DOCUMENT RESUME

ED 282 739 SE 048 162

AUTHOR Treagust, David F.
TITLE Exemplary Practice in High School Biology Classes.
PUB DATE Mar 86
NOTE 17p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (59th, San Francisco, CA, March 28-31, 1986).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Biology; Case Studies; Demonstration Programs; *Educational Quality; High Schools; Inquiry; Instructional Effectiveness; Science Curriculum; Science Education; *Science Instruction; *Secondary School Science; Student Motivation; *Teacher Effectiveness; *Teacher Student Relationship; Teaching Methods
IDENTIFIERS Australia; *Science Education Research

ABSTRACT

In a response to lower test scores in science and mathematics in Australia, the Western Australian Institute of Technology conducted a study to identify high quality science and mathematics teachers in Western Australian schools. This paper describes the teaching practices of one male and one female teacher of biology from two different schools. It identifies those teaching practices which may be considered exemplary and worthy of attention and analysis by other teachers and teacher educators. The study addresses specific aspects of: (1) the intended curriculum; (2) the implemented curriculum; (3) the perceived curriculum; and (4) the achieved curriculum, in terms of the teaching of biology at the high school level. The major focus of these case studies is on the implemented curriculum, particularly with regard to the teachers' classroom organization and management, handling of students from different ability levels, student motivation, and the nature of the academic work. While both teachers were identified as being exemplary, there were differences found in their instructional approaches which tended to be attributed to the personality and teaching philosophy of each teacher. (TW)

EXEMPLARY PRACTICE IN HIGH SCHOOL BIOLOGY CLASSES

David F. Treagust
Science and Mathematics Education Centre
Western Australian Institute of Technology
Perth, Western Australia 6102
AUSTRALIA

A paper presented at the 59th Annual Meeting of the National Association for Research in Science Teaching, San Francisco, California, March 28-31, 1986.

OVERVIEW

The Search for Excellence sponsored by the National Science Teachers Association identified exemplary science programmes throughout the United States (Penick & Yager, 1983). The impetus for such a search in American schools was to identify high quality science programmes and teachers in an endeavour to improve science achievement which in the late 70's and early 80's was reported to be in decline.

In a similar manner, the media in Australia reported on low test scores and lack of quality education in science and mathematics. As a consequence of these concerns in Western Australia, a group of science and mathematics educators centred at the Western Australian Institute of Technology embarked upon the study of Exemplary Practice in Science and Mathematics Education to identify high quality science and mathematics teachers in Western Australian schools, to document exemplary practice through case studies, and to investigate key characteristics common to exemplary teaching. An overview of the study and summary of the findings of case studies involving science teachers in classes from grades 3-12 is provided by Tobin (1986) in the first paper of this symposium.

PURPOSE

This paper describes the teaching practices of one male and one female teacher of biology in two distinctly different schools and identifies those teaching practices which may be considered exemplary and worthy of attention and analysis by other teachers and teacher educators. The paper addresses specific aspects of the intended curriculum, the implemented curriculum, the perceived curriculum and the achieved curriculum in terms of the teaching of biology at the upper secondary level in Years 11 and 12. The major focus of the paper is on the implemented curriculum in terms of the teachers' class organization and management, handling of students of different ability levels, student motivation and the nature of the academic work.

The intended curriculum is described briefly in terms of the syllabus, the text books, teaching foci and the nature of the academic work described by the teachers. The implemented curriculum as described above was based on qualitative and quantitative data from classroom observations. The perceived curriculum is described in terms of student responses to learning environment questionnaires and to interviews. The achieved curriculum is obtained from teacher records about student progress and from interviews with teachers and students. The intention of this paper is to enable the reader to picture the workings of the two classrooms and to identify with the various activities in order to utilize chosen aspects in their own teaching or in science methods courses for preservice teachers.

This study differs from other studies of biology teaching reported in the literature in that here intensive observations only involved two selected teachers with exemplary teaching qualities rather than a sample of several teachers of the subject matter. For example, in Tamir's (1981) study of 22 teachers involved in the Israeli BSCS Adaptation, both direct observations and tape-recordings were made of 109 lessons and data were collected and quantified on the nature of teaching, the number and kinds of questions, instructional techniques and modes of teaching.

METHOD

This study was conducted in intact classrooms in one government and one private catholic high school, as each teacher implemented the regular science curriculum as defined by the syllabus for the last two years of high school which culminates in an externally set examination. No attempt was made to interfere in any way with the content to be taught, the materials to be used and the manner of their presentation. The author and a colleague, Jean Clarke, made observations in the teachers' classrooms.

Sample

The two teachers of upper school biology who were designated as having exemplary teaching behaviours were selected to be involved in this study on the basis of peer and expert nomination. The teachers had eleven and thirteen years experience and both were in charge of their respective subjects in the schools. The male teacher, Mr Reed, worked in a coeducational state government high school which was primarily drawing students from working class backgrounds in a middle to low socioeconomic area where many parents were on government assistance. The female teacher, Mrs Owens, worked in a private catholic all-girls school where the students were generally from families of a middle-class economic status. While there were many superficial differences between the schools, one obvious major difference was school uniform. In the private girls' school, the uniform was worn exclusively: Students in the government school wore their uniform to varying degrees, some students wore a school uniform all the time, others wore no school uniform at all. According to Mr Reed, in the past few years there had been numerous disruptions at the school, some of a serious nature. The introduction of a personal tutor system, emphasizing pastoral care, a house system to stimulate school spirit and a whole school approach to managing student behaviour had resulted in much better behaviour in the school. The time spent in either school was not obviously dissimilar in terms of students' behaviours and/or manners.

Data Collection Procedures

The observations reported in this paper were made mostly during the first term (March-May) and the early weeks of second term (May-June), 1985. The observers were in these two teachers' classrooms on an almost daily basis for several selected biology periods over a six week period and on less frequent occasions at other times. In Mr Reed's Year 11 and 12 classes there were 14 students (5 males and 9 females) and 19 students (7 males and 12 females) respectively. Mrs Owens' Year 11 and 12 biology classes contained 28 and 9 girls respectively.

The study mainly comprised an ethnographic investigation of two biology teachers using the research techniques described by Erickson (1986). The primary data base consisted of narratives of Year 11 and 12 biology lessons taught by the two teachers, 32 by Mr Reed and 22 by Mrs Owens. The reason for more lessons observed in Mr Reed's classes was that his school was within easier commuting distance than was Mrs Owen's. Other data were obtained from the teachers and from a sample of student interviews. During the observation of 54, 50 minute lessons, descriptive information was taken together with a time log of activities. The students who participated in the interactions were identified and an assessment of the interaction was noted. The teachers were asked to comment on notes made of the lessons and at the end of the data collecting period.

The Intended Curriculum

The intended curriculum for the biology lessons was that defined by the Web of Life Biology course which is an Australian adaptation of the green version of Biology Sciences Curriculum Study. The Web of Life is used almost universally in Western Australian biology classrooms, as it is throughout all states of Australia. The syllabus document used by these two teachers clearly is in favour of using the Web of Life as the essential student textbook (Board of Secondary Education, 1985). Details of the adoption and monopolization of Web of Life in Australian classrooms have been described in detail by Lucas (1980a, 1980b).

The Web of Life course has been offered in Years 11 and 12 in Western Australia as a matriculation subject since 1968. The course is based on an inquiry approach to the study of biology and each chapter is organized around key ideas. The organizers of the course intend that the teacher provide learning experiences for the students, through the text by means of teacher-led discussions, through student-student discussions and by laboratory experiments. The teacher ideally acts as a facilitator of access to knowledge rather than as a disseminator of knowledge. Such a role is not always the preferred style of the biology teacher and this has been observed in numerous discussions with biology teachers by the author. Further, teachers' perceptions of the Web of Life course in Western Australia are currently being investigated and the outcomes should highlight concerns of teachers about the utility, suitability and viability of the inquiry approach towards achieving the intended curriculum. One reason for these concerns is that increasing numbers of students in Australia are staying on at school and the Web of Life is seen by many teachers as being too academically demanding for many students who now opt to take this subject.

For both Mr Reed and Mrs Owens, the intended outcome of student learning was understanding of the subject matter, fostering independent learning and success on the externally examined end of Year 12 examination, the Tertiary Admittance Examination (TAE). Throughout much of the teaching sequence observed, and especially in Year 12, parts of the curriculum were continually being highlighted for the students in terms of this or that being important for the end of course examination.

Implemented Curriculum

Class Organization and Management

One facet common to both teachers was their ability to be always thoroughly prepared and organized. This organization was not only apparent in the way both teachers were preparing for class but also in the way the students responded to tasks. Typically students knew this was an organized class and in turn were encouraged to become organized in their own learning.

Both Mr Reed and Mrs Owens used all four distinct classroom structures described by Tobin (1985), as part of their high school science teaching repertoire. These four classroom structures were: whole class non interactive structures involving say, a lecture, video or film; whole class interactive structures where question and answer sequences occur; individualized engagement such as reading from text, working problems in a notebook or copying notes from the teacher blackboard or overhead projector; and small groups of students working together such as in a discussion group or in completing a laboratory exercise. During the time of the observations

in Mr Reed's classes, approximately 15% of class time was spent in whole class non-interactive structures, 15% in whole class interactive sessions, 20% in individualized engagement and 35% small group work. The comparative time spent in this mode of teaching by Mrs Owens was 20%, 20%, 25% and 20% respectively. The remaining 15% of time in both classes by Mr Reed and Mrs Owens which was taken up by transition between activities and classes compares favourably with the 20% of time for these transition activities reported by Rosenshine (1980). Indeed, one facet common to both teachers was the ease with which lessons flowed from one kind of activity to the next. Both Mr Reed and Mrs Owens organized a regular programme of laboratory activities for their classes, usually in accordance with the laboratory guide of the Web of Life. However, both teachers remarked that there were occasions when certain laboratories were supplemented so that, in their estimation, the students could better achieve higher goals or could achieve the same objectives in a shorter period of time.

In Mr Reed's classes students were always aware of exactly what was required of them during each lesson and for the duration of each chapter. At the start of work on a new chapter in the text, a type-written sheet describing readings, exercises and objectives was handed to them. At the beginning of each week Mr Reed usually explained the work to be done for the rest of that week and the first few lessons of the following week and sometimes for the subsequent weeks. According to Mr Reed, this procedure was designed to enable the students to work ahead of their class exercises and to develop a broad picture of each chapter of the text and section of the work. In disseminating these class and homework schedules orally and referring to a typed chapter programme that all students receive, Mr Reed explained that the oral dissemination of information was to ensure that the students learn to listen and plan their own learning schedules. Students were almost always diligent at taking notes about their work schedule and did so without any additional need for direction.

Mrs Owen's class organization was more centrally controlled, in that she initially set the work for the day or the week and students responded to her as class leader. However, this is not to imply that she encouraged the students to be reliant on her. The organization within the all-girls schools was more formal than in Mr Reed's school with the girls standing behind their desks at the start of each lesson. Mrs Owen's greeting of "Good morning Ladies, sit down please" started off the lesson and she simply explained the work to be done that day at that point in time.

Good management and organization with easy flow between segments of the lessons were key features of Mr Reed's and Mrs Owen's teaching; such teaching behaviour would appear to be in accord with Kounin's (1970) work which suggests that communicating awareness prevents the initiation and spread of off-task and disruptive behaviour and this reduces the need for reprimands. Off-task behaviour of students was managed at two levels by Mr Reed and Mrs Owen. Firstly, they employed classroom management techniques which discouraged off-task behaviour and secondly they dealt individually with each person involved. In both teachers' classes, students were all actively engaged in activities for the whole lesson - often continuing after the siren signalled the end of the lesson period.

In group activities and discussions, Mr Reed constantly moved around the groups interacting with the students. Students who completed a task in advance of the rest of the class were given extension work, e.g., extra problems or extra reading material which were non-core materials from the Web of Life course. When Mr Reed was drawing diagrams on the overhead projector - a teacher activity - he kept the class attentive by asking

questions about the content or by comments such as "Like my new pen?". In essence, biology classes were busy occasions for students and teacher alike with little opportunity to engage in off-task behaviour.

When dealing with individual students, Mr Reed's remarks were directed at the person concerned and gave the minimum disruption to the rest of the class. For example, if a student was off-task, Mr Reed's response, in the same breath as he was providing the information was "Do you have this taken down, John?". The student nearly always responded to this in a positive manner without need for any further remark or criticism. As another example, after making eye contact with an off-task boy he said "Greg, please, do you know this?.....Others might not?" On an occasion when one all male group had been off-task during an activity they were asked "Fellows, how much have you achieved?" After the boys indicated the work they had done, Mr Reed responded with "Yes, but are you happy with what you have achieved?" Further questioning of the boys was designed to help them achieve a higher level of knowledge. During all types of lesson activity structures, students were fully engaged for the complete time they were in the classroom and were expected to work to the limits of their ability during this period. Private and personal discussion was permitted but was constantly monitored in the relatively small classes of 14 and 18 students in Years 11 and 12 and students were brought back on task when this private disucssion carried on too long.

Mrs Owens managed her classes easily. She clearly defined expected student behaviour. For example, at the start of a practical exercise she announced that students must work in their own groups and not move around the room. Any minor off-task behaviour which did arise was dealt with quickly and efficiently by a short personal remark which did not interupt the flow of the lesson. In brief, Mrs Owen clearly stated class rules, and when reprimands were given they were designed not to interrupt the flow of the lesson.

Handling of different student ability levels.

Both teachers competently dealt with students of different ability in the same classroom and in each of the four types of classroom structures both teachers sought out and gave special attention to both weak and able students.

In whole class interactive lessons it was obvious from lesson to lesson that all students were encouraged to become involved in class discussion. This situation was apparent time and again when Mr Reed sought answers from the weaker students even when they were not volunteering information. When the more able students had completed class activities in advance of others, they were given extension work. For example, in a Year 11 lesson where students were learning the correct use of the microscope, when students had completed the set problems on the relationship between the field of view and degree of magnification, extra problems were given accompanied by the remark "I'll put up some nasty ones!". Later Mr Reed enquired, "Who got these right? Who did them?". He then was involved in private discussions with students who had completed this work. On other occasions students were referred to copies of the biology newspaper published by the Australian Academy of Science, Biology in Action, which contained an article relating to the current topic. Exercises were given which ensured that the more able students were challenged and remained on task.

This particular publication was used most effectively by Mrs Owens. For example, an article on "A Killer Bug from Outer Space" was used effectively

by directing a Year 11 group of students to read the article and write answers to two questions asked by Mrs Owens: "What evidence is there that the parvovirus was introduced in the distemper vaccine?" and "Give arguments for and against Sir Fred Hoyle's suggestion that the outbreak was due to a space borne disease". Initially students were involved in a whole class discussion about the meaning of evidence, facts and information. After it appeared that these terms were satisfactorily understood, the students were instructed to quietly read the text and independently answer the questions which would be marked for an assignment. This type of assignment was used by Mrs Owens to differentiate the students who were of varying ability levels. In an after class discussion I remarked that some students were writing more than would have been anticipated; Mrs Owens reported that this was usually a sign that the students still writing have not picked out the relevant aspects of the article.

Mr Reed continually gave support to the weaker members of the class, particularly as he moved around during small group discussion time. For example, in laboratory work involving the relationship between the magnification and the field of view, some students grasped the concept quickly while the weaker students were still struggling with this. Mr Reed paid immediate attention to this situation by suggesting students use his method for deriving the relationship, "instead of using that horrible formula in the exercise". He also drew diagrams to make the ideas more concrete.

In addition, during activities involving the whole class he would offer a chance for any student to ask for further explanation, encouraging questioning by a comment such as "I don't want to embarrass you. I want to help you understand". Questions were rephrased to enable a weaker student to have a second attempt at responding. Also when the teacher was interacting with the whole class he appeared careful to elicit responses from all the students. This was done by naming individual students or by eye contact. Students also read their written answers to the Web of Life Student Guide and class test questions. Mr Reed used all these answers for discussion, often soliciting additional information for a weak answer by the remark "Has anyone anything to add to that?"

During laboratory activities Mr Reed encouraged individuals to perform their own calculations and not rely on the strongest group members. In a similar vein, Mrs Owens encouraged each member of a group doing practical work to each be involved and not let one person do all the work. This was amply illustrated in a laboratory experiment involving the dissection of a bull's heart. The students, who were working in groups of two or three, were each invited to "make an incision in the heart and do not be frightened to get your hands dirty." Mrs Owens moved from one group to the next and answered the student's problems or questions and saw her main role here as helping all the students understand the working of the heart.

Small group activities gave ample opportunity for peer interaction. Mr Reed encouraged this in a variety of ways, for example by asking a more knowledgeable student to help others: "Greg, you know how to do that. Be the teacher, explain how its done to the others." Students generally responded to this in a positive manner and became more cognitively involved in the activities. Mr Reed seemed aware of the ability of his students and used strategies to encourage them to use their main potential.

In whole class interactive sessions and individualized work, Mrs Owens' main method of dealing with problems which these senior students had was to encourage them to seek help when problems arose. She then assisted them with

their problem. After an exercise was returned she also invited any student with poor marks to see her afterwards in order to improve the quality of their work. Students were usually willing to take advantage of these opportunities and knew that it was expected of them to perform as well as they were able.

Student Motivation

For the teacher both the content and the pace of the lessons are set by the syllabus for the TAE examination. It is assumed that this examination will also affect the students' attitude and motivation. The biology classes therefore become "work" situations, where the teacher has not much opportunity to change an externally set pattern.

However, Mr Reed and Mrs Owens showed themselves to be understand and encouraging teachers who motivated students to take full advantage of the learning opportunities provided. Motivation took the form of

- manipulating questioning and the social environment to encourage students to participate successfully;
- giving effective praise to the class or individuals;
- encouraging student input by referring to it;
- assisting students to use time effectively;
- giving marks for completion of homework.

The social context and questioning provided by Mr Reed assisted student participation. A more timid student was encouraged to participate in a discussion when, with a smile and a glance, this warning came, "I know who I am going to ask." Similarly, weaker students were encouraged to seek help with a difficult test question. Whilst going over a test involving oxygen used in respiration and replenished by photosynthesis, Mr Reed asked "Is everyone happy with that answer?" and after a question was asked, "Please don't let me pass if you are unable to understand." On another occasion a student who had been upset by being unable to answer a question in an earlier lesson had her confidence boosted by being able to respond to "What does oxygenated blood carry?" Sometimes an event took place over several lessons. For instance in a Year 12 class after Rena confused the path of blood flow in the vascular system each question in this content area in the next lesson was given to her. Both teacher and student appeared to enjoy this game.

Effective praise was given to individuals, especially when tests were returned. There was the simple "Good work, keep it up" as well as praise for an individual who gave an especially good response. "Van gave me a good answer. Read it out." The latter example shows Mr Reed's ability to be aware of individual's performance and use this to further motivate them and indeed the whole class. On an individual level Mr Reed often praised students in a private discussion rather than for the whole class to hear. For example, at the beginning of a Year 11 class one day as Paul was taking chairs off the lab benches, Mr Reed said quietly, "You worked exceptionally well on identifying those animals. You are doing well at motivating yourself. If you continue like this you'll do well in the course". Paul just nodded and went about his business.

Any student input such as the mention of a relevant television report on a

new type of microscope was referred to straight away or later in the lesson. Mrs Owens encouraged whole group interaction with her when students raised issues about some biology related event or programme seen on television. For example, in a Year 12 biology lesson on hormones in which Mrs Owens was examining the function of insulin in the body, the students were more keen to discuss the previous night's television programme about underwater births. In this group of 9 Year 12 girls there was considerable interest in the safety and effect on the child of such a delivery process. Everyone wanted to talk about it. While the conversation was dominated by three girls, all but two became involved in the conversation. Questions were raised regarding the safety of home births and impersonal hospital care. Mrs Owens allowed the girl's interest and questions to be satisfied and then moved on to her teacher directed lesson on the body's use of insulin which proceeded smoothly.

The Nature of Academic Work

Since the biology classes followed the Web of Life biology course produced by the Australian Academy of Science, the content is defined by the upper school examination syllabus and commercially prepared materials. Students were first introduced to the new content by reading the text at home and were required to make written answers to questions from the accompanying student guide. The manner in which both Mr Reed and Mrs Owens dealt with these written answers ensured that students remained fully aware of what was expected of them and the material to be learned. These observed teaching techniques would be consistent with Doyle's (1983) contention that the answers a teacher accepts defines the real tasks in the classroom.

Mr Reed required that students add to their responses during and after group and class discussions on the covered topics. Most student-teacher interactions on a topic therefore took place after the students had already worked on the subject themselves. For discussing and adding to the knowledge which the students had gained from their textbooks Mr Reed favoured most the whole class interactive structure and the one involving small groups. However, towards the end of the school term as pressure grew to cover all the curriculum content, the class worked mainly in the whole class interactive mode. Interchanges between student and teacher were frequent, as often as 18 interactions in five minutes, during whole class interactive activity. When working in small groups the students were encouraged to and did use their peers as resources. Mr Reed encouraged this by saying such things as "Tell the rest how to do it."

Mrs Owens favoured the whole class interactive structure as opposed to the one involving small groups. In our discussion after class, she explained that she found students often missing the point of an exercise which they were discussing in groups and this usually cropped up later as erroneous knowledge. Consequently, in the whole class interactive sessions, special attention was made by her to student answers which were generally not well understood or were elaborate. In the former case, Mrs Owens would emphasize the essential point to be made, often dictating a few notes or referring to an overhead transparency. In the latter case, where one student's answer was generally not understood by the group, she asked all class members to write down their answer and these were later discussed and debated. The effect of this technique was to keep the students' attention on the content to be understood and learned.

Mr Reed's method of using student answers required that even weaker students produced acceptable responses. This was done by rephrasing the question or introducing an analogy to help the students improve their explanation. For

example, Donna was unable to think of any significant advantage lignin would give to plants. Mr Reed asked "Have you any rigid parts?" Donna's reply of "Yes, bones." and the teacher's response "How do they help you?" Donna was then able to suggest the function lignin might have in a plant. Therefore, the level of academic work of even weaker students was kept high. The interactions between students and teacher can be categorised using Doyle's (1983) description of four types of academic tasks. The first type, memory tasks, were rarely used by Mr Reed although students were sometimes asked to recall biological terms. When procedural or routine tasks were performed by the students Mr Reed often gave the students an additional task or questioned them. This had the effect of changing the routine task into one of comprehension. For instance, a Year 11 class used a dichotomous key to identify the family to which a specific plant belonged. Afterwards they were asked to name two features of a particular family using the same key. This involved being able to work backwards through the key. In fact, most tasks in Mr Reed's classroom were comprehension or understanding tasks. This reflected the Web of Life materials which are based on an inquiry approach to the study of biology and consequently, in this context, Mr Reed could be seen as an exemplary teacher of inquiry science.

A feature of Mr Reed's teaching was his ability to tie major biological concepts from the plant and animal kingdom together. Relating these concepts aided the students' understanding of the underlying principles. One example comes from a lesson on the respiratory system when Mr Reed asked "What is the advantage of having all these alveoli?" John replied "They give a large surface area." Where upon Mr Reed compared the features for exchanging materials that is common to alveoli, and nephrons. "What features do alveoli have in common with villi and nephrons?" Responses from students were "Thin membrane.", and "Rich blood supply." These three requirements of structures which exchange materials were further emphasised by Mr Reed with a question on plants. "What parts of plants exchange materials?" The student response of "Leaves, roots." and Mr Reed's searching question of "What can we say about them?" enabled several of the class to say almost in unison "They have a large surface area." In order to make complex ideas more easily understood, Mr Reed frequently provided the students with concrete examples. For example, students had difficulty answering a test question which required them to know the final oxygen content of water after a water weed was suspended in a sealed container for an hour. This problem required the students to appreciate that oxygen was released in photosynthesis and used in respiration. The fourth category of academic task defined by Doyle, opinion tasks, was practised particularly when tests were returned. Students often argued quite effectively for a point they had made in a response to a test question. Although curriculum content was mainly based on the Web of Life course Mr Reed added to this at known "weak spots". For instance ancillary notes were given on transpiration in addition to stress being laid on this topic in class.

In summary, content in Mr Reed's biology classes was intially introduced as homework and was later discussed in whole class or group settings. Interaction between student and teacher was frequent with a strong emphasis being placed on comprehension of concepts. Students contributed a great deal in these biology classes. Indeed part of Mr Reed's philosophy of teaching is a belief in student's acquiring knowledge. This is illustrated in a remark he made after a lesson: "They're a good class. You've just got to draw it out form them."

In both classes Mrs Owens delivered content in a clear, easily understood manner. Students were required to make written responses to the student guide questions at home or in class time. They later exchanged their

responses in a lively class discussion. The biology class also followed practical exercises described in the text. In the lessons observed, interactive whole class activity structures were used in approximately half the lesson time and students were engaged in small group activities in their practical work. The second most favoured activity structure was an individualized structure. Interactions between student and teacher were most frequent during individualized or group activities when students freely sought help from their teacher. Also, in a student-led biology discussion Mrs Owen acted as arbitrator and resource when the class considered responses to guide questions.

Using Doyle's categorization of tasks, memory tasks were given to the students at the start of a lesson when Mrs Owens made a quick revision of the content of the previous lesson. For instance the question "Where does the body get glucose from?" was asked before a brief revision of terms involved in breakdown of carbohydrates. The teacher then outlined the function of the liver. When teaching students in Year 11 how to perform calculations relating the degree of a microscope magnification to size of field of view Mrs Owens relied heavily on telling the class to follow the steps in an algorithm. This revision lesson helped weaker students and also gave some supplementary tuition to one student who had begun the biology course later than the other students. Treating this as a procedural task also was necessary as a number of the students were weak mathematically.

The questions in the Web of Life student guide are mainly of a comprehension nature. The practical work also requires a degree of understanding tasks. When students were given an exercise which required them to describe how various body functions were controlled during exercise, they were required to understand and to relate information from various sources. Mrs Owens also encouraged students to relate knowledge gained in other subject areas to biology. For instance she told students to apply their knowledge of different soil types from geography to the uptake of minerals by plants. Similarly, in a class discussion students were encouraged to put forward their own opinion on the possible vascular structure of a fruit as Mrs Owens did not know this. She suggested that somebody might carry out research in this area if they continued to study biology. In conclusion, students mainly gained new knowledge by reading the textbook. Although memory tasks were used for revision, comprehension tasks were employed frequently.

During Mr Reed's Year 11 biology class an interesting discussion occurred as a result of the topic dealing with Latin names and common names in relation to providing different types of dogs with the correct scientific name or names. Students were encouraged to be creative in coming up with the Latin name for a Great Dane. Several fun-type names were generated until Kim said "Canis familiaris", whereupon Mr Reed asked why did you say that? Out of this came the idea that all dogs are from the same species. Mr Reed followed this with discussion of need for common language for naming animals and plants. "What would happen if you were in a time capsule and were lost in Sherwood Forest?", then quickly to one student, "You can't chase after Robin, Lucy, he's already been taken by Marion, besides you might get an arrow in the head." Then back on task, "How would you order a drink?" Everyone began to talk, so Mr Reed directed all to listen to Deidre who explained that you need a common language to communicate with people in former days in England. John, an Aboriginal boy, volunteered some of language problems of people he knows. These episodes illustrate Mr Reed's use of humour and his ability to encourage students to relate general knowledge of learning to the classroom situation.

An impressive feature of both teachers' classes was the emphasis placed on

students' understanding of the content being learned. Such a creature would appear to be uncommon based on Doyle's (1986) expressed concern that in many classes insufficient emphasis is placed on students understanding and learning.

Assessment.

As described by Doyle (1983, p.185,6), "accountability drives the task system in classrooms and students tend to take seriously only that work for which they are held accountable. If no answers are required or any answer is accepted, then few students will actually attend to the content." Both Mr Reed and Mrs Owens were successful in encouraging students to complete homework assignments and to evaluate them during whole-class or group discussions.

The system of assessment used by Mr Reed bears special mention since it would appear to be a direct reflection of the positive aspects of Doyle's remark. In his Year 11 and 12 classes, Mr Reed used a system of marking that held the students accountable for all the work they did for each chapter. This system has been devised by Mr Reed and another teacher about five years ago in order to ensure that homework was done and also make students aware of what was required of them by way of personal contribution to class and group work. Students were also required to organize themselves in order to have their work in a presentable form. Following the section on classification of animals and plants in the early part of the observation period, the Year 11 class were assessing their homework and personal contribution to classwork, a practice fairly new to these students. Mr Reed distributed mark sheets around the class and each student then collected work from their nominated student. The assessment system required that each student was allocated a total of 10 points for guide questions and problems, structured discussions, and laboratory work and 5 points for both dictionary work and optional work. Marks were deducted for work not completed. Optional work could be extra guide questions or problems or laboratory activities of a summary of an article from Biology in Action.

The major problem in this Year 11 class appeared to be that the work was not handed to the marker in a systematic order and Mr Reed stressed that this would need to be rectified when future work was assessed. At the end of the session Mr Reed gave the students encouragement: "The first time we took more than 50 minutes. This time some of you managed in 35 minutes. Year 12, who were like you this time last year, now only take 12-15 minutes!". In addition to this assessment of written work the students then completed a form designed to assess their contribution to class and group work. Students gave themselves a personal score, obtained a score from two members of this group, and averaged the three scores to obtain the final score.

In discussion about this assessment technique, Mr Reed explained that the gain for him was that it makes the students do their homework and think about what they are doing, and marking was removed. Written assignments and tests were marked by Mr Reed. Students took the assessment procedure seriously since they contributed to their ongoing assessment and would be used by Mr Reed, especially in the Year 12, to guage their success in the externally administered examination. Further, students were required to let a different student do the marking each time and Mr Reed himself regularly marked the work of doubtful students.

This procedure for assessment showed an innovative approach to the perennial problem of making sure homework was done and appeared to be very effective in getting students to complete their work. Spot checks were also carried

out throughout the chapter and students not completing their work would invoke a penalty of -2 from their total chapter mark.

The Perceived Curriculum

An assessment of the classroom environments of Mr Reed and Mrs Owens carried out using the short form of the Classroom Environment Scale (CES). This instrument was developed by Fraser and Fisher (1983) from a longer form of the Classroom Environment Scale (Moos and Trickett, 1974). There are two forms which assess both the actual classroom environment and the preferred or ideal classroom environment. Each form contains 24 items with six scales (Involvement, Affiliation, Teacher Support, Task Orientation, Order and Organization and Rule Clarity), each of which is assessed by four items. The perceived classroom environment in this study has been compared with that in a sample of 2,175 students, 116 classes studied by Fisher and Fraser. The results of the administration of both forms of the CES to students in the biology classes of these two teachers is described by Fraser (1986) in a later paper in this symposium.

Six students of varying ability levels from each of the four classes observed were interviewed at the end of the observation period. Questions were asked regarding their perceptions of the class in terms of the teacher making learning interesting for them and making learning easy, getting feedback on their work, their preference of lesson structure and class routines.

In attempting to summarize these taped interviews the general impression one gains by both Mr Reed and Mrs Owens is that the students consider their teachers to be sensitive to their learning needs, that they believe the teachers enjoy the subject they are teaching, that the teacher "works with us", "doesn't treat you as though you are down there", is interested in you making the best of your own learning.

One major difference between these two teachers was the students reactions to whole group interaction discussions. Without exception students in Mr Reed's class preferred this class structure to all others. Kathy's remark in Year 11 sums up their reasons, "in whole class discussion groups you hear other people's ideas and learn from them". In Mrs Owen's classes, students' opinion about whole class discussion was also that this was the preferred lesson format, but while some students preferred listening to others opinions, "you hear everyone's view and can find out if you are right" as expressed by Lisa in Year 11, other students preferred the discussions led by Mrs Owens, "since with student discussions there are too many side issues" and "Mrs Owens will also ask students who don't say much".

Most students interviewed said their teacher "explains things clearly", "shows us where we go wrong", "he asks us another question to make us think harder", "she makes it easy since she explains things", "by making it interesting, he makes it easier for you". Generally, only positive remarks were made. However, some of the students in Mrs Owens' classes did say they preferred human biology to biology since, according to Alana in Year 12 "in the former there was more interaction with the teacher on a friendship basis, in biology it is just the books and the teacher is only there when we need her".

The Achieved Curriculum

At the time of completing this study the students in all groups had done tests, completed homework assignments and had responded to oral quizzes.

However, no formal data were recorded on test scores in order to provide a measure of the achieved curriculum. In student discussions, the general opinion was that the frequency of tests after each unit was sufficient to give them feedback as to how well they were doing. Students also appreciated the teachers' comments on their progress and most of Mr Reed's students found his assessment program very valuable "since it lets you know how well you're learning, especially compared to other students". In discussions with Mr Reed and Mrs Owens about the students' achievement, the general feeling was that their Year 11 and 12 classes were progressing satisfactorily and were achieving skills in both content and inquiry through the Web of Life course.

CONCLUDING COMMENTS

While both teachers of biology were identified as being exemplary, there were differences in their instructional approach which tended to be influenced by the personality and teaching philosophy of each teacher. Such variation in teaching style of teachers who cover the same curriculum is in agreement with research reported by Tamir (1981).

While it is difficult to make generalizations from two case studies, important comparisons and similarities can be drawn and those aspects which contribute to exemplary teaching practice can be emphasized.

In Western Australia, the Year 11 and 12 syllabus for biology is prescribed by the Board of Secondary Education, so both teachers cover essentially the same content. Features common to both teachers' programmes were:

1. Both Mr Reed and Mrs Owens used all four distinct classroom structures described by Tobin (1985) though to varying degrees. Good class management and organization with smooth transitions between one class structure and another, with a minimum of time wasted, was a facet common to both teachers.

2. Biology lessons in both teachers' classrooms were generally busy occasions for students and teacher alike. Students were kept informed of the work to be covered by the day, by the week and by the unit of the textbook, and consequently there was little opportunity for off-task behaviour. Any off-task behaviour which did arise was dealt with quickly and efficiently by a short personal remark that rarely interrupted the flow of the lessons. Eye contact and addressing the student by name was frequently sufficient to bring off-task students back on-task.

3. A characteristic of both teachers was their attempts to facilitate the students' understanding of the subject matter. For both teachers this was accomplished in a similar way by whole class interactive discussions. There were differences in how this was achieved. Mr Reed tended to solicit information from the students, to get them thinking and talking but usually left the making of conclusions to the students. In this and other respects Mr Reed acts as an ideal model of the inquiry teacher. On the other hand, Mrs Owens solicits information from the students and often sums up the ideas so that earlier confusions are cleared up.

4. Students were expected to think about their work and the answers they gave to guide questions, to problems, to their practical work and to discussions in class. Memory tasks were used for review but were

usually followed by requests for further explanation. Typically students were expected to comprehend what they were learning from the reading, the activities or class discussions; brief low level answers were encouraged to be expanded. In conjunction with this expected level of the academic work both teachers provided regular feedback to students on their progress and understanding of subject matter. Both teachers were also able to address the needs of both low and high ability students in their classroom.

5. Both Mr Reed and Mrs Owens motivated students to take full advantage of the learning opportunities provided by manipulating questioning and the social environment to encourage students to engage in the work, by giving effective praise to the whole class and to individuals, by encouraging student input by referring to it, by helping students to effectively use their time and by giving marks for completion of set work. According to the students interviewed all these points were considered important to their achievement.

6. In both classrooms, students were encouraged and indeed clearly expected to accept responsibility for their own learning. The classroom environment achieved by Mr Reed and Mrs Owens indicated that students did exhibit considerable self reliance and responsibility for their own learning.

While many of these comments may seem obvious to success in the classroom and to exemplary teaching, observations reported by Tobin (1985) in 15 science classrooms indicate that the observations made here are indeed different and do contribute to exemplary teaching in biology.

REFERENCES

Australian Academy of Science. (1983). Biological Science: The Web of Life, Canberra, A.C.T.: Australian Academy of Science.

Board of Secondary Education. (1985). Syllabus 1985. Certificate of secondary education and the Tertiary Admissions Examinations: Part I. Perth: W.C. Brown.

Doyle, W. (1983). Academic Work, Review of Educational Research, 53(2), 159-199.

Erickson, F. (1985). Qualitative research on teaching. In M.C. Wittrock (Ed.). Handbook of Research on Teaching. (3rd Edition). New York: Macmillan.

Fraser, B.J. (1986). Psychosocial environment in classrooms of exemplary teachers. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco.

Fraser, B.J. & Fisher, D.L. (1983). Development and validation of short form of some instruments measuring student perceptions of actual and preferred classroom learning environment. Science Education, 67, 115-131.

Kounin, J.S. (1970). Discipline and group management in classrooms. New York: Holt, Rinehart & Winston.

Lucas, A.M. (1980a). The development of a curriculum monopoly in Australian Secondary Schools: Biological Science: The Web of Life 1: Origins and Spread. Journal of Biological Education, 14(1), 15-28.

Lucas, A.M. (1980b). The development of a curriculum monopoly in Australian Secondary Schools: Biological Science: The Web of Life 2: Research and Comment. Journal of Biological Education, 14(2), 167-174.

Moos, R.H. & Trickett, E.J. (1974). Classroom environment scale manual. Palo Alto, Calif.: Consulting Psychologists Press.

Tamir, P. (1981). Classroom interaction analysis of high school biology classes in Israel. Science Education, 65, 87-103.

Tobin, K.G. (1985). Academic work in science activities. Technical Report Series, Science and Mathematics Education Centre, Western Australian Institute of Technology, Perth, W.A.

Tobin, K.G. (1986). Exemplary practice in science classrooms. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco.

Rosenshine, B.V. (1980). How time is spent in elementary classrooms. In C. Denham & A. Lieberman (Eds.), Time to learn. Washington, D.C.: National Institute of Education.