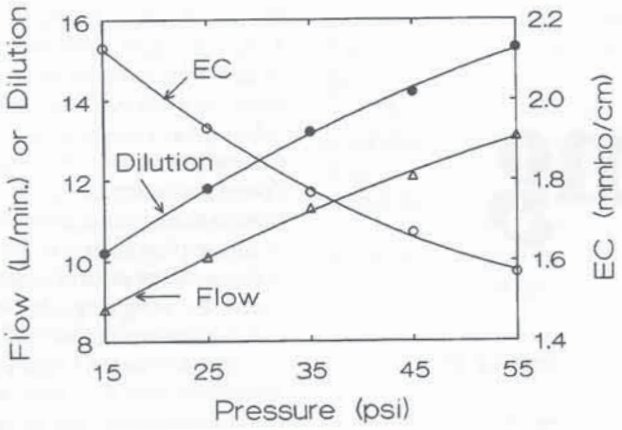

Fig. 2. ***Dilution, water flow, and electrical conductivity of diluted solution for a Venturi-type proportioner operating with water pressure of 15 to 55 psi. Regressions of means are: Dilution = $-0.1x^2 + 1.86x + 8.46$; Flow = $-0.0714x^2 + 1.49x + 7.4$; EC = $0.0186x^2 - 0.249x + 2.36$. For each regression, $r^2 = 0.999$ and $n = 5$.***

(Fig. 2). The dilution should increase from ≈10 at 15 psi to 15 at 55 psi (Fig. 2). This is a lower range than the 12 to 17 usually reported (Boodley, 1981). The water flow increases with pressure, from 2.3 gal/min (8.7 liters·min^{-1}) at 15 psi to 3.5 gal/min (13.2 liters·min^{-1}) at 55 psi. The maximum rate of 3.5 gal/min was 17% greater than the cited maximum of 3 gal/min (11.3 liters·min^{-1}) (Nelson, 1991). The EC at 77F (25C) of the diluted solution declined from 2.1 mmho/cm at 15 psi to 1.6 mmho/cm at 55 psi. The VP dilutions were slightly less than normally cited values (Boodley, 1981), while the maximum water flow was slightly greater (Nelson, 1991).

The experiments reported here would be a simple laboratory exercise for a lower-division horticulture course that would provide experience in calibration and use of VPs and EC meters, use of a balance to estimate solution volume, and preparation and interpretation of graphs and standard curves. The calibration procedures would be useful for VP users to perform to assure accurate fertigation, since water pressure has a major influence on the dilution ratio.

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Decision Cases as a Teaching Component in the Classroom and Workplace

David W. Davis

This paper prefaces the accompanying decision case, "Agricultural Manager's Dilemma," and discusses the guidelines by which decision cases are designed, written, and used. "Agricultural Manager's Dilemma" was prepared for and has been used as one of 12 to 16 decision cases in ANPL 5060, "Management of Integrated Cropping Systems," a four-credit, senior-level capstone experience in the animal and plant systems major at the Univ. of Minnesota College of Agriculture.

The case method has long been featured in the educational programs of law schools, business schools, and medicine, but seldom has been adopted elsewhere. Cases in the legal profession are built around actual court decisions, while in medicine actual clinical situations with individual patients are the focus. The use of cases in business schools, begun in the early 1900s by Harvard Univ., used law school cases as models. Business case focus was on the numerous components of business, including authentic problems of management structure, finance, personnel, inventory control, and sales strategy, to name only a few. Shapiro (1984) points out that they were developed and used with the philosophy "that management is a skill rather than a collection of techniques or concepts," and that "the best way to learn a skill is to practice in a simulation-type process."

We were drawn to the case method in the College of Agriculture in the search for more effective ways to prepare students at the baccalaureate level to emerge as practitioners with greater confidence and skills in decision-making. Central to the case

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method is the use of cases that focus on actual situations, not contrived simulations.

Horticulture and associated agricultural disciplines are integrative, applied sciences, normally drawing on several fields of knowledge in problem-solving. The grower, the crop consultant, and the professional manager, as well as other practitioners in horticulture, recognize the complexity of decision-making in the everyday conduct of their profession. The use of treatment levels, replications, and checks often is not a feasible approach for them to use. Decisions, either in the form of action or recommendation, frequently must be made in a timely fashion. There is seldom time to "accumulate more data." Likewise, the decision-maker may never know if the course of action taken was the best one, because a "control" is seldom available. Over time, a form of "replication" may occur as the decision-maker faces similar situations. We call this "experience," and there are few who deny its importance in the professional development of the practitioner.

As researchers, and sometimes as teachers, we tend to center on one or a few variables at a time. We strive for precision in design and procedure. Students, throughout their prolonged higher education experience, often seek single answers based more on technological information and less on multivariate analysis. At the practitioner level, technological problems often are very complex, involving personnel and ethical considerations that complicate decision-making.

Purpose of the decision case

The central purpose of decision cases, whether in academia or the workplace, is to engage the reader in the analytic process and decision-making. The underlying goal is one of providing experiences that help lead the student to greater wisdom and confidence (Gragg, 1940). Wisdom and the improvement in judgment that arises from the experience gained is virtually impossible to impart to the student with more traditional educational approaches, such as the lecture. Wisdom is acquired with experience and often is a requisite to successful job performance. Authentic decision cases, if skillfully written and taught, are a step in the direction of achieving such goals.

Much of our coursework in academia focuses on technical knowledge, but good decision-making in the workplace often requires the employee to go beyond this knowledge. The relative importance of technical knowledge from several fields, the ability and willingness to consider the viewpoints of others, the ethical issues inherent in arriving at a decision on the problem, and the impact on personnel are important factors that the successful employee must consider in decision-making. Interest in the technical aspects of horticulture may have led many students into the plant sciences, but employers expect much more from students emerging from an academic program than familiarity with technical knowledge.

Decision cases should not be regarded as a panacea. Where the educational objective is to acquire knowledge or develop a concept, the case method has been regarded as inferior to other methods, such as the lecture (Dooley and Skinner, 1977). Similarly, laboratories and problem sets play a strong role in understanding techniques and in acquiring skills in the use of techniques; although, with all of these methods, the case method might play a useful supporting role.

Case writing: Creative yet authentic

There are two principal parts to a decision case: 1) the text and 2) exhibits. Every decision case also is supplemented by an Interpretive Note, an important resource for the person instructing the case. Also, specific questions for the student may be presented in various ways. They may be listed at the end of the case or in the Interpretive Note as a guide to the instructor.

Cases should adhere to specific principles adapted from those used by *Case Research Journal*, published by the North American Case Research Association. These guidelines are summarized as follows:

1) Cases are expected to be decision-oriented and research-based, i.e., there should be acquisition of data and the clarification of issues necessary to put the case into context and establish the need for a decision. The case must be more than the mere description of a situation. There also must be a clear identification of the decision-maker and the point in time at which the decision is to be made. The case writer usually is not identified with the case, i.e., as a personality within it, although the case principal could conceivably be the case writer.
2) Ideally, the case should not rely on materials not included as exhibits within it or as readily available references. The information included should have been available to the decision-maker at the time of the case and should be sufficiently complete to permit a decision to be made. Additional material that might provide useful background for the student also may be added as appendices. These need not be written in the style of the particular case.
3) Cases should be written in the past tense, as a way of emphasizing the historical authenticity of the case.
4) The case should be well-crafted as to organization, rhetoric, and grammar. Historically, figures and tables have been referred to as "exhibits." These are grouped at the end of the text in the order cited in the text.
5) Clear identification of issues should help the student make the transition from the role of spectator to that of participant. There should be one or more issues strongly related to the decision needed.
6) The Interpretive Note should outline the intended use of the case, its objectives, and key issues. It also should provide questions for the student to consider, as well as presentation of rationale for these answers. An overview of the directions in using the case also may be provided.
7) Cases should be classroom-tested, and an assessment of their performance provided, followed by appropriate revision.

A well-written case should arouse interest in the reader (Bennett, 1978). It must identify the principal decision-maker and the problem or dilemma. A goal is for the student or reader to identify with this person and be drawn into the complexity of the problem faced by the decision-maker. Hence, as stated by McNair (1971), "A case is really a distinct literary form," and "A good case is a definite literary accomplishment."

Beyond telling the story and drawing-in the reader, a well-written case also provides the essential resources needed to understand all sides of the situation and arrive at a decision. As a supplement to the text, a series of exhibits generally is presented. These provide the essential data that were available to the decision-maker in the case. Beyond the hard data of the exhibits, the text of the case can describe intangibles, such as unwritten company policy and biases of individuals involved in the situation. While a written case can convey neither all of the information the reader might like to have nor the on-the-job experience of the decision-maker, enough generally can be provided to improve sensitivity to the situation and permit a reasonable decision. Based on research, a well-written case frequently will have a distinct advantage over the real situation by drawing out and more clearly setting forth the critical issues and points of information. In this way, a decision case also may have value for the individual or firm about which it has been written. Thus, it can be a useful management tool in problem-solving.

Procedure in case writing

In case-writing, the first step is identification of an authentic problem situation that provides a teaching opportunity. Subsequently, data are collected through a thorough investigative interview and research process (Shapiro, 1986). Further steps toward the complete written case and Interpretive Note include the development of an outline and several written drafts (Fig. 1) (Stanford, 1980). It is important to consider the audience (students, extension agents, growers, field representatives, crop consultants, etc.) for whom the case is intended. However, a well-written decision case often is suited to more than one kind of audience if the Interpretive Note is written broadly. Also the questions for the class can be recrafted to reflect changes in audience.

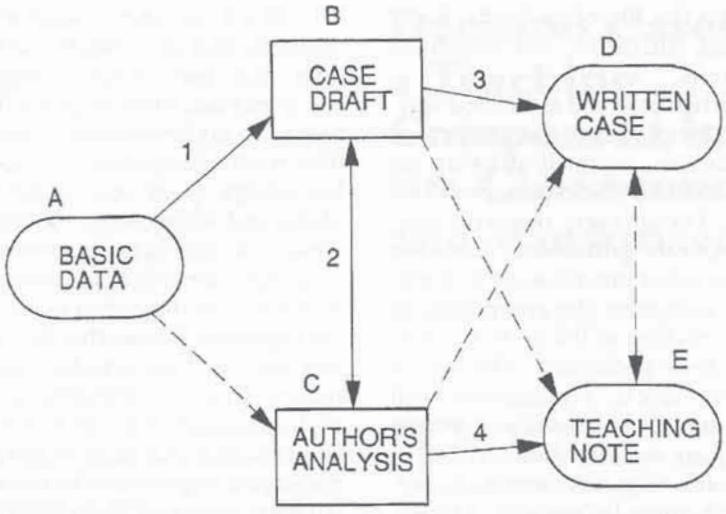

Fig. 1. *The interaction of components in the writing of decision cases. Following the acquisition of basic data (A), an outline and case draft (B) are prepared. The author's analysis (C) of the data and the issues of the case lead to improvement of the written case (D) and to writing the Interpretive Note (E). However, continued interpretation of basic data and case issues by the writer and of the written case by students may lead to revision of both the written case and the Interpretive Note. Adopted from Stanford (1972).*

The drafting of the case and the Interpretive Note ideally will occur simultaneously (Fig. 1). One needs to have the viewpoint of the student in mind during construction of the case. An important element of the Interpretive Note will be the analysis provided by the case writer. That is, as the writer/instructor how do *you* see the alternative solution(s) to the problem(s) posed by the case in light of the issues involved? At the same time, room needs to be provided for alternative solutions and their defense, since there often is no single, exact answer. Thus, the written case and the Interpretive Note are raw materials for the students and the instructor, respectively. Individuals may differ in their interpretation of the basic data of the case, as set forth in the text and exhibits. In the crafting of the case, the case writer should be aware of the interaction among the components of the entire process (Fig. 1) and should use a creative approach toward writing and toward orchestrating discussion in the classroom. The student must be brought in as a participant. In addition to including specific questions that lead to solution(s) to the problem, questions should be posed that encourage the student to think about the process by which a decision is reached. Thus, the student should be asked to look at the situation broadly, as well as in the more narrow reference of the questions.

To summarize, a written case usually will include the following elements, as set forth by Stanford and Crookston (1989).

1) The identity and role of the decision-maker.
2) Issues involved in the decision situation, i.e., the focus.
3) Objectives of the decision-maker in his/her role in the organization.
4) Decision alternatives that may be feasible.
5) Essential information for analysis, decision, support, and appraisal.
6) Work for the student to perform.
7) Use and value of the case in teaching (within the Interpretive Note).
8) Use and value of the case for further contributions to knowledge (via the Interpretive Note).

The final component, the Interpretive Note, is an important resource available only to the instructor. It should describe the state of readiness of the students for whom the particular case is designed and should speak to the ways in which the case might be used. The main issues of the case should

be listed and discussed. The questions for students should be listed, and the rationale for reaching alternative answers to each question should be provided and discussed.

Typically, classroom or workplace discussion of a case recognizes that there is not a single best answer to the problem. Skillful handling of this section often shows that two or more alternative solutions are possible. Thus, the *process* of problem resolution frequently will become the important focus. Highlighting this fact enriches the case and the environment for learning. An instructor new to case teaching can adhere closely to the Interpretive Note, while a more experienced instructor may develop his or her own interpretation. According to Stanford (1980), the well-written Interpretive Note will "tend to add a research dimension by encouraging teachers to take an interpretive position on the material. The outcome can be not only more-imaginative teaching, but a new view of problem-solving by the firm." This open-ended feature of the Interpretive Note is an important resource.

The author's analysis in the Interpretive Note, which accompanies "Agricultural Manager's Dilemma" in this issue of *HortTechnology*, is not provided in its entirety. To do so would make it widely available and thus tend to compromise the case. The full Interpretive Note can be provided upon request.

Case teaching

Case teaching begins with the writing of the case (Stanford, 1980). What is stated, how it is stated, and what is not stated are all part of the strategy. The writer must decide how much to lead the reader in identifying the major issues and must pose useful questions. The major sides of the situation must be brought out. The writer and the instructor must coach the perceptive student to logical resolution of the case. The model established for problem resolution should be useful in the workplace.

The instructor will use the written case and the Interpretive Note to orchestrate deliberation of the case. The teacher's role is analogous to that of an orchestra conductor, probing for points of view, prompting a more critical analysis, and encouraging rebuttal. While case teaching begins with writing the case, the verbal "orchestration" begins with the presentation of the case by the instructor. Arbitrarily, several levels of presentation are possible. At one extreme, the instructor might merely hand the case to the students without providing further commentary. At the other extreme, the instructor might talk the students through the case in detail, spending an hour or more articulating the background, major issues, and study questions of the case, thus leaving less to the imagination and creativity of the students. A more typical presentation provides an intermediate level of detail, outlining the major framework and setting of the case situation so that the students will feel more comfortable and move into the situation easily. Expectations on the part of the instructor should be modest and flexible. Depending on the complexity of the case and on other assignments given, the students may be given minutes, days, or weeks to complete deliberation of a case.

Routinely, at the next class following presentation and assignment of a case, time will be set aside to ask how the work is going and handle questions that have arisen regarding the case. Care must be given at this point to be helpful while avoiding steering the students toward one solution alternative or another. For the instructor who did not write the case, this also is a point at which the Interpretive Note may again be very helpful.

Once the students or student teams have declared their "bottom line" decision(s) and rationale, the case becomes a focus for class discussion. Again, this can be nondirected; anything you can get the students to do or provide without telling them to do it will be a bonus (Bennett, 1978). As noted by C.C. Christensen at the 1990 annual meeting of the North American Care Research Association, "take your students to where they *are* (and thus *start* from there) rather than where you *want* them to be." Begin with a diversity of cases, provide raw materials, and let the students exercise responsibility as active decision-makers, and the theory and principles gradually will emerge (Gragg, 1940).

Finally, most students will want to know the instructor's viewpoint and the decision made (if known) by the individual or firm about which the case was written. These do not absolutely need to be provided, but if they are, then a new dimension of the case is available, i.e., rebuttal by the students, who, frequently by this time, may have acquired some fairly strong convictions about the case. Failure by the instructor to provide a final personal viewpoint should be a satisfactory approach, which may have recognized three possibilities: 1) the students may be left with the confidence that their decision has merit; 2) the case probably will not be compromised, i.e., it can continue to be used in subsequent terms of the course; and 3) it is entirely conceivable that the "best" decision to the case has not been discovered, even by the teacher (Gragg, 1940).

In summary, the use of case method in plant science is stimulating to both students and instructors. It has a place in the repertoire of tools available to instructors in various teaching situations in horticulture and associated disciplines. Decision cases should become a more commonly used resource, and a clearinghouse should be established by ASHS through which cases can be made available.

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