

# Filling the Role of Staff in Flexibly Delivered Atmospheric Science Practicals

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## Introduction

Atmospheric Science at Macquarie University is taught within Physical Geography. Five undergraduate units are taught: two second year and three third year. There are also Atmospheric Science components in two first year units. To this core, students can add units in earth sciences, mathematics, biology, chemistry, physics and computer science to obtain a BSc with a major in Atmospheric Science. However, only 20 to 25% of the students in second year are majoring in Atmospheric Science. The five core units are each one semester in length and have a pattern of two one-hour lectures per week and one three or four hour practical per week. Traditionally, the practicals have involved a variety of activities including field exercises, computer-based sessions, plotting and interpretation exercises, and application problems. The practicals have also served as tutorials.

Material based on the hypertext markup language (HTML) was first introduced into the programme in 1994 with the development of a four week component on remote sensing in one of the third year units. In late 1996 the Atmospheric Science group was awarded a 1997/98 Macquarie University Flagship Grant to broaden the individual and varied developments that had occurred within the units in the programme since 1994. The aim was that at the end of the two year project the five Atmospheric Science core units, with the exception of essential third year fieldwork, would be deliverable in a flexible mode using Internet technologies.

The on-line material that has been developed for each unit follows a similar pattern and includes: standard unit information (course schedule, assessment details, etc.); lecture material (ranging from overheads to detailed notes); practical material (including HTML interfaces to real-time data, research data, simulation software and complex research models); discussion facilities (mail, bulletin board); and a resource section (including glossary, acronyms, library access, textbook errata, reading list and some World Wide Web links). The two second year units also include on-line summative assessment in the form of multiple choice quizzes.

The delivery of the practicals, which also serve the role of tutorials, in a flexible mode presents particular challenges. In addition to the need for interactive material involving simulations, models, visualisation and animation, the role played by a tutor or demonstrator needs to be filled. These staff provide feedback, guidance and checking of student progress throughout a practical. This paper outlines some examples of these and how the absence of staff has been addressed in the flexibly delivered material.

## Examples of Feedback in Practicals

During the course of the traditional Atmospheric Science practicals staff fulfil various roles that are not met by the print-based study guide and/or handouts, or the pre-existing computer-based material. Often the practical times are used by students to ask questions and seek clarification and explanation of various things that are not necessarily related to the practical, and by staff to provide general feedback, and specific feedback to particular students, on a variety of issues (e.g., assignment results, clarification of issues raised by other students). In the flexible delivery mode, the discussion facilities



(mail and bulletin board) and ability to easily put new and updated material on-line, facilitate much of this discourse. The degree to which this works, how it compares with face-to-face interaction, and the associated resource issues will not be discussed in this paper. Rather, the following subsections give examples of how the need for specific feedback related to the practical material has been addressed. The examples chosen are:

- questions that have short specific answers;
- numerical calculations;
- plotting exercises;
- problem solving; and
- animation.

They all come from one of the second year units: GEOS216 Atmospheric Environment. This unit can be done entirely off-campus but it still has the two on-campus lectures. However, because of funding cuts, staff only attend about 60% of the practicals.

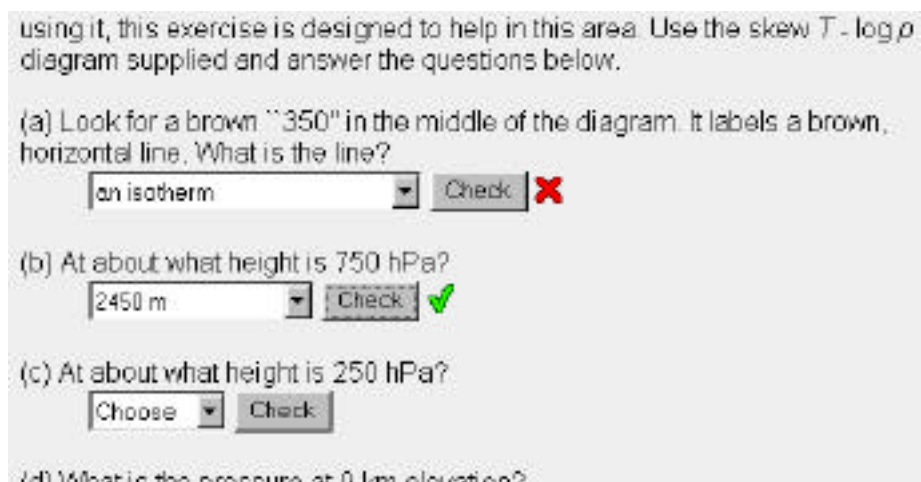
### Questions that have Short Specific Answers

These are questions that have a clearly correct answer. They are usually used in the practicals to check student progress and understanding and build confidence before moving on to other material. Instead of a staff member checking answers, these questions lend themselves well to multiple choice self-checking.

For example, the first of two practicals on aerological diagrams, introduces the skew  $T - \log p$  diagram, explains its use for determination of moisture parameters and potential temperature, and has an exercise on plotting atmospheric soundings. The diagram has five isolines: isobars, isotherms, dry adiabats, saturation adiabats, and saturation mixing ratio lines. The other major feature is the International Civil Aviation Organisation's standard atmosphere's lapse rate. Temperature and dewpoint from atmospheric soundings are plotted on the diagram and various things such as atmospheric moisture content, stability, and cloud base height are calculated.

During the practical students are presented with a series of familiarisation exercises. To allow them to check their answers themselves, they are given a simple multiple choice selection implemented using an HTML form and JavaScript (Figure 1).

Figure 1. An extract from a practical exercise involving familiarisation with the skew  $T - \log p$  aerological diagram. Students can choose their answers by making a selection from the pop-up menus and then clicking the "Check" button. An image of either a green tick or a red cross then appears.



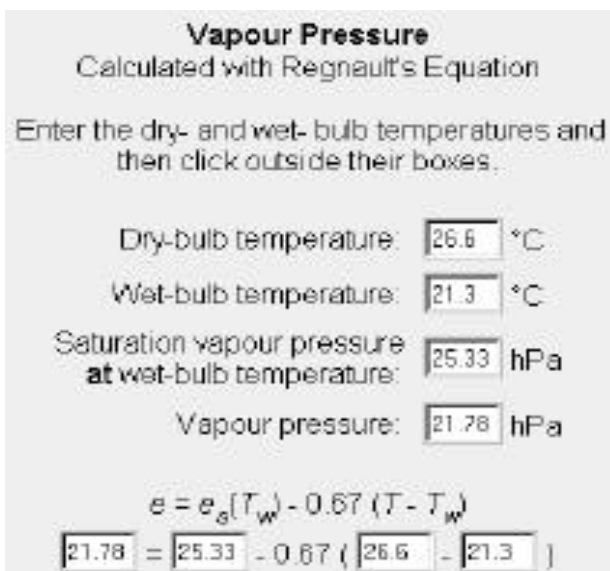
In this instance, the only feedback they get is correct (a tick) or wrong (a cross). Multiple choice self-tests that provide greater feedback are used elsewhere. The familiarisation exercises in this practical are optional in that progression through the material does not require their completion. In other instances the correct completion of such self-tests is necessary. However, this hinders revision unless successful completion is logged and allows free access in subsequent use.

## Simple Numerical Calculations

Students regularly have to carry out numerical calculations in their practicals. These may be example exercises or they may involve the use of the student's own data. Many of these calculations only require basic algebra, but they still present considerable difficulty to many geography students, particularly those who simply declare that they "cannot do maths". Even for more able students, errors are easily made as calculations might require using a table or chart to obtain some of the values involved in a calculation. Thus it is important to not only provide the correct answers but to also show the values of various parts of an equation to indicate where a student might have gone wrong. Feedback other than simply giving the correct answer is also important as subsequent calculations are often reliant on earlier ones, or on the ability to repeat earlier methods.

An example of such a calculation is in a practical dealing with the measurement and expression of humidity. In one part, students obtain observations of dry- and wet-bulb temperatures using a whirling psychrometer. They exchange their observations with others in the class using the bulletin board. As the practicals are scheduled for on-campus students at four different times during each week, this gives them a variety of observations in terms of location, time of day and potentially under different weather conditions. These observations are used by the off-campus students. This electronic entry by the students also makes it easy for staff to collect the results for use as examples in various situations and future years.

Students then have to calculate saturation vapour pressure, vapour pressure, dew-point temperature, mixing ratio and relative humidity. To facilitate the checking of their own individual calculations they have access for each calculation to a calculator which is implemented using an HTML form and JavaScript. In some instances these calculators simply check that they have correctly used a table of values (e.g., a saturation vapour pressure table). In others, such as the calculation of vapour pressure, their application of an equation is checked with each component being displayed (Figure 2).



**Vapour Pressure**  
Calculated with Regnault's Equation

Enter the dry- and wet- bulb temperatures and then click outside their boxes.

Dry-bulb temperature:  °C  
Wet-bulb temperature:  °C  
Saturation vapour pressure at wet-bulb temperature:  hPa  
Vapour pressure:  hPa

$$e = e_s(T_w) - 0.67 (T - T_w)$$

=  - 0.67 (  -  )

Figure 2. A vapour pressure calculator used by students to check their own calculations. They enter their observed dry- and wet-bulb temperatures in the appropriate boxes and the calculator fills in the other boxes.

## Plotting

Often students need to plot and interpret data. Sometimes the data also need to be manipulated mathematically before plotting. When present, staff can check each stage of this process and point out errors to students.

In a flexible mode where staff are not present, a strategy similar to that for the calculations mentioned above has been employed. Numerical calculations are checked with the use of an HTML form and JavaScript, and plotting is carried out by submitting the form to a common gateway

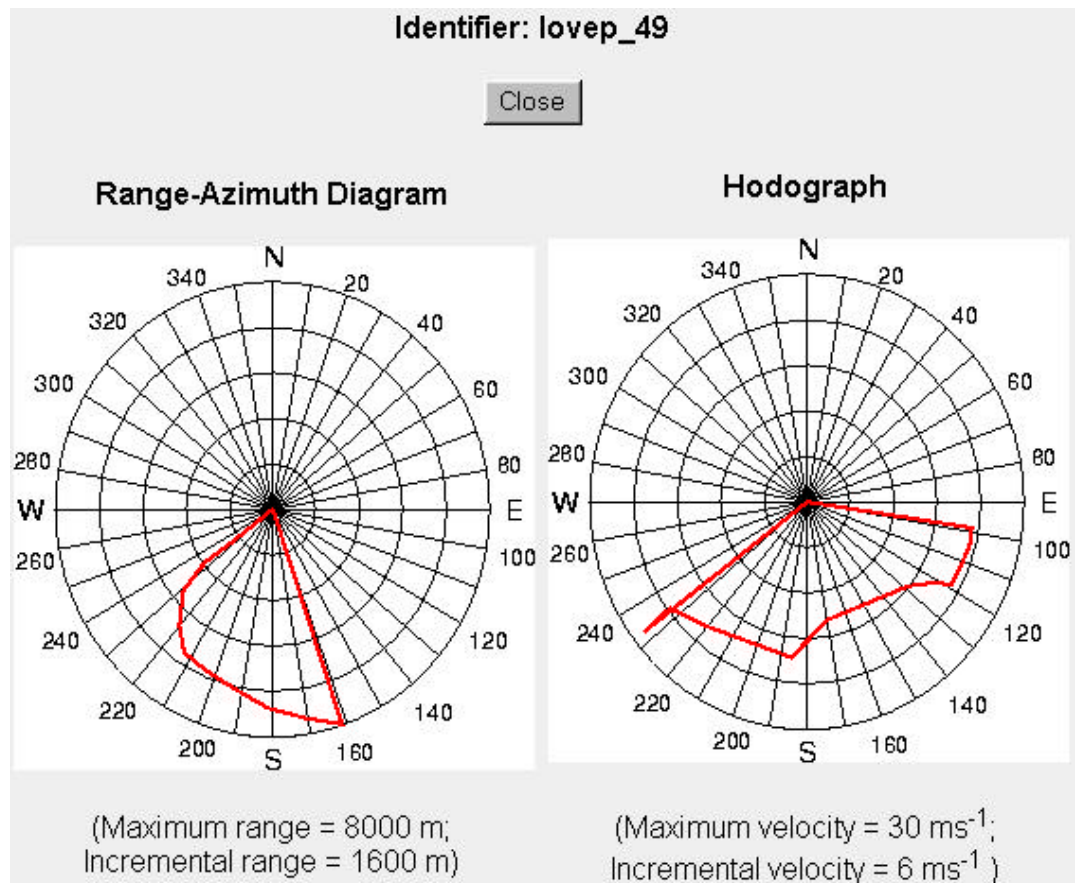
interface (CGI) script that then calls programs that do any additional calculations and the plotting.

An example of this is a practical in which on-campus students launch a weather balloon and track it with a theodolite. They then have to calculate the balloon's position and velocity at various heights and plot these on range-azimuth and speed-direction (hodograph) plots. After checking and then submitting the HTML form (Figure 3) the plots are returned along with an identifier (Figure 4). This identifier allows the student to retrieve their data and plots at a later date for revision purposes or if they have to leave the practical at this point before moving on to the interpretation section. Additionally, this storage enables the discussion amongst students of each others results and the use of the data by off-campus students. It also allows staff to build up an archive of useful wind profiles for use in discussions with students and for use as examples in future years.

Observed			Calculated			
$d'_d =$ <input type="text"/> m	$v_z =$ <input type="text"/>		position		velocity	
$ms^{-1}$			height (m)	range (m)	speed ( $ms^{-1}$ )	direction (degrees)
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Figure 3. This HTML form and the associated JavaScript are used by students to check their calculations of a weather balloon's position and velocity from their observed theodolite readings. The form can be submitted to generate range-azimuth and hodograph plots (Figure 4).

Figure 4. Part of the response from the weather balloon position form (Figure 3). The identifier at the top allows students to retrieve their plots and data at any later date.

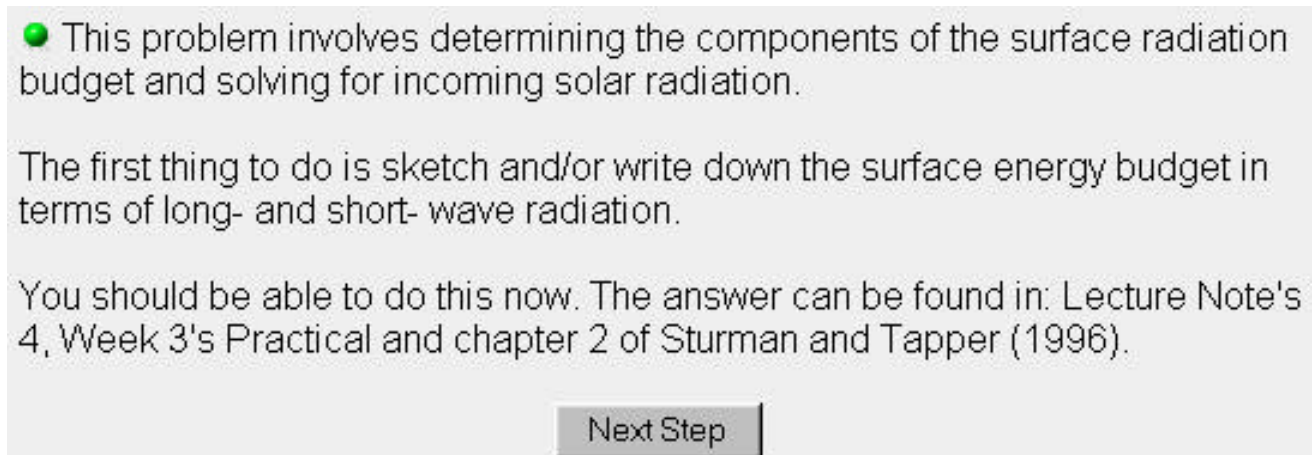


## Problem Solving

Students are given application problems to show how the concepts they are learning can be brought together and applied to real-world examples. One of the important things staff do in practicals is assist students in understanding how to go about solving these problems. Most of the difficulties the students have with the problems are not the actual algebraic manipulations. Their difficulties are predominantly in knowing how to approach the problems. To simulate the role of a staff member students can access the final numerical answer to see if they have got it correct. They then have the option of building up a model solution by working through a series of steps. At each step they are given the opportunity to complete the problem themselves. To encourage them to do this, each step might contain hints, references or HTML links to lecture or practical material.

These stepped solutions are simply a series of appropriately linked HTML pages. However, to facilitate their generation and maintenance they are sourced from a single file that contains the sequence: part of final solution, hint/information on how to solve, part of final solution, hint/information on how to solve, etc. The HTML pages are then generated by processing this file with a simple script.

For example, in a problem involving the surface energy budget students are given various bits of information and then asked to calculate, amongst other things, incoming solar radiation. The first step starts by re-iterating very simply the objective. It then indicates that a diagram should be drawn and gives some references (Figure 5). The next step gives an appropriate diagram and introduces the associated energy balance equation (Figure 6). This example then proceeds with the identification and calculation of the various components from the information supplied in the problem. As each known variable is identified its colour on the diagram is changed to black. At each step the relevant equations are represented on the diagram as well as in the text.



● This problem involves determining the components of the surface radiation budget and solving for incoming solar radiation.

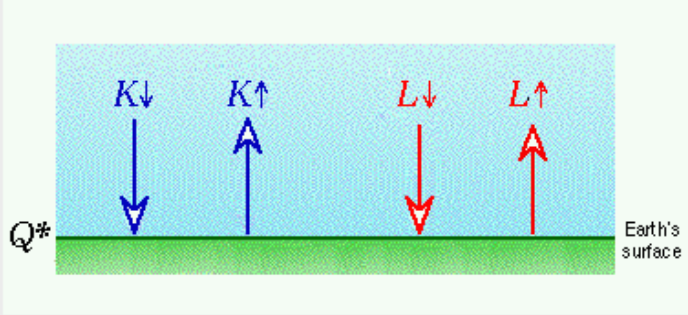
The first thing to do is sketch and/or write down the surface energy budget in terms of long- and short- wave radiation.

You should be able to do this now. The answer can be found in: Lecture Note's 4, Week 3's Practical and chapter 2 of Sturman and Tapper (1996).

Next Step

Figure 5. The first step students are given in a problem requiring them to calculate incoming solar radiation. They are given the important step of constructing a diagram and some references to help them. The next step is shown in Figure 6.

● The surface radiation budget can be shown schematically as



Symbolically, this can be written as

$$Q^* = K \downarrow - K \uparrow + L \downarrow - L \uparrow$$

The next thing to do is identify which components are known and how the others relate to other information you are given.

Next Step

Figure 6. The second step students are given in a problem requiring them to calculate incoming solar radiation (*cf.* Figure 5). They are given a diagram and the mathematical relationship between the variables in the diagram. As these variables are identified in subsequent steps their colour changes to black. The variables are also replaced on the diagram by the equations needed to calculate them.

### Animation

Often staff use handwaving and drawing successive things in different colours and/or erasing and re-drawing to indicate temporal or other changes in physical state. In some instances this type of feedback can be achieved in the absence of staff by the use of animation. This is particularly successful when students can construct their own animations for their own cases.

An example of this is soil temperature profiles, their diurnal variation and how they depend on characteristics of the soil. A simple HTML form interface (Figure 7) is used to allow students to choose soil type and depth, and the length in days and speed of an animation of the soil temperature profile. At the end of the animation three hourly profiles are shown in colour on a single still frame (Figure 8).

diurnal variation of soil temperature will shortly appear. You should interpret the evolution of the profile, compare the different soil types, and discuss your observations with your colleagues.

Soil Type:  Soil Depth (cm):

Time Period:  Time Lapse between images:

Figure 7. An HTML form interface which produces an animation of a soil temperature profile. At the end of the animation a still frame with three hourly profiles is displayed (Figure 8).

### Conclusion

Some of the ways in which the absence of staff can be compensated for in flexibly delivered Atmospheric Science practicals have been shown. All of the examples here were used in a second year undergraduate Atmospheric Science unit in first semester, 1997 and are being used in first

semester, 1998. Some evaluation has been done and more is in progress. The evaluations to date have not been focussed on the feedback mechanisms mentioned here, but some of the open comments received relate to them.

Overall, student response towards the material based on Internet technologies is very positive. When presented with the statement “I would be more likely to enrol in a unit like GEOS216 if it offered a program with similar on-line access” the number of responses in each of the categories no response, strongly agree, neutral, disagree, strongly disagree and not applicable were 0, 20, 19, 12, 3, 2 and 1, respectively. That is, 68% of students agreed with the statement and approximately 89% agreed or were neutral. However, one consistent comment received was that more feedback was required in the practicals.

This highlights the importance of including feedback mechanisms such as those discussed here and the need to introduce and intersperse more of these throughout the material. To do this effectively will require some analysis of actual student use of the material. This is essential in order to identify to what extent the different mechanisms are actually utilised in each learning context.

Another consistent comment was the need for more staff presence in practicals to answer queries at the time of a problem. This comment needs to be considered in the light of a very poor attendance at the practicals where staff were available. However, there is no doubt that in many situations students do benefit from individual feedback at the time a query arises. One solution to this problem for spatially distant students would be to have staff available at particular times for synchronous communication. This should be implemented along with encouragement for peer response and interaction via the communication facilities. Greater HTML linking between practical and lecture material might also assist.

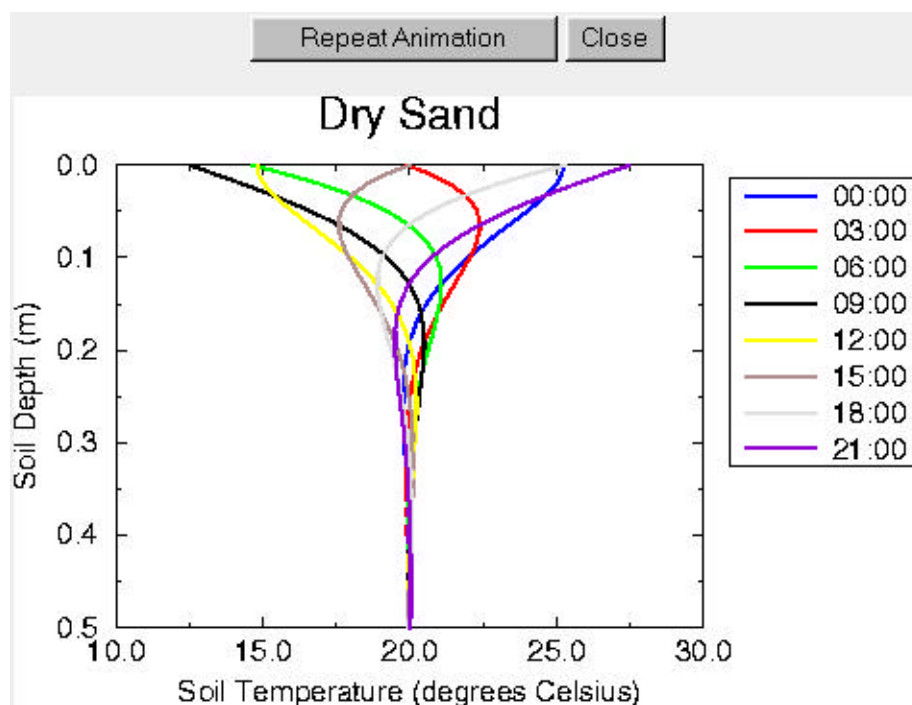


Figure 8. The still frame with three hourly profiles that is displayed at the end of a student constructed animation of a soil temperature profile (see Figure 7). The different profiles are in colour.

## Acknowledgement

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