The Contribution of IEA Research to Australian Education

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Abstract

This article considers the contribution of research undertaken as part of theIEA studies to Australian education, and in particular to educational theory, practice, policy making and the conduct of research. While there have been criticisms of the tests employed and constraints have been imposed on publication, the research carried out has gone well beyond the monitoring of student performance and has made a substantial contribution to Australian education over a period of 30 years. Areas where policy making has been influenced include retention rates, social class differences, gender differences, time and school learning, and curriculum differences between the Australian states. In addition, IEA research has contributed to the improvement of educational practice by showing the significance of student attitudes and values, an emphasis on process, opportunity to learn, time spent on homework, and class size as well as whole group instruction. Neville Postlethwaite's marked influence on this work is acknowledged.

1 Introduction

It is almost exactly 30 years since a representative of Australia first attended a General Assembly Meeting of the International Association for the Evaluation of Educational Achievement (IEA). As a consequence, it is an appropriate time to reflect on the contribution of IEA to the development of education and, in particular, educational research in Australia. This contribution can be seen not only in the field of educational research, but also in the way educators think about education - educational theory; in the policies developed at national and state levels - educational policy making; and in the things done and attitudes held by both teachers and students in schools and classrooms - educational practice. This article summarizes the contribution of IEA to education in Australia in all four areas. Moreover, it contends that with only a short term perspective, and with increasing dependence on headlines for a knowledge of events in education, it is possible all too readily to ignore this contribution. Furthermore, it argues strongly that with a growing emphasis on critical theory in viewing Australian education, accompanied by a rejection of empirical investigation, it is possible to question or dismiss what has been a very substantial contribution over a period of 30 years.

The national centre for IEA in Australia has throughout the period under review been The Australian Council for Educational Research (ACER). From the outset, in 1963, when the ACER was first invited to participate in the IEA program of research there have been vigorous and frequently uninformed criticisms of both the IEA enterprise and the tests that have been proposed for IEA studies (Connell 1980). Thus, the tests developed for the First IEA Mathematics Study in 1964 were argued to be of such low quality and unrelated to the mathematics taught in Australian schools, that it was inappropriate for Australia to be involved in the comparative study which was proposed. Moreover, it was argued that the Australian context was so different from that of Europe and the United States, little was to be gained from participation. A similar view was held in New Zealand (Connell 1980). It required the intervention of Sir Fred Schonell and the offer to supply tests from England at no cost that led to this study being carried out in Australia with minimal expenditure. Opposition to such a study was maintained, and in one of the six Australian states, where there was no experience of educational research, staff in senior administrative positions advised against participation. The government schools in the five remaining states took part in the study, and samples of high quality were tested although the officers of one state system argued that information on father's occupation was irrelevant, and directed its teachers to order students not to answer this question. Many students in that state, however, did answer this question and useful, if incomplete, data were obtained on occupational status across Australia.

In due course, a national report was prepared under the title *Variation in Mathematics Education in Australia* (Keeves 1968). Nevertheless, the Director General of Education in one of the states delayed approval for the publication of the report for nearly a year, but on the assumption that approval would finally be given, 500 copies were printed. However, close to his last day in office, before retirement, that Director General notified the Director of the Australian Council for Educational Research that he would withhold approval. Two objections to the report were advanced, the first related to interstate comparisons and the second to methods of analysis. In the interstate comparisons, it was shown that the state of which he was Director General gave less time to the teaching of mathematics under the scheme of instruction that had recently been introduced, and its students performed at a correspondingly lower level. The report, therefore, implied criticisms of the policies and practices within that state. The second objection challenged the use of regression analysis in the examination of the effects of school and home variables on educational outcomes, contending that to employ statistics other than partial correlations was unsound. The use of regression analysis in this way was novel and was clearly not understood. As a consequence, of the 500 copies printed all except 25 were pulped. Approximately 12 copies were sent overseas to collaborating IEA centres, and the remainder held in reserve.

This situation is instructive in so far as it reveals a rejection in Australia, first, of empirical research by a senior administrator who had actually had some research experience. Second, it indicates an unwillingness to permit the questioning of policy and the fostering of open discussion on educational practices. Third, it reveals a lack of appreciation of empirical educational research methodology. In the large bureaucratic school systems that operate in the Australian states, Ministers of Education and their Chief Executive Officers, 30 years on, still sometimes maintain the same perspectives, although the right of an independent research organization, such as the ACER to publish the findings of research, while still occasionally challenged, has now been established. Nevertheless, this situation has ensured that, where the collaboration of a school system is sought for the collection of data, it is necessary to avoid direct confrontation in the publication and release of findings.

This caution has limited the open discussion of results from IEA studies within Australia, and to some extent has limited the use made of the findings of these studies. However, by opening up a topic for discussion and by showing that meaningful data can be collected, IEA researchers in Australia have indicated new directions that other researchers have followed, sometimes with a marked influence on educational policy.

2 Impact on Policy at National and State Levels

Many policy-related issues have been raised initially in Australia by IEA studies. Therefore, it is necessary to limit discussion in this article to five of greatest significance.

2.1 Retention Rates

In 1964, the National Case Study Questionnaire for the First IEA Mathematics Study (Husén 1967) required the calculation of retention rates for all Australian states and for the country as a whole. This work revealed striking results because the immediate post-war generation of children, in 1963 and 1964, were reaching the upper secondary school grade levels. As a consequence, a monograph, titled *Staying Longer at School* (Radford 1966), was prepared and published that not only revealed trends across Australia in increased enrolment and participation at the post-compulsory levels of schooling, but also employed an index that in due course was to become a key index of the outcomes of education in Australia. This index is widely referred to as the *retention rate*. Although the contribution of IEA research to this development is nowhere acknowledged, there is little doubt that the use by IEA of the retention rate index, at a time when significant change in the value of the index was occurring, led to the emergence and employment of an indicator currently of considerable importance in Australian schooling. It should be noted, however, that this indicator is not accepted or widely employed in higher education in Australia. As a consequence, there are commonly serious misunderstandings of the changes that are currently taking place.

A further result which was well treated in the international report of the First IEA Mathematics Study (Husén 1967) and the Australian report (Keeves 1968, pp. 149, 164) established, both across countries and between systems within Australia, the significance of the inverse relationship between retention rate and achievement. This work led to the development of the concept of yield (Postlethwaite 1967) of a school system. Furthermore, a model was advanced by Walker (Husén 1967, pp. 135-139) as an explanation of the observed relationships. This model led directly to the development of a procedure for the equating of student performance in the tertiary entry scores between the different state systems of Australia, that would permit portability of scores from one state to another (Keeves 1994).

2.2 Social Class Differences

The First IEA Mathematics Study (Husén 1967), as mentioned above, collected information on father's occupation, and through the use of a simple nine-point occupational scale, developed at the University of Chicago, the data were examined for relationships between social class, as measured on the occupational scale, and student achievement and attitudes. In addition, relationships were found for Australia between social class and retention at school at the post-compulsory grades (Keeves 1968). Not only had such results not been recorded previously in Australia with national samples of students, but a general occupational scale, based on skill and skill type was not developed until the mid-1960s, well after the IEA data had been processed. With access to an Australian occupational scale other studies were undertaken that confirmed the IEA findings relating to Australia that had been eventually released in summary form (Keeves & Radford 1969). Subsequently, in the IEA Six-Subject Study, analyses were undertaken in which social class indicators at the school level were employed that showed the strength of influence of the social class composition of the community served by a school (Rosier 1972). In recognition of this influence, the Interim Committee for the Australian Schools Commission (1973, p. 20) proposed compensatory programs at the school level in order to overcome social disadvantage. This approach was subsequently validated by Ross (1983) at the ACER, and these programs have been maintained in order to raise the quality of education provided across Australia.

2.3 Gender Differences

Both the First IEA Mathematics Study (Husén 1967), and the First IEA Science Study (Comber & Keeves 1973) provided unequivocal evidence of gender differences in the subject areas of mathematics and the sciences. In mathematics, the effect size of the gender difference varied across countries in a manner that appeared to be related to the role of women in society (Keeves 1973).

In the natural sciences, the gender differences varied consistently across age levels and subject fields. Gradually, it was recognized that programs could be implemented to increase the participation and performance of girls in the areas of mathematics and the sciences. The data collected in subsequent IEA studies in Australia have shown significant reductions in the magnitude of the gender effect size in science (Keeves 1992) and decreases in gender ratios for both mathematics and science yields at the terminal secondary school stage (Moss 1982; Keeves 1992). These results indicate very convincingly that such gender differences were to a significant extent societally based and the introduction of policies and programs to overcome gender bias could have recognizable effects. However, the evidence from the Second IEA Science Study (Keeves 1992) in some other countries indicates that a gender balance must be sought, because there is the danger that the participation and performance of boys might under certain circumstances be adversely affected by programs and circumstances that favour girls.

2.4 Time and School Learning

The relationship between curricular time and educational achievement in the Australian state school systems for the field of mathematics (Keeves 1968) has been referred to above. Further analyses were carried out using the data collected in the First IEA Science Study and the findings in both subject areas of mathematics and science were eventually released (Keeves 1976) when recognition of the influence of time on school learning was being widely accepted as a result of the publication of the findings of IEA research (Bloom 1974; Carroll 1975). Significant positive relationships between time on task and quantity of instruction were confirmed by the IEA Classroom Environment Study (Bourke 1984; Sellin 1991), but negative relationships were observed between quantity of instruction and attitudes. When at one time the relationship between time and achievement was questioned (Husén 1974, pp. 51-52), it is today widely acknowledged. Moreover, where alternative activities continue to intrude on instructional time, the need to maintain a balance is generally recognized.

2.5 Curriculum Differences Between the Australian States

Prior to the development of tests, each IEA study, in which Australia has participated, has required that a detailed analysis of the school curriculum should be undertaken in the subject field under survey. In the Australian setting, this has involved a separate analysis for each of the states and territories which were participating in the study. The analyses have been published in the fields of mathematics (Keeves 1968; Rosier 1980a) and science (Rosier & Banks 1990; Rosier & Long 1991).

The general finding from these analyses has been the uniformity in the mathematics and science curricula across the Australian states and territories, so that a national perspective of the curriculum of the schools in these areas is meaningful. However, the different ages and conditions of entry to schooling in the different states sometimes serve to confound comparisons by grade. As a consequence, the only sound comparisons of performance between the

Australian states and territories has been through the use of age samples rather than grade samples.

Rosier (1980b) has also explored relationships between curriculum content ratings and student achievement with consistent results which indicated that the differences between states in achievement were related to the curriculum differences that exist in the field of mathematics. Similar results were found in science at the 14-year-old or middle secondary school level (Rosier & Banks 1990). Moreover, Rosier and Long (1991) showed at the pre-university level in science that not only were the differences between states in curriculum content small but the differences between states in achievement expressed as a percentage of the variance in student scores were also small except in the field of Physics where it exceeded five per cent.

The policy implications of this work are of considerable significance in so far as they indicate that the between-state differences in curriculum content are relatively small, as are the between-state differences in achievement. However, the lack of uniformity between states in curriculum specification serves to accentuate superficial differences as far as teachers and school principals are concerned. Moreover, the differences between states in age of entry to school and as a consequence in age-grade distribution also becomes a serious handicap to those students who shift from one state to another during the course of their schooling. The Australian Government has, during recent years, sought to introduce national curriculum statements and profiles that should in due course facilitate the transfer of students from state to state at the school level. The detailed curriculum analyses carried out for IEA studies have served to provide a basis for the comparisons of curricula between states, and for the subsequent convergence of curricula through the development of national curriculum statements and profiles (Curriculum Corporation 1994; Francis 1994).

3 Impact on Practice at the School and Classroom Levels

The identification of teaching practices that are beneficial for augmenting student achievement has proved difficult in IEA research studies. This is partly related to problems that occur in the analysis of data from longitudinal studies arising from the unreliability of gain scores which involve measurement at only two occasions, and from the emerging evidence that the differences in variance between classes within schools are generally small. The analysis of data has also been seriously handicapped by an inability to partition and examine effectively the variance into its different components (intra-individual, interindividual, between classes, between schools, and between sectors or school systems). Nevertheless, IEA research has contributed to the improvement of educational practice in five areas, namely by showing the importance for student learning of (1) student attitudes and values, (2) an emphasis on process, (3) opportunity to learn, (4) time spent on homework, and (5) class size and whole group instruction.

3.1 Student Attitudes and Values

IEA studies have, since the First IEA Mathematics Study (Husén 1967), sought to measure student attitudes and values and to examine their interrelation with achievement. The measurement of attitudes and values across countries with the problems of translation of attitudinal statements into different languages has been fraught with many difficulties, not the least being the limited number of items that could be used in a survey associated with a particular scale. Hence, the scales employed have commonly had lower reliabilities than were considered desirable for effective comparisons both between and within countries. Nevertheless, unequivocal evidence has emerged of important relationships between attitudes and achievement. Recent developments in the analysis of data using latent variable path analysis have permitted the employment of more stable and more meaningful variables for attitudinal constructs with strong evidence of consistent findings within and across countries (Keeves 1992; Postlethwaite & Wiley 1992). Moreover, the teasing out of the magnitudes of the reciprocal relationships between attitudes and achievement in IEA studies has confirmed not only that greater learning led to more favourable attitudes, but also that more positive attitudes influenced the growth of student learning (Anderson, Ryan & Shapiro 1989; Sellin 1991; Johnson 1993). A consequence of such evidence is that in the Australian national curriculum statements and profiles, the importance of the development of favourable attitudes and values towards a subject field has been clearly recognized and teachers are encouraged to foster attitudinal outcomes of the courses they teach in mathematics and science (Curriculum Corporation 1994).

3.2 Emphasis on Process

In the First IEA Mathematics Study (Husén 1967), attempts were made to measure the views of students with respect to the teaching of mathematics as well as their views of school and school learning, and their attitudes towards mathematics as a process. Further analysis of the Australian data confirmed the differences which were hypothesized from an examination of curricula in New South Wales and Victoria, namely, that at the lower secondary school level, students in New South Wales would hold the opinion that mathematics was an open and creative process and would view mathematics teaching as involving inquiry and discovery to a greater extent than would their counterparts in Victoria. Similar differences were not found in the primary school curricula or in students' views and attitudes. From these results it was inferred that curricular factors were associated with the development of the differences in views and attitudes which were found at the lower secondary stage (Keeves 1966).

In both the First and Second IEA Science Studies (Comber & Keeves 1973; Keeves 1992), not only were similar attempts made to measure students' views of science teaching and students' understanding of science as a process, but attempts were also made to measure student performance on practical tasks. The taxonomic classification of school science in terms of a two-way grid of content and process, which was developed in 1966 by Klopfer (1971) for the first science study was subsequently published in the *Handbook of Formative and Summative Evaluation of Student Learning* (Bloom, Hastings & Madaus 1971). This work has served to emphasize the importance in the learning of science of the processes of science which are concerned with investigation and inquiry, as well as the content of school science viewed as a whole, rather than as completely separate fields of biology, chemistry, earth science and physics. Empirical evidence from the two science studies confirm the validity of viewing school science as a single entity, in spite of the way in which it is presented in the schools of the United States, and to a lesser extent in some parts of Europe (Comber & Keeves 1973; Keeves 1992; Postlethwaite & Wiley 1992). These perspectives of science in schools, which involve both science as a unity of content and science as a process have recently been accepted in the development of the Australian national curriculum statements and profiles (Curriculum Corporation 1994). However, strong criticisms of these perspectives have been mounted in Australia both by professional scientists, who are struggling to maintain their territory at a time when growth in science is occuring at the interfaces between fields (Husén & Keeves 1991), and by educational psychologists who seek to emphasize a constructivist view of school science.

3.3 Opportunity to Learn

IEA studies have, where possible, sought to measure the opportunity that students have had to learn the content which was assessed by the items included in the tests. Opportunity to learn can be examined at two distinct levels within Australia, first between state systems of education, and second, between schools across state systems of education. Successive Australian reports in mathematics (Keeves 1968, 1976; Rosier 1980a) and science (Keeves 1976; Rosier & Banks 1990; Rosier & Long 1991) have established the existence of generally significant relationships at both levels.

Critics in Australia of the IEA studies have contended that such results were merely evidence that the tests were biased in favour of particular groups. However, they have failed to acknowledge that these relationships between opportunity to learn and achievement are maintained at the between-country, between-state and between-school levels of analysis in Australia. Moreover, in the between-school analyses these effects hold in Australia even after control for other factors that have been found to influence achievement. Furthermore, these critics fail to consider the procedures employed in the construction of the tests at cross-national level in which every attempt is made to sample in a representative way from the content that is common across countries. Analyses of data in both mathematics (Rosier 1980a) and science (Keeves 1992) have sought to link the curriculum content ratings with incidence of items in a test, opportunity to learn, and student achievement. The results have confirmed the general consistency of the interrelationships anticipated.

In addition, for educational practice, these relationships between opportunity to learn and achievement provide evidence to support the old adage that "Students only learn what you teach them". Both the specification of the curriculum and the learning that takes place in schools and classrooms is completely dependent on careful and systematic planning and instruction.

Very few countries permit schools and teachers to develop their own curricula and two countries that did in 1984 were Australia and England (Keeves 1992). Both countries have moved towards a more detailed specification of the curriculum at the national level. These countries have also seen the need to introduce testing programs which would serve to direct teachers' attention to adhering to the specified curriculum, in order to ensure that all students are provided with an opportunity to learn.

3.4 Time Spent on Homework

At the primary school level, relationships are not observed between time spent on homework and student achievement. However, at the lower and middle secondary school levels in Australia, both in mathematics (Keeves 1968, 1976; Rosier 1980a) and in science (Rosier 1973; Keeves 1976; Rosier & Banks 1990), positive relationships are recorded consistently between time spent on all homework and student achievement, whether at the student or systemic levels of analysis. It should be noted, nevertheless, that when other factors are taken into account consistent relationships are not generally observed in the specific subject areas at these levels which are associated with time spent on mathematics homework and time spent on science homework.

At the terminal secondary school level, both in mathematics (Keeves 1968, 1976; Rosier 1980a) and in science (Rosier 1973; Keeves 1976, 1992), time spent on mathematics homework and time spent on science homework are strongly related to mathematics and science achievement respectively. The relationships recorded at the terminal secondary school level suggest that homework serves as an extension of curricular time provided for student learning. However, the relationships at the lower and middle secondary school levels, which involve a general measure of time spent on all homework, are perhaps best considered as an indicator of motivation or diligence rather than an extension of curricular time.

The evidence for Australia in mathematics (Rosier 1980a) showed that between 164 and 1978 time spent on mathematics homework decreased in most states at the lower and middle secondary school levels and in all states at the pre-university level. Except in Victoria at the pre-university level, there was also a general decline at both age levels in time spent on all homework. However, in the field of science, for Australia as a whole, time spent on science homework had increased at both the lower and middle secondary school levels and the terminal secondary school level (Keeves 1992). Thus, it is unclear whether the importance of homework, both across all subjects and specific subject areas has been fully accepted by teachers and students since homework is acknowledged to have an influence on student performance, but there is some evidence of a decline between occasions in the time actually spent on homework. There have been some failures to collect, analyse and report data on homework in consistent and meaningful ways in IEA studies. There are, nevertheless, implications for classroom practice that need to be heeded by schools and teachers across the country.

3.5 Class Size and Whole Group Instruction

The IEA mathematics and science studies in Australia have generally found positive correlations between class size and achievement (Lafleur, Summer & Witton 1974), which are not significant when other factors are taken into account. The Classroom Environment Study (Bourke 1984) provided a rare opportunity to investigate this relationship in the teaching and learning of mathematics in primary school classrooms. This study found that class size was positively related to student achievement and negatively related to student attitudes towards the importance of mathematics. However, in an analysis at the class level, a suppressor relationship was recorded, arising from the high correlations with student ability, which changed the sign of the positive correlation between class size and achievement (0.18) to a negative regression coefficient (-0.24). Such results are difficult to interpret (Bourke 1986). Nevertheless, it must be acknowledged that there is little clear evidence to support the costly reductions in class size that teacher unions propose.

Bourke (1984, p. 215) considers these anomalous results in the following terms: "An explanation probably revolves around teacher, as well as student selection for large and small classes, and a possible lack of knowledge by teachers of instructional practices that could be used to take advantage of smaller classes".

Both Fordham (1983) and Bourke (1984) have presented evidence that many teachers, when provided with smaller classes, do not shift from whole group methods of instruction in mathematics at the mid-primary school level. Moreover, Bourke (1984) has reported a positive correlation between the use of whole group instruction and student achievement. It is now difficult in Australia to sustain a case for further reductions in class size, because the benefits are equivocal and the costs are substantial.

4 Impact on Educational Theory

IEA research has had a very marked, but mainly unacknowledged impact on educational theory. This impact has been in five areas, and while this influence has been felt strongly in Australia, the effects have also been felt in other parts of the world. First, IEA has contributed a new approach to inquiry in comparative education. Second, IEA research, largely through the efforts of Bloom (Bloom et al. 1971) has publicized the Tylerian evaluation triangle. Third, IEA has developed a theory of curriculum implementation. Fourth, Peaker (1971) has brought the construction and testing of models to the field of educational theory and research. Finally, IEA has provided the setting for the testing of Carroll's (1963) model of school learning, and the promulgation of this model.

While the Lake Mohok Conference of 1967 (Super 1969) advanced, in part, a theoretical framework for comparative education, the complexity of the task of integrating the different contributions presented into coherent theory largely defeated IEA scholars. The problems of combining the many different facets of a multilevel situation awaits the efforts of a creative comparative educational theorist.

4.1 Empirical Comparative Education

Comparative education in the past has largely comprised descriptive case studies of individual countries. Commonly the research methods employed have been ethnographic as the research undertaken has emphasized the influence of the cultural context of a country. The founders of IEA in the late 1950s recognized that within a particular country there was often insufficient variation in the conditions of education to make it possible to detect by existing methods of statistical analysis the effects of particular factors on learning outcomes. They argued that cross-national or comparative studies could employ the greater variation that existed across countries which would assist in identifying common factors of importance. The general findings produced over the past 30 years have affirmed their confidence in establishing significant findings and in a common theoretical perspective for education which applies across the world. This approach does not imply the identification of unchanging universal generalizations. As an example, the pattern of gender effects in mathematics and science, while largely common across countries, must be expected to change as human agencies introduce compensatory programs in a quest for greater equity. It is, nevertheless, of considerable value not only to report an initial pattern, which could serve to stimulate change, but also to be able to follow in a systematic way the effects of programs of intervention. IEA research in Australia has accomplished the recording of such change in the field of gender differences (Moss 1982; Keeves 1992).

The IEA approach to empirical research in comparative education should not be confused with the single scientific method advanced in the mid-1960s by Holmes (1965). Multiple methods of inquiry are required to achieve greater understanding. There is no one scientific method of investigation that applies in all situations. However, the IEA perspective which maintains that education is a process having much in common across the schools of the world, raises not only the theoretical issues concerned with why this should be so, but also the research questions, that are concerned with the identification of similarities and differences in educational processes and the examination of models of these processes.

4.2 The Evaluation Triangle

Tyler (1949) proposed the evaluation triangle to show the interactions between the goals of education, the modes of instruction and the assessment of outcomes. This approach has guided IEA studies as they have sought to map the curriculum, to measure instructional processes, and to assess with accuracy a range of educational outcomes. These ideas were developed by IEA at the Granna Workshop that was conducted in Sweden in 1971, and that examined in detail the seminal work *Handbook of Formative and Summative Evaluation of Student Learning* (Bloom et al. 1971). While much has been written and said about curriculum evaluation in Australia, the theoretical framework guiding such work continues to be the evaluation triangle advanced by Tyler. All major curriculum evaluation studies conducted in Australia during the past three decades have employed these approaches (Keeves 1968; Ainley 1978; Rosier 1980a; Rosier & Banks 1990; Rosier & Long 1991). If state wide monitoring studies are to advance beyond merely documenting levels of achievement at different stages of primary schooling, they must take into consideration the educational goals of the state systems of education, the curricula provided and the methods of instruction employed. The absence of a theoretical perspective in such monitoring studies results from a failure to incorporate the theoretical framework that Tyler proposed and IEA has disseminated to educational research across the world.

4.3 Curriculum Implementation Theory

From the Granna Workshop in 1971 also came a theoretical view of curriculum implementation that has been tested, in part, in reporting the results of the First and Second IEA Science Studies and the Second IEA Mathematics Study (Keeves 1974a, 1992; Rosier 1980b; Robitaille & Garden 1988; Rosier & Keeves 1991) and, in particular, in the IEA studies in Australia (Rosier 1980a;

Rosier & Banks 1990; Rosier & Long 1991). In this theory the curriculum is considered to exist at three levels (a) the intended curriculum, (b) the implemented curriculum, and (c) the achieved curriculum, which are influenced by the antecedent and contextual factors operating at the systemic, classroom and student levels respectively. The intended curriculum is customarily developed at the system level and is set in the context of the educational system; the implemented curriculum relates to the classroom conditions and is located in the context of the school and classroom; while the achieved curriculum is related to student circumstances and occurs in the context of the individual student. Moreover, it is clear that the implemented curriculum is dependent on the intended curriculum, and the achieved curriculum depends upon the curriculum that is implemented in the classroom. A more detailed discussion of this theory was initially presented by Travers and Westbury (1989) and was extended by Rosier and Keeves (1991). To date, the links between the intended and achieved curricula, and between the implemented and achieved curricula have been examined, but other relationships remain to be tested with Australian data, as Australia moves towards a national curriculum (Curriculum Corporation 1994; Francis 1994).

4.4 Path Models and their Examination

Theoretical perspectives are only fruitful if they provide both explanatory hypotheses and models that can be subjected to examination and that can subsequently be rejected or parameters of the models estimated. Peaker (1971) in his efforts to map out strategies for the analysis of IEA data during the decade from the mid-1960s, when he was not only involved in the design of samples for IEA research, but also in the analysis of the data collected, first applied the methods of path analysis to educational data. This was a seminal contribution and was quickly adopted in Australian studies (Keeves 1972) to examine the factors influencing change in achievement over time. The introduction of path modelling has transformed educational research, in so far as it has permitted the development of theory in situations where many factors are involved in explanation of observed effects. From theory, models can be advanced which can be checked by statistical analysis. Without the capability of examining and verifying deductions from theory, theory will rapidly atrophy or be ignored.

4.5 The Model of School Learning

The model of school learning advanced by Carroll (1963) lay dormant for more than a decade until Bloom (1974) examined and verified aspects of the model with IEA data. Likewise, the IEA study of French as a Foreign Language provided Carroll (1975) with the opportunity to check the model against empirical evidence. This model has subsequently been the source of many theoretical discussions of the factors involving schools and homes that influence student achievement. Moreover, a causal model derived from Carroll's model of school learning was advanced at the commencement of the Second IEA Science Study and was examined in the analyses of data collected in the study at the 10-year-old, the 14-year-old and the terminal secondary school levels (Keeves 1992).

5 Impact on Research Methodology in Australian Educational Research

A major impact of IEA research has been felt on the methods employed in empirical research in education not only in Australia, but throughout the world. There are at least five areas where IEA studies have introduced new research strategies into Australia and have, as a consequence, transformed the procedures employed. The first area involves the use of multiple choice testing in survey studies, together with the use of optical mark read answer sheets. The second area is concerned with the design of a sample in survey research together with the accurate estimation of sampling errors. Third, there is the introduction of longitudinal and trend studies. Fourth, there is the need for the multilevel analysis of data which IEA research has introduced into Australia through the work of the Second IEA Science Study. Finally, IEA introduced into Australia ways of collecting data to examine systematically the effects of classrooms on educational outcomes.

5.1 Multiple Choice Testing

When the First IEA Mathematics Study was undertaken in 1964, multiple choice tests had not been used on a large scale to measure student achievement in mathematics at the pre-university level. Moreover, optical mark-read (OMR) answer sheets had not previously been employed in Australia in the assessment of student performance. While some staff at the Australian Council for

Educational Research (ACER) were highly critical of the tests proposed for use in the IEA studies (Connell 1980), the IEA surveys did open up new procedures for the conduct of survey research in Australia. Furthermore, the introduction of OMR answer sheets gradually transformed many of the testing programs undertaken by the ACER.

5.2 Sampling and Sampling Errors

Under the direction of Peaker, IEA developed a strategy for sampling in educational surveys that is not only readily put into operation, but also yields samples of high quality (Rosier & Ross 1992). In addition, calculation of sampling errors for complex and highly stratified cluster samples is a major problem of which educational research workers throughout the world are largely unaware. Australian researchers at the ACER, guided by IEA experience, have carried out statistical analyses to examine the problems of estimation of sampling error (Ross 1978; Wilson 1983; Farish 1984). The dissemination of their findings and the use of appropriate procedures for the calculation of sampling errors remains an ongoing problem, that is completely ignored by the widely used statistical packages.

5.3 Longitudinal and Trend Studies

While all except one of the IEA studies carried out in Australia have been essentially cross-sectional studies, research workers at the ACER have sought to take advantage of the existence of a high quality initial sample associated with an IEA project by conducting follow-up studies that have introduced a longitudinal component (Lewis 1976a; Lewis 1976b; Rosier 1978; Jones 1988). In addition, a longitudinal component was incorporated into both the second mathematics and science studies in Australia through the design of what are sometimes called trend studies in which an initial investigation is replicated on a second occasion (Rosier 1980a; Rosier & Banks 1990; Rosier & Long 1991). A further extension of existing IEA studies was carried out through case studies of high and low performing schools in science in order to identify policies and practices, that were characteristic of the schools and that led them to perform above and below expectation (Owen 1975; Wilson 1975).

5.4 Multilevel Analyses

Two of the major problems in the analysis of data assembled through the use of cluster samples are the appropriate estimation of effects at the levels of the student and the school or class, and the estimation of errors arising from a complex sample design. These problems may be overcome through the use of multilevel analysis. An initial investigation using Australian data exposed the nature and extent of the problem (Keeves & Lewis 1983) and a preliminary attempt to investigate the problem was carried out prior to the analysis of the data for the Second IEA Science Study (Larkin & Keeves 1984; Keeves & Larkin 1986). While the analytical procedures that have since been developed have not been employed in the analyses of data collected in IEA studies, three doctoral theses have been undertaken that have analyzed Australian data and have used hierarchical linear modelling procedures (Kotte 1992; Young 1991; Johnson 1995). Future studies of schools and classrooms will not have any excuse to continue to make the errors associated with inappropriate methods of analysis which have occurred in the past in studies which involve multilevel data.

5.5 Classroom and School Processes

IEA researchers in Australia have always been sensitive to the criticisms that their activities were seen by many as being "essentially one of monitoring student performance" (Connell 1980, p. 295). As a consequence, they have always sought opportunities to investigate in more appropriate ways the processes at work in schools and classrooms. Secondary analyses were undertaken of data from the First IEA Mathematics Study to examine in greater detail the students' views of school and classroom processes (Keeves 1966). Furthermore, a longitudinal study was conducted in the schools in Canberra at the same time as the First IEA Science Study was undertaken that examined in detail the behaviour of students and teachers in mathematics and science classrooms (Keeves 1972, 1974b) which involved extensive observation of teacher and student behaviours in the natural classroom setting. The IEA Classroom Environment Study provided an opportunity to extend this work and, in the course of this study, the context of school learning was investigated (Fordham 1983) and teacher and student behaviour were examined in an observational study that involved the administration of a pre-test and post-test three months apart to a sample of mathematics classrooms (Bourke 1984). Now that appropriate methods of multilevel analysis are readily available for the examination of behavioural data, this type of research emerges as an important and exciting possibility for future investigations in Australia.

6 Postscript

Throughout the period of 30 years that this article reviews, Neville Postlethwaite has been the driving force behind IEA; first as Executive Director, for a period of ten years from 1962 to 1972; then as Chairman for a period of eight years from 1978 to 1986; and subsequently for a period of nine years in a variety of roles. In this time he has acted as host to an international centre, as author, as director of a study which was the largest undertaken by IEA in the field of Reading Literacy, and finally until his retirement in 1995, as critic and adviser to emerging studies. He has directed and incited IEA, through times of both ample resources and severe poverty, towards the goal of high quality research and the reporting of clear messages for policy makers in the field of education across the IEA world and the educational world at large. For over a decade, he has repeatedly urged that an account should be written of IEA's contribution to Australian education and has proposed that each country which has been involved in IEA work for a prolonged period should also write a similar account for publication. Although he would never accept that such a publication did more than record IEA's achievements across the world, the publication really provides a testimony to what he had achieved in his professional life from Hamburg, Paris and Stockholm, in the positions of executive director, consultant and university professor.

Bibliography

Ainley, J.G. (1978). *The Australian Science Facilities Program: A Study of its Influence on Science Education in Australian Schools*. Hawthorn: ACER.

Anderson, L.W., Ryan, D.W. & Shapiro, B.J. (1989). *The IEA Classroom Environment Study*. Oxford: Pergamon.

Bloom, B.S. (1974). Time and Learning. *American Psychologist*, *29* (9), 682-688.

Bloom, B.S., Hastings, J.T. & Madaus G.F. (1971). *Handbook of Formative and Summative Evaluation of Student Learning*. New York: McGraw-Hill.

Bourke, S.F. (1984). *The Teaching and Learning of Mathematics*. Hawthorn: ACER.

Bourke, S.F. (1986). How Small is Better: Some Relationships Between Class-size, Teaching Practices, and Student Achievement. *American Educational Research Journal, 23* (4), 558-571.
Comber, L.C. & Keeves, J.P. (1973). *Science Education in Nineteen Countries*. Stockholm: Almqvist & Wiksell.
Connell, W.F. (1980). *The Australian Council for Educational Research. 1930-1980*. Hawthorn: ACER.
Carroll, J.B. (1963). A Model of School Learning. *Teacher College Record, 64* (8), 723-733.
Carroll, J.B. (1975). *The Teaching of French as a Foreign Language in Eight Countries*. Stockholm: Almqvist and Wiksell.
Curriculum Corporation (1994). *Introducing Statements and Profiles*. Melbourne: Curriculum Corporation.
Farish, S.J. (1984). *Investigating Item Stability*. Hawthorn: ACER.
Fordham, A.M. (1983). *The Context of Teaching and Learning*. Hawthorn: ACER.
Francis, D. (1994). *CURASS, Guidelines, Papers*. Melbourne: Curriculum Corporation.
Holmes, B. (1965). *Problems in Education: A Comparative Approach*. London: Routledge & Kegan.
Husén, T. (Ed.). (1967). *International Study of Achievement in Mathematics. Vol. 2*. Stockholm: Almqvist & Wiksell.
Husén, T. (1974). *The Learning Society*. London: Methuen.
Husén, T. & Keeves, J.P. (Eds.). (1991). *Issues in Science Education: Science Competence in a Social and Ecological Context*. Oxford: Pergamon.
Interim Committee of the Australian Schools Commission [P.H. Karmel, Chairman]. (1973). *Schools in Australia*. Canberra: Australian Government Publishing Service.
Johnson, T.G. (1993). *Student Attitudes to Science and Achievement in Science*. Unpublished MA thesis. Adelaide: The Flinders University of South Australia.
Johnson, T.G. (1995). *Multilevel Models of Student Achievement in Science*. Unpublished Ph.D. thesis. Adelaide: The Flinders University of South Australia.
Jones, W.B. (1988). *Secondary School Mathematics and Technological Careers*. Hawthorn: ACER.
Keeves, J.P. (1966). *Students Attitudes Concerning Mathematics*. Unpublished M.Ed. thesis. University of Melbourne.
Keeves, J.P. (1968). *Variation in Mathematics Education in Australia*. Hawthorn: ACER.
Keeves, J.P. (1972). *Educational Environment and Student Achievement*. Stockholm: Almqvist & Wiksell.
Keeves, J.P. (1973). Differences between the Sexes in Mathematics and Science Courses. *International Review of Education, 19* (1), 47-63.
Keeves, J.P. (1974a). The IEA Science Project: Science Achievement in Three Countries - Australia, the Federal Republic of Germany, and the United States. In German Commission for UNESCO (Ed.), *Implementation of Curricula in Science Education* (pp. 158-178. Cologne: German Commission for Unesco.
Keeves, J.P. (1974b). *Can Teachers Make a Difference. Home Environment and School Study Report, 1974: 1*. Hawthorn: ACER.
Keeves, J.P. (1976). *Curriculum Factors Influencing School Learning: Time and Opportunity to Learn. IEA (Australia) Report 1976: 2*. Hawthorn: ACER.

Keeves, J.P. (Ed.). (1992). *The IEA Study of Science III: Changes in Science Education and Achievement: 1970 to 1984*. Oxford: Pergamon.

Keeves, J.P. (1994). *National Examinations, Design, Procedures and Reporting*. Paris: IIEP.

Keeves, J.P. & Larkin, A.I. (1986). The Context of Academic Motivation. *International Journal of Educational Research, 10* (2), 205-213.

Keeves. J.P. & Lewis, R. (1983). Issues in the Analysis of Data from Natural Classroom Settings. *Australian Journal of Education, 27*, 274-287.

Keeves, J.P. & Radford, W.C. (1969). *Some Aspects of Performance in Mathematics in Australian Schools*. Hawthorn: ACER.

Klopfer, L.E. (1971). Evaluation of Learning in Science. In B.S. Bloom, J.T. Hastings & G.F. Madaus (1971), *Handbook of Formative and Summative Evaluation of Student Learning*. New York: McGraw-Hill.

Kotte, D. (1992). *Gender Differences in Science Achievement in 10 Countries*. Frankfurt: Lang.

Lafleur, C.D., Summer, R.J. & Witton, E. (1974). *Class Size Survey*. Canberra: Australian Government Publishing Service.

Larkin, A.I. & Keeves, J.P. (1984). *The Class Size Question: A Study at Different Levels of Analysis*. Hawthorn: ACER.

Lewis, R. (1976a). *Transition from School to Post-Secondary Education in Australia. IEA (Australia) Report 1976: 1*. Hawthorn: ACER.

Lewis, R. (1976b). *Transition from Schooling at Year 12 to Work in Australia. IEA (Australia) Report 1976: 3*. Hawthorn: ACER.

Moss, J.D. (1982). *Towards Equality: Progress by Girls in Mathematics in Australian Secondary Schools*. Hawthorn: ACER.

Owen, J.M. (1975). *The Effects of Schools on Achievement in Science. IEA (Australia) Report 1975: 1*. Hawthorn: ACER.

Peaker, G.F. (1971). *The Plowden Children Four Years Later*. London: NFER.

Postlethwaite, T.N. (1967). *School Organization and Student Achievement*. Stockholm: Almqvist & Wiksell.

Postlethwaite, T.N. & Wiley, D. (1992). *The IEA Study of Science II: Science Achievement in Twenty-Three Countries*. Oxford: Pergamon.

Radford, W.C. (1966). *Staying Longer at School*. Hawthorn: ACER.

Robitaille, D.F. & Garden, R.A. (1988). *The IEA Study of Mathematics II: Contexts and Outcomes of School Mathematics*. Oxford: Pergamon.

Rosier, M.J. (1972). *Some Differences between Population II Schools in Australia. IEA (Australia) Report 1972:4*. Hawthorn: ACER.

Rosier, M.J. (1973). *Variation between Australian States in Science Achievement. IEA (Australia) Report 1973: 5*. Hawthorn: ACER.

Rosier, M.J. (1978). *Early School Leavers in Australia*. Stockholm: Almqvist and Wiksell.

Rosier, M.J. (1980a). *Changes in Secondary School Mathematics in Australia 1964-1978*. Hawthorn: ACER.

Rosier, M.J. (1980b). The Second IEA Mathematics Study in Australia. In H.G. Steiner (Ed.), *Comparative Studies of Mathematics Curricula. Change and Stability 1960-1980* (pp. 230-238). Bielefeld: Institut für Didaktik der Mathematik an der Universität Bielefeld.
Rosier, M.J. & Banks, D.K. (1990). *The Scientific Literacy of Australian Students*. Hawthorn: ACER.
Rosier, M.J. & Keeves, J.P. (1991). *The IEA Study of Science I: Science Education and Curricula in Twenty-Three Countries*. Oxford: Pergamon.
Rosier, M.J. & Long, M.G. (1991). *The Science Achievement of Year 12 Students in Australia*. Hawthorn: ACER.
Rosier, M.J. & Ross, K.N. (1992). Sampling and Administration. In J.P. Keeves (Ed.), *The IEA Technical Handbook* (pp. 51-90). The Hague: IEA.
Ross, K.N. (1978). *Searching for Uncertainty*. Hawthorn: ACER.
Ross, K.N. (1983). *Social Area Indicators of Educational Need*. Hawthorn: ACER.
Sellin, N. (1991). *Statistical Model Building in Research on Teaching: The Case of a Study in Eight Countries*. Unpublished Ph.D. thesis. University of Hamburg.
Super, D.E. (Ed.). (1969). *Towards a Cross-National Model of Educational Achievement in a National Economy*. New York: Teacher College, Columbia University.
Travers, K.J. & Westbury, I. (Eds.). (1989). *The IEA Study of Mathematics I: Analysis of Mathematics Curricula*. Oxford: Pergamon.
Tyler, R.W. (1949). *Basic Principles of Curriculum and Instruction*. Chicago: University of Chicago Press.
Wilson, A. (1975). *The Effects of Schools in Victoria in the Science Achievement of Junior Secondary Students. IEA (Australia) Report 1975: 2*. Hawthorn: ACER.
Wilson, M. (1983). *Adventures in Uncertainty*. Hawthorn: ACER.
Young, D. (1991). *Gender Differences in Science Achievement: Secondary Analysis of Data from the Second International Science Study*. Unpublished Ph.D. thesis. Curtin University of Technology.