

A CROSS-CULTURAL STUDY OF FACTORS INFLUENCING STUDENTS' UNDERSTANDING OF SCIENCE LESSONS

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The literature on teacher effectiveness identifies numerous presage, process and context variables that influence student learning in school classrooms. Much of this literature reports studies in which the data were gathered by direct or indirect observation and/or by analysis of information supplied by teachers. (See for example, Dunkin & Biddle, 1974; Brophy & Good, 1986; Borich, 1988). While such studies have provided a wealth of useful information for teachers and teacher educators, they have often failed to take account of students' views of the phenomena that are being studied. When student views are taken into account, they can provide insights into teacher effectiveness that are difficult to obtain in any other way (Killen, 1991). The study reported in this paper examines teaching through the eyes of junior high school students from four countries (Australia, USA, Finland and the Republic of South Africa) in an attempt to identify aspects of teacher effectiveness that were common and unique to the four sites. It was concerned with identifying teacher behaviours that students saw as helping them understand particular science or mathematics lessons and with identifying teacher behaviours that students saw as inhibiting their understanding of those lessons. The study was a direct extension of the author's earlier investigations of teacher clarity (Killen, 1990).

Teacher clarity was identified by Rosenshine and Furst (1971) as the most promising variable in process-product research on teacher effectiveness. Since then, there have been numerous studies that have attempted to quantify the essential elements of clear teaching (Cruickshank, Myers & Moenjak, 1975); to define teacher clarity in terms of low-inference teacher behaviours (Bush, 1976); to determine the extent to which student perceptions of clear teaching are consistent across age levels (Bush, Kennedy & Cruickshank, 1977) and across geographic locations (Kennedy, Cruickshank, Bush & Myers, 1978); to explore relationships between teacher clarity and student achievement (Hines, 1981; Killen, 1990); to examine the stability of teacher clarity across subject matter and classes (Williams, 1983); to train teachers to be more clear (Metcalfe, 1990); and to determine the extent to which teachers can benefit from systematic feedback concerning their clarity (Killen, 1991). As a result of these, and other, research activities, there are now two reasonably well-defined bodies of literature on teacher clarity. The body of literature represented by the studies cited above is concerned principally with the cognitive aspects of clarity. The most generally accepted definition of cognitive clarity is that provided by Cruickshank and Kennedy (1986, p.43): 'a cluster of teacher behaviours that result in learners gaining knowledge or understanding of a topic, if they possess adequate interest, aptitude, opportunity and time'. Another body of

literature (represented by Chilcoat, 1987; Smith, 1985; Denham & Land, 1981; Land, 1981) is concerned principally with the verbal aspects of clarity, the speech patterns and methods of expressing ideas that teachers use. While the verbal and cognitive aspects of clarity are obviously related (Civikly, 1992), it is often convenient to study them separately. This paper is concerned with a cross-cultural study of cognitive clarity.

By definition, a teacher is not teaching clearly unless the students understand the information that is presented. Quite obviously, there will be many occasions when some students understand the information being presented by their teachers and others in the same class do not understand. Therefore, teacher clarity is very much a function of individual students' perceptions of their instructional experiences (Killen, 1990). However, there is considerable evidence that certain

teacher behaviours are more likely than others to lead to student understanding, and it is these behaviours that have come to be known as the prime discriminators of teacher clarity (Kennedy, et al., 1978). Many of these aspects of clear teaching (such as the teacher explaining things simply, or the teacher repeating things that are hard to understand) have been identified by asking students to recall a clear teacher and to describe what that person did when he/she was teaching clearly. In the main, these studies have been conducted in the USA and Australia. The study reported here is different in a number of important aspects: first, it was concerned with identifying teacher behaviours that students saw as helping them understand a particular lesson, rather than with identifying teacher behaviours that occurred over an extended period. Second, it required students to identify teacher behaviours that they saw as inhibiting their understanding of aspects of that same lesson. Third, the study was conducted in four countries, using identical data gathering techniques. These methods were designed to eliminate the vagueness inherent in asking students to recall teaching events that occurred months or years previously, and to identify aspects of teacher clarity that were common and unique to the four sites in which data were gathered.

RESEARCH PROCEDURES

The investigation was conducted in four countries, Australia, Finland, Republic of South Africa, and the USA. Data were gathered in typical junior high school classes in each country; approximately 80% of the data were obtained from science classes and the remainder from mathematics classes.

The subjects

The subjects for the study were 955 students (272 in Australia, 346 in Finland, 161 in the Republic of South Africa, 176 in the USA) with approximately equal numbers of males and females in each country. The students in Australia, Finland and the USA ranged in age from 13 years to 16 years. The South African students ranged in age from 13 to 20

years (19 of them being older than 16 years). The classes in which the data were gathered were chosen for convenience. Although neither the schools nor the teachers were selected randomly, there was no reason to believe that they were atypical of junior high school science and mathematics classes in the four countries in the study. In Australia, Finland and the Republic of South Africa the data were from complete classes. In the USA the data were from a random selection of students in each class in the study.

Data gathering

The instrument used to gather data for this research was very simple: it asked students two open-ended questions: 'In this lesson what things did the teacher do to make it easy for you to understand the lesson?' and 'In this lesson what things did the teacher do that confused you or made it difficult for you to understand the lesson?' The students answered these questions at the end of regular lessons in general science, physics, chemistry, biology or mathematics.

Sixty seven teachers (9 from Australia, 10 from Finland, 6 from the Republic of South Africa, and 37 from the USA) participated in the study. They were free to choose the class, time and subject in which to gather data; the only restriction was that the data needed to come from science or mathematics classes in junior high school. The teachers explained to their students that their answers to the questions would provide data for a research project and that all the information would be treated confidentially. Those teachers who wanted to read the responses of their students asked their permission to do so; the remaining teachers passed the student responses to the researchers without reading them.

The data from each country were summarised by the researcher in that

country and then forwarded to Australia for collation.

RESULTS

The answers to the two questions posed to the students were analysed separately. The teacher behaviours that students most frequently identified as making it easy for them to understand their lessons are summarised in Table 1, and are referred to as facilitating teacher behaviours. The teacher behaviours that students most frequently identified as causing them to become confused are summarised in Table 2, and are referred to as limiting teacher behaviours.

Facilitating Teacher Behaviours

Across the four countries, ninety-seven percent of the students in the study responded to the question that asked them to identify things that their teacher did to make it easy for them to understand the lesson content (the other three percent, mainly Australian and American students, either wrote 'Nothing' or did not respond to the question). The students identified 1580 facilitating teacher behaviours (an average of 1.6 per student).

An attempt was made to group similar responses into a single category where this did not conceal essential differences between the responses.

Thus, responses such as "the teacher explained things thoroughly" and "the teacher explained things fully" were placed in the same category, whereas "the teacher explained things simply" was placed in a separate category. The task of classifying the responses was not a simple one because of the wide range in the quality of the students' responses; because of the different forms of expression used by the students in each country; and because the Finnish responses had been translated into English before they were coded. Those students who attempted to explain what the teacher did to help them understand the lesson gave answers that ranged from "Told us about it" to "Our teacher explained the content clearly and basically so that information was easy to take in. She drew diagrams to show what happens and she used examples that we can understand. She also explained the information in different ways. Experiments were also used." Responses such as this latter one were split into multiple entries in the summary in Table 1.

The 43 categories of teacher behaviour in Table 1 have been further grouped into six broad categories which, for convenience, have been labelled teacher explanations, demonstrations/use of teaching aids, student activities, teacher interaction with students, teacher help for individual students, and teacher communications style. Table 1 shows the percentage of students in each country who gave responses that were coded into the 43 categories. These percentages do not total 100% because some students gave multiple responses and because it was decided to include only those categories that contained at least 1% of the responses from students in at least one country.

The entries in Tables 1 and 2 are the result of the researchers classifying the responses from their respective countries individually, and then collaborating to reach agreement on the final classification system. It is accepted that someone else attempting to summarise the same data may have placed some responses in somewhat different categories. However, the important point (at this preliminary stage of what will be an ongoing research project) is that the data in Tables 1 and 2 fall into several major categories; any minor variations in the interpretation of individual student responses are unlikely to change these categories significantly. A totally independent analysis of a subset of the data from this research (McGinnis, 1993) did not produce any important variations in the classification of the students' responses.

It is quite clear from Table 1 that students see the quality of teacher explanations as playing a key role in helping them to understand their lessons. Approximately 50% of the students mentioned their teacher's explanations as at least part of what helped them understand the lesson. This is not surprising since a large part of science teaching

is concerned with explanations (Dagher & Cossman, 1992). Indeed, since "explanations are the heart of what is usually meant by teaching" (Leinhardt, Putman, Stein & Baxter, 1991, p.89), it would be unusual

for students in any lesson to not see teacher explanations as the main factor contributing to their understanding. The teachers' use of specific teaching aids (diagrams, charts, chalkboard, etc.) also figured prominently in the students' responses, as did references to the teachers' use of examples.

The data from Finland often described the teacher explaining, then writing on the blackboard, followed by students taking notes, a pattern not evident in the data from other countries. The data from Australia and the Republic of South Africa suggested that the lessons frequently involved oral explanations and demonstrations, but contained fewer references to student notetaking. The data from the USA contained the greatest percentage of references to the teachers' use of instructional media, examples, structured lessons and teacher-student interaction. Only 6% of the students (none from Finland or South Africa) made reference to their teachers helping individual students, and only 14% of the students made any references to their teacher interacting with the students (asking questions, checking student understanding, answering students' questions, etc.). Reports of teacher-student interactions were far more frequent from the USA students than from any of the other groups. Similarly, there were few comments on student activities (other than the notetaking of the Finnish students). Overall, it seems that the lessons were either very teacher-centred, or else the students failed to comment on the student-centred aspects of the lessons.

It is particularly interesting that only a few students in this study were able to identify specific aspects of their teacher's explanations as the key to their understanding of the lesson. For example, some students identified specific teacher behaviours such as explaining in simple/common terms, repeating new things several times, and explaining step by step. These are all low-inference teacher behaviours that a trained observer might be expected to identify as aspects of teacher clarity (Hines, 1981). The majority of students made only general comments such as the teacher explained things. Whether the differences in the specificity of the comments resulted from differences in the students' ability to perceive what was helping them to understand, or whether they simply indicated differences in the students' ability to express their ideas is not known.

Allowing for some differences in terminology, about half of the teacher facilitating behaviours identified in Table 1 are teacher behaviours that earlier studies (Cruickshank et al., 1975; Bush, 1976; Kennedy et al., 1978; and Hines, 1981) had identified as prime discriminators of teacher clarity; these behaviours are marked (#) in Table 1. These teacher behaviours account for approximately 72% of the teacher facilitating behaviours identified by students in this study. Some of the facilitating behaviours mentioned frequently in this study that do not seem to have been mentioned in earlier literature on teacher clarity were the teacher's use of experiments (which is probably more prominent in science classes than many other classes), the teacher's use of personal anecdotes, the teacher's use of everyday things in explanations, and student activities/worksheets.

The students in this study did not mention several teacher behaviours that had been identified as important components of teacher clarity in earlier studies (e.g., Hines, 1981). For example, no students indicated that their understanding was assisted by their teacher telling them what it was they were expected to learn, or by pointing out which things were important to learn, or by comparing new material to what has already been learned, or by giving them time to think about what was being taught. Whether these things simply did not occur, or whether they occurred without being seen as important by the students,

or whether they were so common as to be taken for granted, is not known but will be the focus of future study.

Limiting Teacher Behaviours

The teacher behaviours that students identified as confusing them, or making it difficult for them to understand the lesson (Table 2) have been referred to as limiting teacher behaviours because they have the potential to limit students' understanding. The students appeared to have greater difficulty identifying limiting teacher behaviours than they had identifying facilitating teacher behaviours. Overall, 49% of the students either did not respond to this question or responded by writing 'Nothing'. The Finnish students were most reluctant to identify limiting teacher behaviours (67% of them did not identify any limiting teacher behaviours) whereas the students from the USA were most willing to identify limiting teacher behaviours (only 19% failing to do so). Overall, the students identified a total of 700 specific teacher behaviours that they perceived as limiting their understanding of their lessons. The procedure used by the researchers to interpret and categorise these responses was similar to that used for the facilitating behaviours.

As with the facilitating teacher behaviours, the comments that students made about limiting teacher behaviours were grouped where this seemed appropriate. Thus, "changing the subject" and "straying from the subject" were grouped, whereas "did not explain fully" and "did not explain clearly" were kept as separate categories. It is obvious from Table 2 that some of the limiting teacher behaviours are simply opposites of the facilitating teacher behaviours in Table 1. For example "The teacher spoke too quickly" (Table 2) and "The teacher explained things slowly" (Table 1). However, there were some quite distinct limiting behaviours such as "The teacher made mistakes" and "The teacher used mathematical symbols that were not understood". For convenience, the limiting teacher behaviours were placed into five broad categories: teacher explanations, lesson structure, pace of the lesson, teacher questioning, and teacher communications style. The most obvious thing from Table 2 is that the students from the USA were best able (or at least most willing) to identify limiting teacher behaviours. Perhaps the reason for this is a cultural one. Students in the USA (and to a slightly lesser extent in Australia) are encouraged to offer their opinions on classroom events and to

participate in many student-centred learning activities. The more didactic approaches taken in the classrooms in the Republic of South Africa and in Finland are not conducive to students being critical of their teachers. Given these differences, there were five areas of reasonably consistent criticisms of teachers from students across the four countries: their teachers presented information too quickly (identified by 15% of the students); teachers gave confusing explanations (identified by 6% of the students); teachers included too much information in lessons (identified by 5% of the students); teachers often used words the students did not understand (identified by 4% of the students); and teachers often strayed from the subject (identified by 4% of the students).

Many of the limiting teacher behaviours (or their opposites) had previously been identified in the literature as being associated with teacher clarity; they are marked (#) in Table 2. In total, these behaviours account for approximately 56% of the teacher limiting behaviours identified by students in this study. Of particular interest was the fact that several of the limiting behaviours were elements of verbal clarity (Smith, 1985). These factors, mumbling, monotonous voice, using unfinished sentences, and speaking too quickly, are generally not considered part of cognitive clarity (Cruickshank & Kennedy, 1986) but they appeared to limit the understanding of some of the students in this study. This highlights one of the difficulties of

trying to study separate constructs (such as cognitive clarity and verbal clarity) in regular classrooms.

DISCUSSION AND CONCLUSIONS

The research reported in his paper attempted to take a very basic approach to the study of teacher clarity by asking school students what things teachers did to help them understand lesson content. The methods used were different from earlier research on teacher clarity (e.g., Cruickshank et al., 1975) in three important ways: firstly the students in this study were asked to identify things that their teacher did in a particular lesson that helped them understand, or that confused them; secondly, the information was gathered immediately after the lesson about which the students were commenting; and thirdly, the data were gathered in several culturally different locations. This approach was taken in an attempt to overcome some difficulties in earlier research on teacher clarity; namely the problems of students being vague in their attempts to target a clear teacher and to remember accurately what that teacher did when he or she was teaching clearly, the inevitable difficulties of seeking data from students long after the event they are recalling, and the limited context in which the data had been gathered. The findings of this research both reinforce and extend the findings of earlier studies of teacher clarity. The very close correspondence between the prime discriminators of teacher clarity identified by Kennedy et al. (1978) and Hines (1981) and the

teacher facilitating behaviours identified in this study suggests that the two research approaches were each appropriate ways to identify teacher behaviours that facilitate student learning (i.e., teacher clarity behaviours). However, this study highlighted several additional aspects of teacher clarity, such as the desirability of teachers using everyday language and examples in their explanations, and the benefits of teachers engaging students actively in learning. It was quite evident in this research that the students were much more readily able to identify things that helped them understand than they were able to identify things that confused them. Whereas 97% of the students could identify at least one teacher facilitating behaviour, only 51% of students could identify at least one limiting teacher behaviour. Perhaps the students were simply more willing to claim that they understand everything than to admit that they were confused, but it seems more likely that many students were unable to identify what it was that they did not understand or why they did not understand it. The difficulty some students had in identifying why they did not understand everything was summed up best by the student who commented "Nothing (confused me), but you still sometimes don't understand" and by the student who simply wrote "I just didn't understand some things".

This aspect of the study deserves further investigation because getting students to identify what they don't understand is an important step in helping them to understand. It is quite possible that some students thought that they were understanding the lesson when actually they were not. As Killen (1990) discovered, when students think that they understand everything, they tend to rate their teacher's clarity very high, even when they do not really understand the lesson sufficiently to be able to apply their newly gained knowledge at a later time. Of course, there were some students who could identify precisely when they became confused, such as the student who wrote "(The teacher) used two similar examples of the right and wrong things to do, and didn't explain exact differences between them".

Frequently, students in the same class appeared to perceive particular teacher behaviours quite differently. For example, one student wrote "She explained things in our words" and in the same lesson another student wrote "She used words that no-one really knows the meaning of".

These two students were obviously operating from quite different

levels of prior knowledge, a fact that an effective teacher would need to take into account. In another lesson, one student wrote "The teacher gave us some information about the topic, then we had to answer questions on the information she gave us. She explained to people who didn't understand the work, in easier form, and it helped them to understand it". Another student in this class saw things differently, writing "Mrs. H. made it difficult for us because she just talked about things and didn't show as anything". These two students appear to have interpreted their teacher's behaviours very differently.

On some occasions it seems that students were simply describing the same events differently. For example, when one student wrote "the

teacher explained things in detail" she was apparently referring to what another student described as "the teacher used lots of everyday examples". This methodological problem is difficult to overcome when the data are coming from students rather than from trained observers. However, the occurrence of these different descriptions is unlikely to detract significantly from the overall findings of the study.

The study did reveal some differences in students views of facilitating and limiting teacher behaviours across the four countries from which data were gathered. The differences in the teacher facilitating behaviours were only minor. Those behaviours that were identified by at least 1% of the students in only one country accounted for less than 5% of the 1580 responses. There were greater differences in the teacher limiting behaviours, with the behaviours that were identified by at least 1% of the students in only one country accounted for about 18% of the 700 responses. This later figure was due to the fact that the USA students identified many more teacher limiting behaviours than students from any of the other countries.

It seems that very few students were aware of precisely what it was that was helping them to understand the content of the lessons in this study. Comments such as "the teacher gave detailed explanations", or "the teacher did an experiment" do not reveal very much about the processes by which the students came to an understanding of the lesson.

Comments such as "the teacher explained things by giving examples of different scenarios to illustrate how a particular concept is applied to a situation" reveal that the student at least knows why the teacher was providing the examples, but do not necessarily indicate just how those examples helped the student to understand the concept. More research is required to determine just how important it is for students to know how they come to understand something.

Whatever the reasons for the students' different perceptions and descriptions of their learning experiences, they draw attention to the fact that students' perceptions of teacher behaviours can moderate the effect that these behaviours have on student learning. If different students perceive the same teacher behaviours in different ways, the effects of these behaviours will probably be different for the various students. Some teacher behaviours appear to influence student learning very directly. However, Killen (1990) found that when students are aware that teachers are using particular behaviours (providing examples, emphasising important points, giving students time to think, and so on) this does not necessarily help them to understand the lesson. It is only when these behaviours actually help students to understand that the behaviours have a significant impact on student learning. The present study highlights the need for further research into how students' perceptions of teacher clarity influence their learning.

Because the data in this study were limited to students' comments on what helped them to understand and what confused them, it was not possible to identify the type of explanations that were most helpful to students. Dagher and Cossman (1992) suggested that science teachers' explanations fall into ten categories (analogical, anthropomorphic,

functional, genetic, mechanical, metaphysical, practical, rational,

tautological and teleological) and that individual teachers are likely to vary considerably in their use of each type of explanation. Further, the various types of explanation are not necessarily equally effective in facilitating student understanding of particular types of content. While it was not the purpose of this study to determine what types of explanation best help students to understand particular science content, the frequent reference to teacher explanations suggest that this an area that should be investigated further.

As well as information on teacher behaviours that help students to understand science and mathematics lessons, this study also provided information about teacher behaviours which inhibit student understanding. This reinforced the idea that students can be confused either by certain teacher actions (such as using words that students don't understand), or by the omission of other teacher actions (such as not giving students time to think about new information). This aspect of the analysis of student comments also emphasised the close relationship between verbal clarity and cognitive clarity.

One of the issues that was not investigated in this study was students' conception of what it means to understand something in science. Anderson and Roth (1989) make the point that understanding of science is an elusive concept; it can mean different things to different people (p.265). They also suggest that "students who say they understand a topic often mean that they are prepared to answer recall questions about it; in their experience, this is the sole or primary function of scientific knowledge" (p.266). Further, Anderson and Roth suggest that "scientific knowledge consists of the ability to use scientific knowledge to describe, explain, predict, and control the world around us" (p.270). Junior high school students may not be able to judge whether or not they have this level of understanding. The next phase in this cross-cultural study will investigate what students mean when they say they understand science lessons, and whether or not this is the type of understanding that science teachers are attempting to facilitate.

The approach to the study of teacher clarity described here has a number of benefits beyond simply validating previous research. In particular, it illustrates how a very simple instrument and research procedure can produce valuable data that classroom teachers can use to improve their teaching and their students' learning. By getting feedback on how students perceive their lessons, teachers are in a better position to maximise student learning. The procedure (of asking students simple questions about how they perceived a lesson) can be used with minimum disruption to normal classroom activities and it has numerous side-benefits, such as giving students a feeling that they have some say in the way they are taught. By using a technique such as the one described here, teachers really do make their classrooms places of learning, not just for their students but also for themselves.

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Table 1:Facilitating teacher behaviours identified by students.

(To be included, a behaviour must have been identified by at least 1% of the students in one of the groups.)

Table 2:Limiting teacher behaviours identified by students.

(To be included, a behaviour must have been identified by at least 1% of the students in one of the groups.)