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ABSTRACT

Educational research has all too often failed to be implemented on a large-scale basis. This paper describes the multiplier effect of a professional development program for teachers and for trainers in the United Kingdom, and how that program was developed, monitored, and evaluated. Cognitive Acceleration through Science Education (CASE) is a program for students in grades 6-9 that focuses on cognitive conflict and metacognition and that has a track record of long-term increases in student academic achievement. The CASE method involves a significant change in professional practice by most teachers. CASE uses a model of continuing professional development (CPD) that includes coaching, working with whole departments in schools, and integrating both practical and theoretical elements. The critical outcome measure in the evaluation of the CASE professional development program is student achievement. The paper also assesses the extent to which teachers actually used the CASE innovation in their classes (level of use). Data were gathered from interviews with and a questionnaire of teacher cohorts for the years 1991-93 (over 100 teachers from 13 schools) and 1994-96 (88 teachers from 11 schools). The study also conducted interviews with principals and heads of science departments or program coordinators at each school. The study found that teachers' commitment and level of use were significantly greater in schools where there was a unity of vision between the principal and the head of the science department; that teachers' level of use was significantly related to the presence of at least one person who was deeply committed to making the innovation work in that school; and that there was a greater sense of staff ownership in schools where the science department head had adopted CASE for staff-development purposes or because of a belief in the value of children's thinking, and where there was a formal structure for regular discussion. Five figures and one table are included. (Contains 15 references.) (LMI)

Paper for AERA March 1997

FACTORS INFLUENCING UPTAKE OF A LARGE SCALE CURRICULUM INNOVATION

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Introduction

Educational research has been remarkably sucessful in showing how the fundamental work of psychologists, philosophers, and sociologists can be translated into practical classroom procedures which improve the immediate quality of learning and the long term effects on students' life chances. This work has, however, too often been limited to lab school experiments conducted at a few sites and has failed to take off into large scale implementation - for example through adoption by school districts. Blame for this failure of the educational system as a whole to realise the benefits of well-researched practice may be placed on: the researchers, concerned with academic publication and moving on to the next new work or on their failure as publicists; on the conservatism of teachers and school managers; on short-sightedness of politicians concerned more with elections a couple of years away than with benefits to the society which may not show up for 10 years; or, inevitably, on lack of funding. At different times and in different places probably all of these accusations can be justified, and may be summarised as the inertia of the system, like a massive tanker whose direction cannot be changed by a few speed-boats of research.

In this paper I will describe a case in which one such speedboat, by persistence over many years and attention to publicity and multiplier effects, is beginning systematically to shift the tanker of practice in one country. In particular I will focus on the multiplier effect of a professional development program for teachers and for trainers, and how that program was developed, and is monitored and evaluated. I believe that there are lessons in this case study as much for the methodology of evaluating staff development as for the particulars of the innovation described.

The CASE program

Cognitive Acceelration through Science Education (CASE) is a program for grade 6 - 9 students which focuses on cognitive conflict and metacognition. Special activities (Adey, Shayer, & Yates, 1992; Adey, Shayer, & Yates, 1995b) are delivered by teachers about once every two weeks, instead of a normal science lesson, over a two year period. The CASE method involves a significant change in professional practice by most teachers who use it, and a school which wishes to embark on CASE teaching is advised to contract for an extensive staff development program in which all science teachers will participate over the two years in which CASE is first taught.

The reason that schools are willing, and often eager, to participate in the staff development is that CASE has a proven track record of increasing students' academic achievement for years after they have participated, and across all academic subjcets. The success of CASE has been widely reported in the academic literature (Adey & Shayer, 1993; Adey & Shayer, 1994; Shayer & Adey, 1996) and also in the national press in the UK. One example of the sort of effect that CASE can have on gains in achievement is shown in figure 1.

(figure 1 about here)

The fact that we know that CASE can have a long term far transfer effect on students is important in the evaluation of the professional development program for its introduction. This is because we evaluate the professional development in terms of the effect on students' cognitive growth and learning. If we were not assured that the innovation (CASE) can, under the right crcumstances, have the effect then we would not know wthether any failure to find an effect was due to the staff development or to the innovation itself.

CASE CPD

(In the UK, "Continuing Professional Development" and its acronym CPD have become the currently fashionable shorthand for what we used to call INSET, and in the US is usually referred to as Staff Development).

It is well established (Joyce, Showers, & Rolheiser-Bennett, 1987) that short centre-based inservice courses, however well designed and delivered, have no significant and permanent effect on teachers' practice. CASE CPD was designed on athe assumptions that (a) a long 'drip-feed' process would be required; (b) it is necessary for the CPD program to include elements of learning theory and management-of-change as well as the practical introduction to the techniques of teaching for cognitive acceelration; (c) a coaching element was essential, when tutors worked with teachers in their own classrooms; and (d) it would be necessary to work with whole departments in schools, not just individual teachers. Accordingly, schools who wished to participate in the CASE CPD program were required to agree to continue the program for two years, to release teachers for centre days and to allow access to tutors for coaching, and to involve the whole department. The cost of the whole program to the school is in the region of $5000. The recent devolvement of budget control from school boards to individual schools facilitates school Principals' ability to make such choices for themselves.

A summary of the complete program is shown below:

Two year CASE-CPD program.

Year / month	In Centre	In school	Purpose / activities
1 / Sept.		1/2 day	Meet with Principal Meet with all science teachers, outline principles, timetable, and commitment required. Provide plenty of opportunity for questions and for all to raise concerns.
1 / Sept.	2 days		Introduction to underlying theory. Go through first 6 activities. The testing programme and administration of the pre-test. Development of individual school plans.
1 / Sept. - Dec.		1/2 day	Coach and/or team-teach with teachers starting implementation in their own classes
1 / Jan.	2 days		Feedback from schools on progress so far. More depth on theory. Next few activities. Issues around the management of change in the schools.
1 / Jan. - June		1/2 day	Coach and/or team teach with teachers in their own classes; Possible sessions with whole department.
1/ May	3 days		Residential conference: 1 day for CPD program participants only, 2 days to include many others. Sharing experiences, working on bridging, writing own "Thinking Science" type materials.
2 / Oct.	1 day		Next activities. Updating school plans, further management issues
2 / Oct. - May		2 x 1/2 days	Coach and/or team teach with teachers in their own classes; Possible sessions with whole department.
2 / June	1 day		Post-testing, data collection. Forward plans and the network for continuing support.

The first such program was started in September 1991, and we have started a new one every year since. We have also run specially modified programs for Trainers, who after two years become able to run their own CASE CPD courses, with some quality control provided by a network of Trainers. We are currently recruiting strongly for the 7th cohort of CASE CPD starting in September 1997. The King's College CASE CPD program has reached, either directly or through CASE trainers who we have trained, some 10% of the secondary schools of

the United Kingdom. Many more schools are using the materials without participating in a full inservice course, but we do not have data from such schools to be able to compare with that from schools within our program.

Process-product research revisited

There are a number of levels at whch professional development programs can be evaluated. The most trivial (and useless) form of evlauation is the questionnaire given to participants at the end of an inservice day. We do not do that. At the top level, at least for a professional development program whose aim is to equip teachers with the skills required to raise their students' general thinking ability, the most compelling evaluation is gains in pupil ability and achievement which can be attributed unequivocally to the professional development of the teachers. This is not a simple thing to do, and many have claimed that such process - product research is so difficult that it cannot be done, and should not even be attempted. Richardson (1994) makes the case that much investigation of teacher development in the past has been very instrumental, treating teachers like objects to be manipulated in a vain search for sets of teacher behaviours which can be relied upon to deliver good student learning. As a reaction to such dubious practices, the trend in classroom research has shifted towards ethnographic studies of classroom ecologies. Here we will look again at this question, and make the argument that while ethnographic studies have value for certain purposes, both socio-political and professional voices are quite reasonable in requiring some measure of outcome from investment in staff development, and that process-product research not only can yield useful information, but is the only approach which can in principle provide guidance to teachers and teacher educators on how professional practice might be changed to yield higher student achievement. Firstly, some of the specific criticisms of process-product research should be considered.

Doyle (1977) criticises studies in which specific teacher behaviours are correlated with student outcomes for the idiosyncratic way in which particular behaviours are chosen for study, and the unwarranted assumption of causality underlying the correlation. He compares the process-product paradigm unfavourably with the 'classroom ecology' paradigm:

> "...the purpose of the ecological paradigm ... is to build and verify a coherent explanatory model of how classrooms work, a model that can be used to ask questions and interpret answers about teacher effectiveness"

It is clear that ethnographic studies of classrooms can - at a cost - provide far richer accounts of what happens in classrooms than can simply quantitative studies (see for example, Gardner, 1974; Tobin, 1990). But whilst such studies provide rich descriptions, it is less clear how they can lead to prescriptions, that is, to advice to teachers or teacher educators about ways of improving their practice.

Fenstermacher (1979) also makes much of the problem of causality. He exemplifies the point with correlations found between, for example, the use of probing follow-up questions by the teacher and student achievement. He concludes that there is no way of telling from this correlation whether it is the nature of the questions that causes enhanced achievement, or whether higher achieving students provide feedback to teachers which encourages them to use higher level questioning techniques. Such criticism can be met by intervention studies, in which a teacher behaviour postulated as causally related to student achievement is specifically introduced, and changes in student outcomes observed. Fenstermacher's main criticism, however, is that process-product researchers necessarily, and unconsciously, make assumptions about what counts as "good" education. He claims that quantitative researchers are unaware that the products they strive for are no more than culturally determined norms. But how important is such awareness? If teachers, students, parents, university admissions tutors, and employers all agree that test grades are the best measures available of achievement and aptitude then it seems that aiming for higher grades is a perfectly respectable aim for teachers and teacher educators. Evaluation of inservice programs for teachers whose aims are the development of instruction must always, finally, look for evidence of increased student performance on measures which have wide popular credibility.

A further problem with process-product research is interaction between particular teacher behaviours and particular learner personalities, learning styles, or context, which makes

generalisation of results from individual studies difficult. In an elegant study, Gardner (1974) showed how the use made by different pupils of a given teacher behaviour was mediated by personality, such that the application of a simple process-product model could easily lead to erroneous conclusions. Where a particular teacher characteristic at first sight appeared unrelated to pupil performance, deeper analysis showed that it positively affected pupils of one personality type, and negatively affected pupils of a different personality type.

Brophy & Good (1986) in a thorough review of process-product research recognise all of these problems, and after eliminating studies which fail to meet their rather stringent criteria for acceptability, conclude

> "Despite the importance of the subject there has been remarkably little systematic research linking teacher behaviour to student achievement. A major reason for this is cost." (p.329)

They mean, of course, the cost of thorough and well designed studies. They find, however, that with more sophisticated observation methods and experimental designs, some reliable relationships began to be established between certain teacher attitudes and behaviours (such as warmth, business-like manner, enthusiasm, organisation, variety, clarity, structuring comments, probing follow-up questions, and focus on academic activities) and students' achievement. They conclude that process-product research is viable, but that it is difficult and requires careful attention to experimental design and interpretation to make its findings valid and usable.

Even if general criticisms of process-product research can be met, there remain two problems particular to staff development which have received less attention in the literature. The first is the dilution effect. An inservice staff development program can only be one of many influences on teachers, and a particular teacher can be only one of many influences on the students. The effect of one particular staff development program is likely to be so diluted in its effect on students as to be undetectable.

The second is the difficulty of isolating sources of failures of an inservice programme. Inservice courses are often based on unsupported assumptions about what constitutes effective teaching and learning. The measurability of outcomes associated with such assumed good practice presents a problem. If you are not sure whether or not teaching method X works, in any sense, then evaluation of an inservice programme designed to introduce method X which shows no gain in pupil learning may either be because the inservice programme was poorly delivered, or because method X does not work. There is no way of telling which.

Both of these problems can, in principle, be overcome: by making the staff development programme sufficiently extensive so that its effect is substantial, and by evaluating the methods being advocated separately and establishing that, at least under optimum conditions, they can indeed lead to enhanced student achievement. We believe that both of these conditions are met in the present study. The extent of the inservice has programme has already been outlined, and the CASE methods have been shown to be effective independently of the present INSET evaluation study.

The evaluation model

It follows from the foregoing discussion that the critical outcome measure in the evaluation of CASE CPD should be a measure of pupil gain. We do this routinely now by measuring the cognitive gains made by individual students in experimental groups compared with controls, and also at the class and school level by assessing the "value added" effect of the CASE intervention on sutudents' achievement (see figure 1).

As an intermediate outcome variable we have assessed the extent to which teachers are actually using the CASE innovation in their classes. This is described as their Level of Use.

We are concerned, particularly, with the effect of a set of mediating variables between the input of participation in the program, and the intermediate and final outcome variables (LoU and cognitive gain). The following are postulated as mediating variables which might severally or together influence the extent to which participation in CASE CPD is translated into actual use of CASE and pupils' cognitive growth.

1 the sense of ownership felt by each teacher of the CASE methods (SOO);
2 perceived effectiveness of communication about the project within the school science department (COM);
3 teachers' attitudes to and familiarity with the theoretical bases of CASE (THEO);
4 a number of factors within the school management (SMI), including:
   a) management commitment
   b) unity of vision
   c) profile of CASE within and outside the school
   d) Senior management's reasons for buying in CASE
   e) CASE co-ordinator's reasons for promoting CASE
   f) formal communication systems within the school related to CASE

Figure 2 illustrates the conceptual framework in which the input, mediating, and outcome variables are related.

(figure 2 about here)

Instruments for assessing these factors were:

A Cognitive levels are assessed with Piagetian Reasoning Tasks (Shayer, Adey, & Wylam, 1981; Shayer, Wylam, Küchemann, & Adey, 1978), demonstrated class tasks which yield levels of cognitive development of individuals in a group on a scale from preoperational through mature formal operations.

B Level of Use (LoU) was determined using a Level of Use scale developed by Hall & Loucks (1977) based on a structured interview which yields a score on a scale from 0 (is not using the innovation and has no intention of using it) to 6 (is not only using the innovation comprehensively, but has modified it to suit local conditions while retaining the original main features).

C Semi-structured interviews with (i) a Principal or Deputy Principal responsible for curriculum or professional development, and (ii) the Head of Science Department and/or CASE co-ordinator in each school yield data for the SMI factors.

D A 16 item questionnaire designed to tap variables SOO, COM, and THEO was posted to every teacher in the program, together with a reply-paid envelope. Follow-up phone calls and some individual interviews (added to the LoU interview) ensure returns in the order of 75%.

Validation, pre-trials, and rater cross-checking of most of these instruments have been described previously. The new factor in this paper is THEO. The questionnaire for the 1st cohort (1991-93) contained some probes about teachers understanding of metacognition and cognitive conflict (two of the key aspects of CASE methods), but they were open-ended and because of some diffidence about appearing to be testing teachers' understanding, they were optional. No one answered them. for the 1996 survey, 12 Lickert-type attitude statements with 4 possible choices (strongly agree, agree, disagree, strongly disagree) were drafted and shared with faculty colleagues for comment on construct validity. After revision they were added as subsections to one item in the questionnaire. The direction of agreement /disagreement with CASE type theoretical understanding varied. For example "It does not matter if pupils sometimes leave the class a bit confused" was scored 3 for strongly agree, and 0 for strongly disagree, while "The most effective way of imparting knowledge is for the teacher to talk and the pupils to listen" was scored 0 for strongly agree and 3 for strongly disagree. An internal consistency check (Cronbach alpha with Horst modification for varying 'facilities') showed that two of the subitems did not contribute to the same construct as the others, and inspection of their wording showed them to be ambiguous or over-strongly worded (e.g. "In *each* lesson, it is *essential* ..."). A THEO score was computed from the remaining 10 subitems.

Sample

Two studies have been conducted so far. The first study was made of the 1st cohort of teachers who participated in CASE training from 1991 - 93, and a further study has been made of the 4th, 1994 -96 cohort. Over 100 teachers from 13 schools were involved in the first study, and 88 teachers from 11 schools in the second. Results from the first cohort have been reported previously, but will be summarised below. Data from the 4th cohort are still being processed, but some preliminary results can be reported.

Results

In the cohort 1 study (Adey, 1995) we obtained LoU data from 40 teachers, and cognitive gain data from 35 classes, but both measures together were only available from 18 tecahers / classes. For this sample, the correlation between Level of Use and students' cognitive gain was 0.61 ($p<.01$) - this in spite of the limited range of levels of Use available from an all-CASE sample. The relationship is illustrated in figure 3.

(figure 3)

In our original research on CASE (Adey & Shayer, 1993) we showed that cognitive gain is directly related to subsequent gaisn in academic achievement of CASE groups compared with control groups.

There was also a strong relationship (correlation 0.79) between th extent to which teachers communicated with one another, formally and informally, within a department and the mean Level of Use of CASE in that school. This relationship is illustrated in figure 4.

(figure 4)

Interviews with Principals and Heads of departments were analysed as follows: statements within transcripts of each interview which related to the factors being investigated were pasted into a table where the column heading was the factor under consideration, and the row labels were codes for the schools. Virtually all of the interview material was allocated to the table. Two independent judges then ranked each school for each factor, and these ranks were used as the "scores" for determining rank correlation coefficients between the factors extracted from the interviews and other varaibles. The method is described in more detail in Adey, Dillon, & Simon (1995a) A number of significant relaionships were found, perhaps the most important being:

- COM and LoU were significatly greater in schools where there was a unity of vision between the Principal and the head of the science department;
- LoU was significatly related to the presence of at least one person who was deeply committed to making the innovation work in that school;
- Where the motivation of the Head of Science for adopting CASE was either for staff development purposes, or because of a general belief in the value of children's thinking (as opposed to doing it just because of exam results, or because someoe else was paying for it), there was a much greater sense of ownership amongst the satff;
- A formal structure for regular discussion of the innovation also had a significant effect on teachers' sense of ownership.

At the time of preparing this paper, we do not yet have post test data from the 4th cohort schools and although all LoU interviews have been conducted, analysis and verification (each interview rated by two raters) has not been completed. It is possible that more analysis will be completed by the time this paper is presented in Chicago. I do however have one new relationship to report from the 1996 study. A strong relationship was found between teachers' THEO score (a measure of their understanding and acceptance of the theoretical bases of CASE) and their sense of ownership of the method. Correlation bewteen THEO and SOO is 0.409 ($N = 60$ $p<.001$). The relationship is illustrated in figure 5.

(figure 5)

A weaker, but still significant, relationship was found between THEO and COM (correlation .314, $p < .01$)

Discussion

There are two main points which I would like to emphasise, within the context of this symposium: "Research into Practice".

The first is that we have shown that it is possible to translate a research based method into large scale take-up by a school system. Although at times it seems that many of the clients (teachers, school Principals, school boards, local government, and other funders) are impervious even to well-documented evidence of positive long term effects on academic standards, the combination of robust curriculum description, sound theoretical foundatiions, demonstrable long term effects, and (let's face it) a good PR machine is finally bringing about a radical re-thinking of teaching methods and departmental management practice in a large and increasing proportion of UK schools. But it has taken nearly fifteen years. I believe it was President Nixon who said "Just when I start to get sick of my own voice saying the same thing over and over, people start to listen".

The second point is methodological. I believe we have established the viability of a method for evaluating staff development programs which combines quantitative and qualitative data collection and analysis in a way which will yield a detailed account of the relationship between key factors in teachers and schools which mediate in the effectiveness of the program. These factors are all, in principle, amenable to intervention, and so we will soon be in a much stronger position to maximise the effect of staff development on pupils' achievement. a case for combined quanti system whereby the translation of a research-based teaching method into large scale use within a school system is being accomplished and at the same time the associated professional development of teachers can be systematically evaluated.

Aknowledgements

I would like to thank Professor Margaret Rutherford of the University of Witwatersrand, Ulrike Burrmann (graduate student of the University of Potsdam), and Sarah McGlinn (undergraduate psychology student of Middlesex University), for many hours of help in interviewing, cross-validating, and (Sarah) data-entry.

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fig 1: Value added effect of CASE training

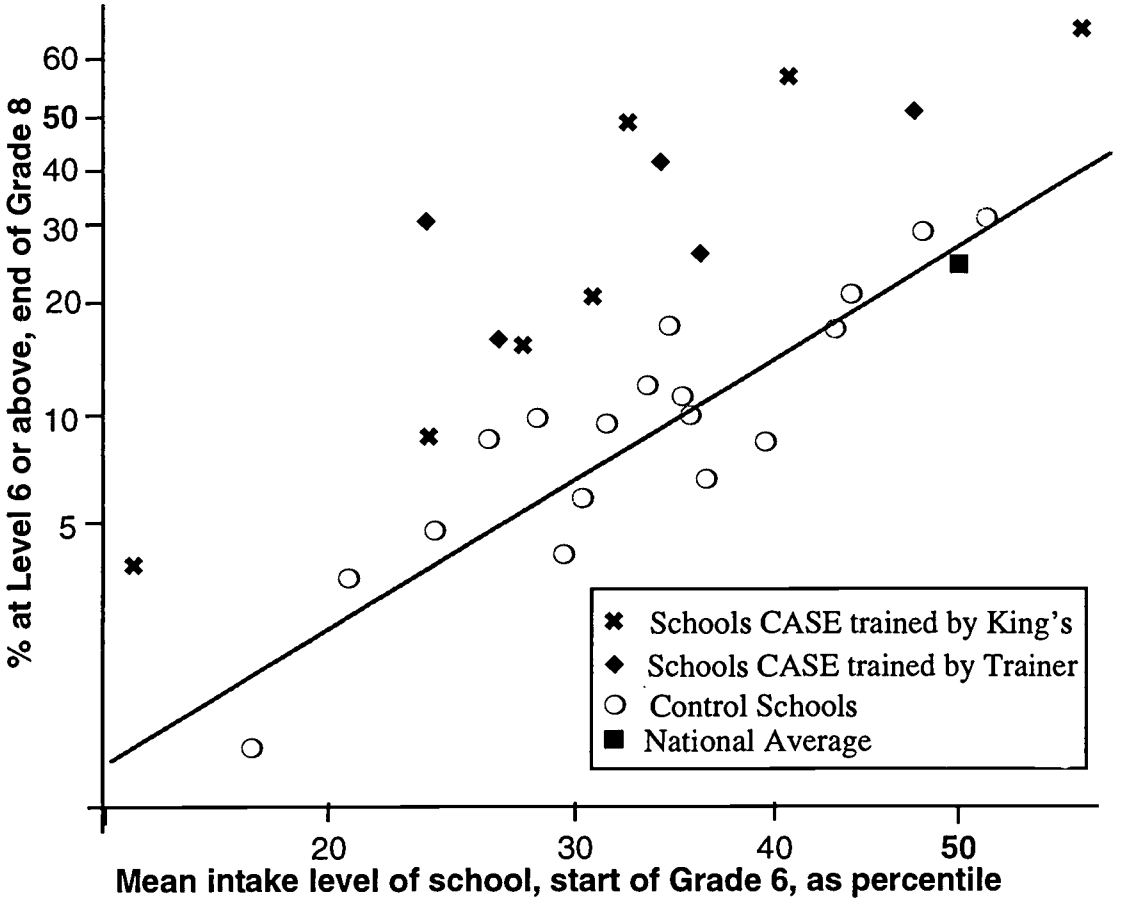


Figure 2: Conceptual Framework of Study

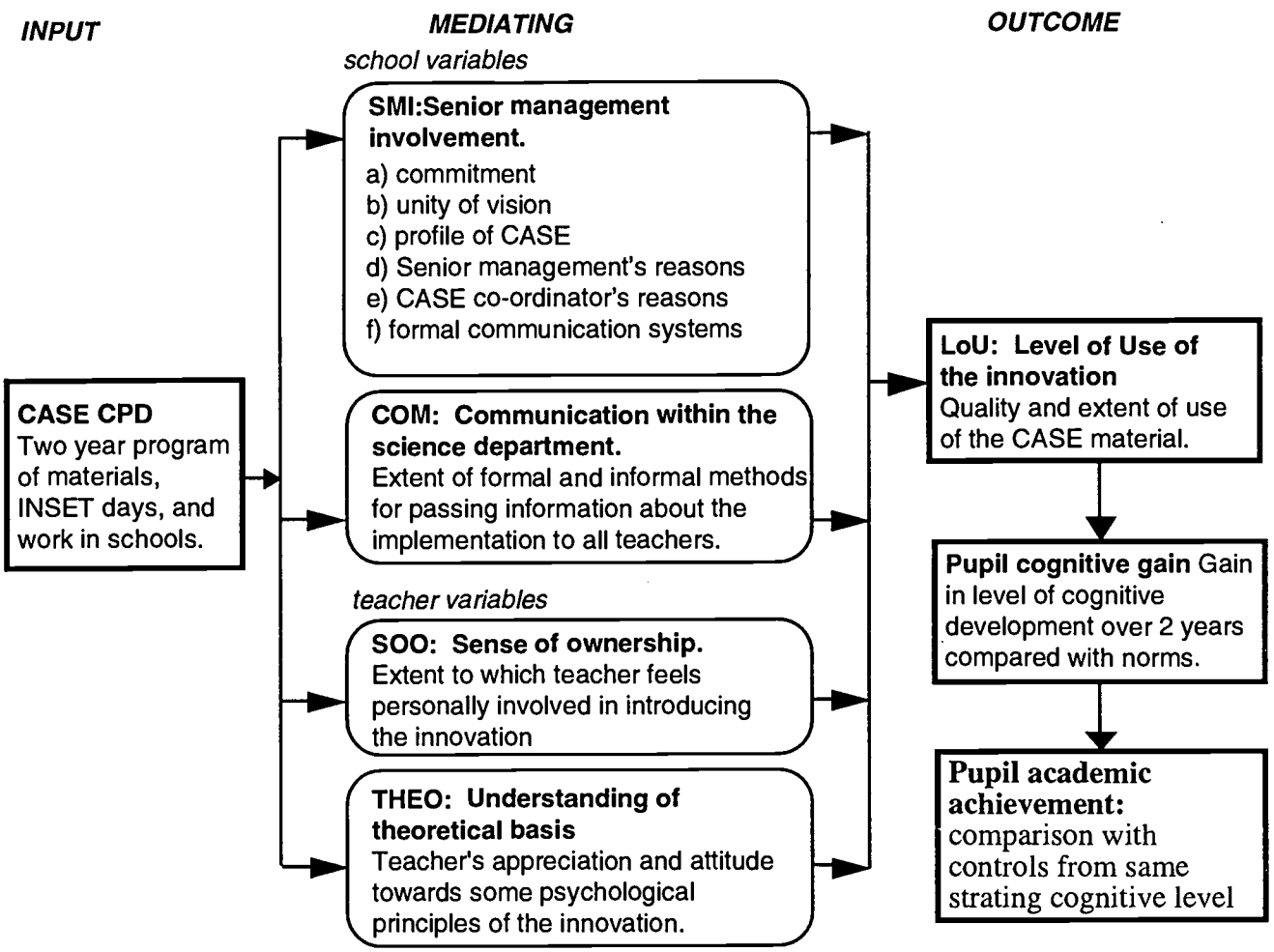


Figure 3: The relationship of Level of Use of CASE and Cognitive Gains (by teacher and mean class effect sizes)

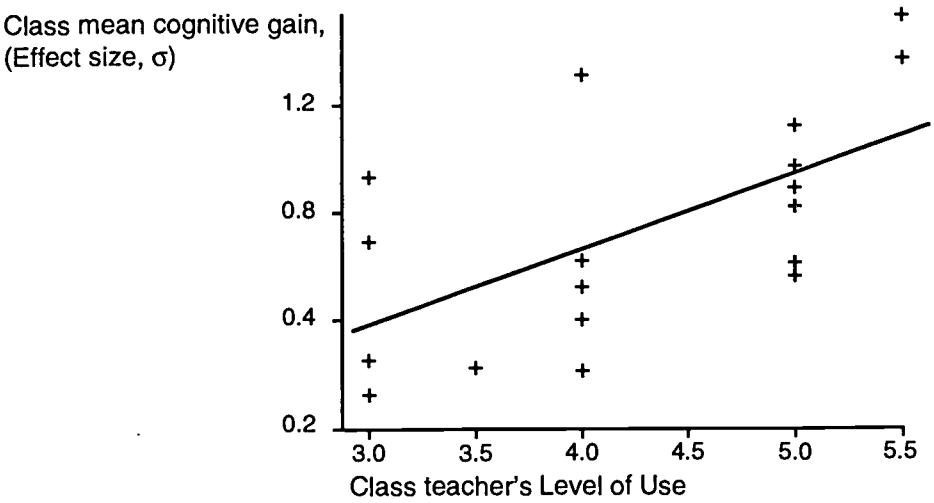


Figure 4: Relationship of Level of Use of CASE to reported level of formal and informal communication about CASE in the department, school means

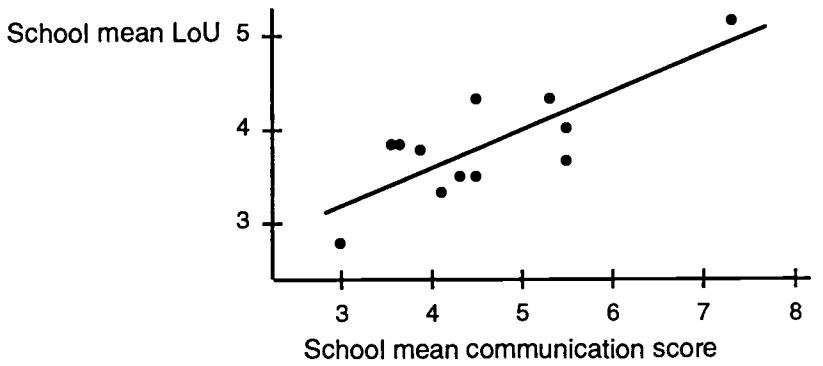
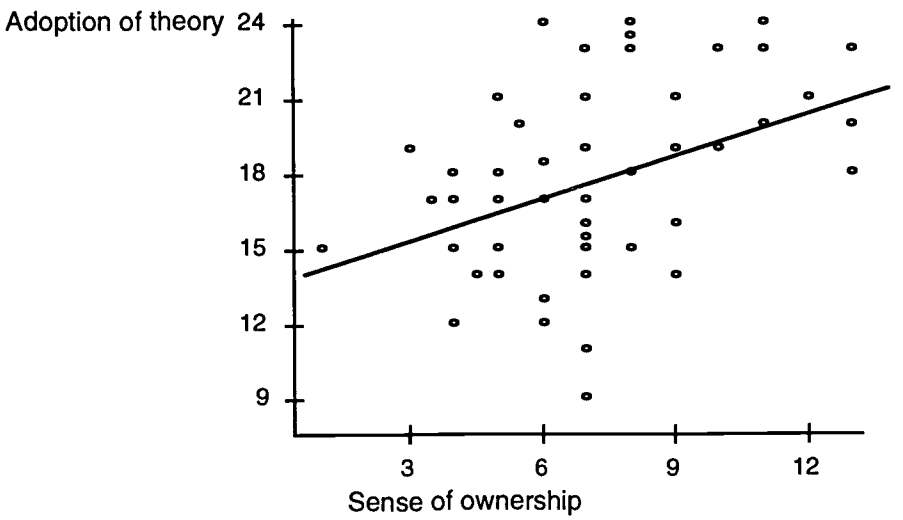


Figure 5: Relationship between teachers' adoption of the theory of CASE teaching and their sense of ownership of the innovation.



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