DIAGNOSIS, a Microcomputer-Based Teaching Aid

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ABSTRACT
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The MS-DOS computer package DIAGNOSIS was constructed as an aid for teaching plant disease diagnosis to crop protection students. The program places students into field and laboratory scenarios, where they must look for clues to the causes of plant disorders. After giving and justifying a diagnosis, students then receive an automatic debriefing on their problem-solving approach. Student input is recorded to disk for later assessment by the tutor. Output may consist of text and graphics, and the software allows the simple construction of local scenarios by individual tutors.

For many years, computer simulations have been used to teach principles of plant pathology in various institutions throughout the world (5). Most of these programs incorporate one or more models of a system or subsystem allowing students to manage a crop/pest/disease interaction and perhaps show a financial return at completion. APPLESCAB (1) and TURFBLIGHT (2) are examples. DIAGNOSIS differs from these. Plant protection students need to acquire the "art" of disease diagnosis (4) along with management skills. DIAGNOSIS was designed as a training tool to assist in that objective.

The idea for DIAGNOSIS arose from the concept of text-based adventure games, common on the mainframe and early microcomputers of the late 1970s and early 1980s. In an adventure game, clues must be found and deductions made to solve a puzzle and to progress. In many respects, this "detective work" is similar to the process of plant disease diagnosis. Clues are sought in the field, a tentative conclusion is reached, and the conclusion is confirmed or rejected later in the laboratory.

DIAGNOSIS is designed to make students aware of the critical field and laboratory observations required for accurate diagnosis. It is designed to supplement rather than replace practical hands-on sessions in the laboratory. The program can monitor an individual student's *approach* to the problem both in the laboratory and in the field, an aspect difficult to assess by such traditional teaching methods as lectures and laboratory exercises.

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Because tutors write their own "local" situations for students to evaluate, the program can be used anywhere in the world. The student's progress is monitored during the game and recorded to disk for marking by the tutor. The student must justify the diagnosis reached, and this justification is also recorded to disk for marking. The computer can give a review of the session, reporting observations made, other observations that could have been appropriate, and the significance of the observations. Images can be included.

There are some limitations. The program in its current form is designed largely for diseases caused by fungi and nematodes. It can also be used for insect pests, viral and bacterial diseases, and noninfectious disorders, although the confirmatory laboratory procedures (e.g., insect incubation chambers, DNA probes, chemical leaf analysis) are not available in the present version.

The program. The DIAGNOSIS package consists of several programs written in Pascal using the Turbo-Pascal compiler (version 5.5, Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA 95066). The programs can be run with a minimum of 256K of RAM (random access memory), although more memory is needed if the tutor wishes to include pictures. A VGA/EGA or Hercules graphics card is required for the title page, but this screen can be omitted if the hardware is unavailable. The program comes ready to run, with five disease scenarios (requiring a high-resolution VGA graphics card) included. A text editor and graphics software can be used to construct other disease scenarios.

An overview of DIAGNOSIS. *Start.* Figure 1 shows the major steps in the program. After being loaded, DIAGNOSIS presents a graphic screen of a stylized diseased plant and asks for the player's initials. These initials are then used as the name of an output file to which all student operations are written. This text file can be printed out and marked at completion of the exercise.

In the field. A field scenario then appears on the top half of the screen. This remains visible until the student either moves to the laboratory for further tests or feels confident to make a diagnosis and quit.

The lower half of the screen contains the input and response area. Input requires a verb and a noun unless otherwise directed. Figure 2 shows the response to the command "Examine roots" in one of the scenarios supplied with the package. In some cases, a word alone will elicit some action. For example, the response to the command "Ask grower" is "Ask grower about what?" The student then types a single noun.

The vocabulary is limited but includes such verbs as examine, cut, smell, feel, take, eat, ask (grower), and go. Synonyms are included. Nouns include appropriate parts of the plant or objects in the immediate environment.

The program keeps track of objects that are collected for use in the laboratory. What can and cannot be collected depends on the scenario the tutor has constructed.

In the laboratory. After making observations in the field, the student normally spends time in the laboratory examining and taking isolations from the specimens collected. This step can be omitted if the player is confident of the causal agent(s) on the basis of field observations alone. If the player elects to move to the laboratory, a preliminary diagnosis based on the field survey is requested and saved to disk.

In the laboratory, a split screen is shown as before, and the student selects one or more common procedures to perform (Fig. 3). The material available for examination is that collected in the field. Both in the field and in the laboratory, the response to any input can consist of textual and/or graphic information, depending entirely on how the scenario has been constructed by the tutor. Students are expected to use literature and other resources during the game, just as they would for a real diagnosis.

The diagnosis. When confident about the cause of the problem, the player is asked to provide and justify a diagnosis

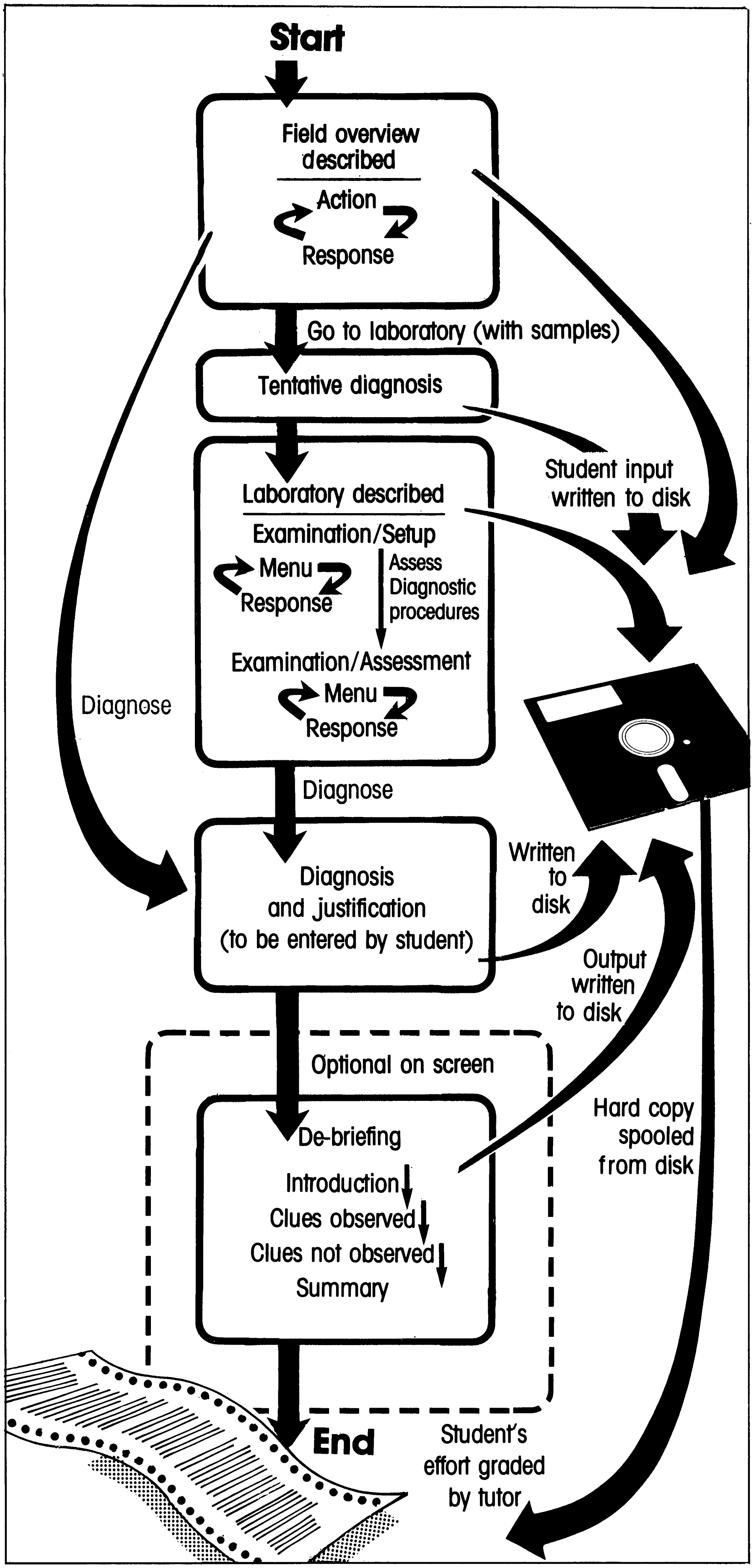

Fig. 1. Main steps in DIAGNOSIS.

You are standing in a young apple orchard. Most of the 4 to 5 year old trees here appear small and unthrifty. It is close to harvest, but the few small fruit these sick trees have produced litter the weedy ground.

From your conversations with the grower, it seems the plants have never done well, but this year has been particularly bad.

As you walk through the affected block, you notice the most pathetic specimens lie in the low areas. You stop in front of one particularly unhealthy tree for a closer examination.

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You dig up some surface roots close to the trunk. These roots are black and unhealthy looking. You run your fingernail down a typical specimen and the cortex comes away in a slimy mass!

What will you do next!

Fig. 2. A typical field situation showing a response to the command "Examine roots" in one of the supplied scenarios.

You are in the laboratory. On the bench to your right are assorted microscopes. Equipment for the examination of specimens is also here, including slides, mounting fluid, needles, scalpels and tissue papers. On surrounding benches lie petri dishes, filter paper, glass rods, bunsen burners, measuring cylinders, sterilizing solutions, agar plates, and all other paraphernalia needed for a diagnostic exercise.

Several others are here, all working on their own diagnostic problems.

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Select the procedure you wish to carry out:

1. Examine fresh tissue
2. Plate tissue to agar
3. Put the tissue in high humidity
4. Extract nematodes from the tissue/soil
5. Assess 2,3 and 4 (if appropriate)
6. Give a diagnosis

Select a procedure...

Fig. 3. A typical laboratory scenario showing the available options.

What is your diagnosis? Collar rot of apples caused by <u>Phytophthora cactorum</u>

List the observations which led you to this conclusion. At the end of each line press <ENTER> and when finished press <F1>

1. The crop is situated in a high-rainfall area, and the trees most affected were in the low-lying areas. There seemed to be a relationship between the diseased trees and water. Root-rotting Oomycetes require high soil moisture for zoospore movement.

2. Above-ground and below-ground symptoms were consistent with those of collar rot. Oospores were observed in diseased tissue.

3. The grower said the variety was Cox's orange. This variety is very susceptible to <u>Phytophthora cactorum</u>.

Fig. 4. Screen showing student diagnosis and justification.

Important clues you observed...

- The leaves showed symptoms of nutrient and water stress, usually an indication that something is amiss with the roots.
- The cortex (inner bark) of the roots was rotten, a common symptom of a root rot disease.
- The apple variety, Cox's orange, is very susceptible to this fungus.
- Oospores could be seen in diseased tissue under high magnification.

Press <SPACE BAR> to continue...

Important clues you <u>did not</u> observe...

- An examination of the soil would have proved useful. It was heavy and would hold water for some time, which is conducive to many root rots.
- The weed species present indicated a heavy, wet soil. You should have noted these.
- Cutting away some of the bark on the crown would have been worthwhile. The brown discolored wood you would have seen is typical of crown rot caused by this fungus.
- Often asking the right questions can be helpful. If asked about the weather, the grower would have remarked on how much rain had fallen lately, a factor conducive to this rootrot.
- To confirm your suspicions, you should always isolate to agar where possible and examine the organism under high magnification.
- It would have been worth asking the grower about drainage of his property. It was poor (thus contributing to waterlogging and root rot)

Press <SPACE BAR> to continue...

Fig. 5. Two screens from a typical debriefing session.

in a few paragraphs, which are typed into the computer and written to disk for later assessment (Fig. 4). Then follows an automatic review of the session.

The review. In constructing the scenario, a tutor can specify up to 12 important "clues" that the student should discover. The program keeps track of which clues are uncovered, and these are presented to the student along with clues that were missed (Fig. 5). The correct diagnosis and other pertinent information are also given, and the output is appended to the student's disk file.

The program then terminates, closing the student input disk file, which can be printed for assessment. The package allows tutors to omit this automatic debriefing if they wish.

Building a scenario. A tutor using the DIAGNOSIS package can create many different disease scenarios. A simple text file is first created that contains all the textual descriptions, responses, and other information required by the main program but which may differ depending on the disease selected (Fig. 6). One of the subprograms in the DIAGNOSIS package can then be used to convert this (source) text file to a Pascal data file. It is this data file that is read by the main program on execution. An unlimited number of scenarios can be constructed in this way, with the main program controlling the flow, checking student input, and displaying the appropriate responses read from the data file.

The format of the text file must be absolutely correct for a successful compilation. To achieve this, responses must be arranged under headings pertaining to the particular commands that cause them to be displayed. Also, the textual responses cannot exceed six lines. Deviations from the correct format are detected by error traps in the conversion program, thus ensuring the validity of the resultant data file. A template file is available in the package to allow a tutor to construct a scenario simply by filling in the blanks between the formatting headings.

Graphics. The ease of incorporating graphics in a DIAGNOSIS scenario varies according to the tutor's hardware configuration. Apart from the optional title, the software does not handle graphic screens directly but instead can run any user-supplied external graphics display program (from within itself) as determined by the tutor when the scenario is constructed. For example, tutors using their own software can draw or digitize pictures of an image associated with a particular response, then use "viewing" software to display it when the response is called for. This technique has proved successful with many different graphic viewing programs (e.g., VPIC.EXE, version 4.0, Bob Montgomery, 543 Via Fontana No. 203, Altamonte Springs, FL 32714-3172) and graphic formats such as GIF (3).

DIAGNOSIS provides an inexpensive and interesting way for students to practice the methodology of plant disease diagnosis in a controlled, monitored environment. The program allows a tutor to assess student performance and provides immediate feedback. Local scenarios can be easily created, allowing the program to be used anywhere in the world. DIAGNOSIS is available, at a cost of $60.00 U.S., from the author, Department of Plant Science, Massey University, Palmerston North, New Zealand.

Template	Comments	Part
TEXT INPUT TEMPLATE		
HELP AVAILABLE? Y	Determines if on-line help is available to students	Part 1
FIELD SCREEN		
....	Text describing field and overview	Field verb/noun combinations
EXAMINE LEAVES	verb/noun combination	
CLUE *Y1*	Indicates if action reveals a clue	
PICTURE = *leaves.gif.*	Name of file containing graphic image (if present).	
....	Textual response to command (in this case "Examine leaves").	
• • (etc. All verb/noun • combinations are formatted in • the same way) •		
ASK GROWER ABOUT ... WEATHER CLUE *Y6* PICTURE = *none* .... VARIETY CLUE *Y7* PICTURE = *none* • • (etc. ...) •	Covers all replies from the grower regarding specific questions	Part 2 Grower Replies
WHAT CAN BE TAKEN PLANT *n* LEAVES *y* ROOTS *y* • • (etc. ...) •	Determines what object can be collected for Laboratory diagnosis	Part 3 Field Objects
LAB SCREEN		Part 4
....	Description of Laboratory	
MICROEXAMINATION OF .. ROOTS	Menu selection	Lab menu selection
CLUE *y8*		
PICTURE = *roots. gif.*	Picture file named "roots. gif"	
....	Text preceeding picture file	
• • (etc. — All objects and menu • selections formatted this way) •		
DIAGNOSIS *Phytophthora root rot*	Correct diagnosis written here	Part 5 The De-briefing
DE-BRIEFING INTRO ...		
....	Text introducing de-briefing	
CLUES FOUND 1. .... 2. .... • • (etc. ...) •	Text associated with numbered clues to be shown if appropriate clue has been observed	
END CLUES FOUND		
CLUES LOST 1. .... 2. .... • • (etc. ...) •	Text associated with numbered clue, to be shown if appropriate clue has *not* been observed	
END CLUES LOST		
DE-BRIEFING END		
GRAPHICS SHOW PROGRAM	Name of program which will show graphic screens	
END		

Fig. 6. Format of scenario text file used to create a data file for DIAGNOSIS. All text in italics or represented by leader dots is supplied by the tutor building the scenario.

LITERATURE CITED

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Botanic Gardens of Adelaide. Contact: Librarian, E. G. Denny, North Terrace, Adelaide, SA 5000, Australia.

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Busch Agricultural Resources, Inc. Contact: Michael Bjarko, Barley Breeder, 3515 E. County Road 52, Ft. Collins, CO 80524; 303/221-5622; fax: 303/482-5965. Busch Agricultural Resources is the agricultural subsidiary of Anheuser-Busch, Inc., and the supplier of the malted barley, hops, and rice used in the brewing of Anheuser-Busch beers. Its efforts are concentrated into six major areas of operation: malting barley; hops contracting and production; rice contracting, milling, and marketing; land application and turf marketing; agricultural research in barley, rice, and hops; and a grain/seed operation network for the contracting, processing, and storage of malting barley and seed. The company supports research in an effort to control diseases of barley, rice, and hops.