to the problem.

AN ISSUE IN WATER QUALITY: NITRATE CONTAMINATION OF OUR WATER SUPPLY
It's probably safe to say that everyone is interested in keeping our surface water and groundwater clean. Groundwater is our main source of drinking water. Surface waters provide many recreational and industrial uses, and they are an important part of our natural environment. Yet, when problems with water contamination arise, there is often tremendous disagreement about the source of the problem and about the best solutions.

Here are some facts and issues:
- Nitrate levels in our ground and surface waters are increasing throughout the USA. Several wells in Washington state have nitrate levels above maximum tolerance levels set by the USEPA.
- Nitrate causes methemoglobinemia in babies (blue baby syndrome), causing oxygen depletion in the infant’s blood system. Nitrate toxicity is also implicated in long-term effects on occurrence of cancer, birth defects, and nervous system damage in livestock and humans.
- The sources of nitrate are numerous, including agricultural and urban activities and natural sources. Some argue that we need to change the way we manage our crops and livestock, lawns and landscape nurseries, and our sewage disposal.
- This is a very explosive issue among the various interest groups representing (i) producers or farmers, (ii) government regulatory agencies, (iii) agrichemical industry, (iv) university researchers and extension personnel, and (v) the public.

MOCK TOWN HALL MEETING AND MIND MAPPING WORKSHOP
A mock town hall meeting will be held to discuss concerns on nitrate levels in the drinking wells of the region. You will represent one of the five interest groups listed above. You will meet with others to present the views of your interest group to the whole group. We will assemble views and ideas into an overall picture of the situation (mind map), and solutions to the problems will be explored.

BACKGROUND READING ASSIGNMENT
A collection of reports and popular news articles related to nitrate contamination is enclosed. These articles reflect various perspectives. Read these articles to become familiar with the basic issues and pay particular attention to issues related to your assigned perspective. It will be easier for you to contribute to the workshop if you have read these articles ahead of time.

While you are reading these articles, take some notes on the following questions as they apply to your interest group:
1. How concerned should we be over nitrate contamination of our water supply? Why?
2. Where is the nitrate coming from?
3. What, if anything, needs to be done to reduce nitrate contamination of our water supply?
4. What should be responsibilities of each interest group in reducing nitrate contamination?
5. How can the interest groups work together to solve this problem?

See you at the Town Hall Meeting!

Fig. 1. Introductory overview of the mock town hall meeting exercise that was sent to high school recruits before the Agriscience Leadership Conference.
Table 1. Summary of evaluations from college students in Soil Fertility (1990, 1991, and 1993) on the mind mapping exercise and from high school students on the role playing/town hall exercise on nitrate contamination of surface and ground water.

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the supplemental reading materials provide you with a better understanding of the various perspectives on nitrate contamination?</td>
<td>48</td>
<td>22</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>1.48</td>
</tr>
<tr>
<td>Did you acquire a greater appreciation for viewpoints held by the various interest groups?</td>
<td>44</td>
<td>26</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1.49</td>
</tr>
<tr>
<td>Did you gain a greater appreciation for viewpoints that were contrary to your own?</td>
<td>46</td>
<td>20</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1.57</td>
</tr>
<tr>
<td>Did you enjoy participating in the group mind-mapping (town hall meeting) exercise?</td>
<td>39</td>
<td>30</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1.69</td>
</tr>
<tr>
<td>Would you have rather had more traditional lectures on these subjects in place of the mind mapping (town hall meeting) exercise?</td>
<td>36</td>
<td>23</td>
<td>11</td>
<td>4</td>
<td>2</td>
<td>1.85</td>
</tr>
<tr>
<td>Did this exercise help to illustrate the importance of having a solid background in the scientific principles of soil fertility when making decisions at the agronomic, political, or environmental levels?</td>
<td>43</td>
<td>27</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1.53</td>
</tr>
<tr>
<td>Did the exercise increase your level of interest in soil fertility (soil science)?</td>
<td>39</td>
<td>22</td>
<td>10</td>
<td>4</td>
<td>1</td>
<td>1.73</td>
</tr>
<tr>
<td>Was the discussion helpful in integrating your knowledge of soil fertility principles to address issues in production, environmental protection, and resource management?</td>
<td>10</td>
<td>14</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1.89</td>
</tr>
<tr>
<td>Do you anticipate using the mind-mapping technique in the future to comprehend complex issues and problems?</td>
<td>10</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2.29</td>
</tr>
</tbody>
</table>

† Values and descriptions in parentheses refer to the survey of Agriscience Leadership participants.
‡ This question was posed in the 1993 college student survey only.

the nitrate issue without the use of a formal case study. Inclusion of opinionated articles and editorials helped students to understand the perspectives and issues confronting the various interest groups, as indicated by student responses to Question 1 (Table 1). Of the college and high school students that turned in the surveys, 88% responded positively (by circling 1 or 2) concerning the helpfulness of the reading material. Providing articles from local and regional publications may have heightened the students' interests in the exercises, because they were able to relate this problem to their own region.

**Mind Mapping Nitrate Issues**

The mind mapping exercise preceded technical lectures on nitrogen cycling and management. A composite of the student mind maps constructed in the Soil Fertility course illustrates the range of ideas, facts, and concepts that were discussed in the small-group forums (Fig. 2). Four categories of action were typically discussed: identifying the sources of nitrate, informing and communicating with the public, assessing the health risk, and controlling nitrogen inputs with best management practices.

The assessments of the health risk included a discussion of the nature of methemoglobinemia and cancer (Fig. 2). Students were quick to point out that although several articles alluded to these health threats, quantitative data on the severity and frequency were rarely mentioned. Nevertheless, birth defects (Mufford, 1991) and occasional infant deaths (Carpenter et al., 1991) have been attributed to high nitrate levels in drinking water. Some students recognized this apparent lack of data. The infrequency of methemoglobinemia cases was recognized. This lead to a discussion of the problem of sorting reality vs. perceptions of publicized issues. Students realized that the USEPA standard of 10 mg NO₃-N/L (10 ppm) nitrate-nitrogen was an overriding factor affecting policy and management decisions. Newspaper and magazine articles describing nitrate contamination of eastern Washington wells (Anonymous, 1993) and the closing of a local municipal well due to nitrate levels above the USEPA standard (Huspeni, 1993) illustrated the relevance of the problem to the local region. Filtration of nitrate-contaminated water was recognized as an expensive last resort (Hergert, 1986; Carpenter et al., 1991).

Students representing the public expressed a need to be informed on these health issues. They felt it was the role of the government to monitor and regulate drinking water quality, and that the government and university extension service were responsible for accurately disseminating information to the press and public (Fig. 2). They wanted the growers to explore alternative, more sustainable systems for producing food and fiber. Some mock consumers indicated organic systems were more environmentally friendly, and they preferred food grown without agrichemicals (Corliss, 1989; Nelson, 1989). The student representatives of the agrichemical industry countered that there is no mass demand for organically grown food (Associated Press, 1989).

The mock grower and agrichemical industry groups wanted the public to understand that nitrate comes from many sources (Fig. 2), and that everyone is responsible for our water quality (Clark and Richardson, 1986). They pointed to manure, sewage, and natural nitrogen cycling as other major contributors to the problem (Hergert, 1986). Several industries were scrutinized, including greenhouse operations (Mufford, 1991), animal farming (Williams, 1988; Clark and Richardson, 1986), and field-crop agriculture (Sorenson, 1993). Many of the students had previous experience with these industries or intentions to enter into these industries, making this exercise particularly relevant. After recognizing the multiple sources of nitrate and the difficulty in tracing the sources, the students generally agreed that everyone had to work together to solve this complex problem, and that blaming any one group was unproductive.

The students discussed approaches to solving the nitrate problem, focusing on agricultural sources (Fig. 2).
Interactions were outlined among research, information dissemination and adoption of best management practices, establishment of guidelines and regulations, and provision of incentives and funding. Government representatives outlined their role in providing universities with research and extension funding such as the Agriculture in Concert with the Environment (ACE) grant program, establishing regulations on fertilizer containment and use (Agric. Res. Dep., 1990) manure management (Bierlink, 1992; Greene, 1993), and subsidizing farmers for adopting environmentally friendly management plans that include soil and manure testing (Hermanson and Thomason, 1993; Greene, 1993) and controlling nitrogen inputs in sensitive areas (Hoyer et al., 1987). Taxation on fertilizer sales and fines for industrial polluters was debated as an avenue for funding these programs (Swoboda, 1988; Mufford, 1991), in addition to public taxation. University representatives were told by the public and government groups to shift their emphasis from production to environmental issues (Seely, 1988). Incentives for grower adoption of nutrient best management programs were discussed in relation to the Farm Bill and the Clean Water Act (Johnson, 1991). The recognition of regional environments and cropping systems illustrated the need for flexibility and local control of regulations.

Mock grower and industry representatives expressed concerns for the build up of too many governmental regulations and taxes (Fig. 2) that are costly and time consuming, rendering growers less competitive in the marketplace (Swoboda, 1988). These groups did not want government regulators unfamiliar with agriculture's needs and constraints to be setting policy. Some agribusiness representatives wanted the public and government to know they were taking proactive approaches to environmental problems on a voluntary basis, in recognition of changing times and public attitudes toward agriculture (Eng, 1988; Peck, 1993). They expressed a need to become part of the solution, not the problem. Projecting a more positive public image was one approach to addressing the perception problems, by telling the public that the growers and industry are good stewards of the land and the environment (McGregor, 1991; Peck, 1993). Growers demanded unbiased soil testing, recommendations, and advice from the industry and university groups (Halas Steel, 1988). The industry and universities recognized the need to reinforce collaborations and cooperation (McGregor, 1991).

The students indicated that this alternative teaching forum was enjoyable and preferable to the lecture and note-taking format for learning about these issues (Table 1). The students expressed a greater appreciation of viewpoints other than their own after participating in the mind mapping exercise. This increased understanding was also indicated by the Soil Fertility students in their written argumentative essays. Although the students were instructed to write an editorial that supported one opinionated view, many students recognized the importance of acknowledging opposing views.

The discussion of pressing social and environmental issues provided students insight into the role and importance of science in these debates. These effects were verified in the evaluations, in which students indicated an increased appreciation of the importance of understanding soil fertility principles in addressing the nitrate problem.

The mind mapping also helped students to pull together and integrate diverse ideas and perspectives (Table 1). Most Soil Fertility students surveyed in 1993 indicated they might apply the mind mapping technique to try to comprehend other complex situations.

**Role Playing during a Mock Town Hall Meeting**

The high school students prepared for the mock town hall meeting by conferring with other students assigned to the same interest group. The students within each interest group summarized their perspectives and determined the format for their presentation to the town council. While some groups elected one or two representatives to present their group’s perspective, other groups decided to have each student in the group present one concept or view. The independent town council, which was also made up of students, was asked questions for clarification at the end of each presentation.

Less interaction occurred among the interest groups than in the Soil Fertility mind mapping exercise; therefore, the potential linkages among society’s interest groups were not as fully explored. Nevertheless, viewpoints and arguments

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**Fig. 2. A composite mind map of issues, perceptions, facts, actions, and interest group interactions related to nitrate contamination.**

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were aired, and the students were exposed to the complexities and of the nitrate problem. The town council listed some resolutions and recommendations for solving the problem after the presentations. The workshop facilitator mind mapped the main issues the students raised, and reinforced the spirit of cooperation and interaction among groups. The mind map, while not nearly as complex as the composite map shown in Fig. 2, incorporated many of the main elements.

Sixteen of the 20 high school students gave the highest rating to the town hall meeting based on enjoyment. An overall survey conducted by the Agriscience Leadership organizers indicated that it was the most highly rated event of the 2-d conference (T. Nichols, 1993, personal communication). The students indicated a greater appreciation of the viewpoints of the various interest groups, and of viewpoints contrary to their own (Table 1).

Most students indicated the exercise illustrated the importance of applying scientific principles in soil fertility to address these complex issues. A lower percentage of students found this exercise enhanced their interests in soil fertility and soil science, possibly because much of the meeting was spent discussing the social and political aspects of the nitrate situation, and less time was devoted to the technical aspects of nitrogen cycling.

CONCLUSION

Mind mapping and role playing were incorporated into a Soil Fertility course and a high school recruiting workshop to stimulate and motivate students, and to increase their appreciation of science and the role it plays in society. The exercises enhanced student interactions and encouraged understanding of various perspectives on nitrate contamination. Soil Fertility students integrated perspectives to formulate global views and problem-solving approaches, and were motivated to learn from subsequent technical lectures on nitrogen cycling and management.

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