An interim evaluation of a two year cognitive intervention programme in technology education for Key Stage 4 students

This is a fascinating research article, both procedurally and substantively. It provides:

- a valuable introduction to the concept of "cognitive acceleration"
- an account of the development of a research design to test a hypothesis
- some fascinating data – and associated conclusions.

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Abstract

This paper is an interim report and evaluation of a two-year intervention programme in technology for students aged 15+ designed and implemented by three teachers. It describes the cognitive models that underpin the intervention.

Data has been collected and analysed after one year of the programme. Use has been made of a Piagetian Reasoning Task as a pre/post test and mock GCSE examination results. Actual GCSE examination results will be used to evaluate the full effects of the intervention after the full two-year programme.

The results described in this paper suggest that a story is emerging that such an intervention can improve the information processing capability of the student and that specific or near transfer effects have occurred in technology. There is little or no evidence as yet as to whether general or far transfer effects have occurred.

Introduction

Cognitive Intervention programmes purporting to raise student achievement have become major areas of research in education and educational psychology (see Feuerstein, Rand, Hoffman, Miller 1980; Shayer and Beasley 1987; Blagg 1991; Shayer and Adey 1993; Strang and Shayer 1993), yet there has been relatively little attention devoted to research into the cognitive aspects of technology capability. Nevertheless, researchers have examined the value of a number of models developed to explain technology capability and ways in which technology capability might be enhanced. Notable amongst these has been the Assessment of Performance Unit design and technology project (1985-91).

Technology has only very recently developed as a curriculum activity in the UK and there remains much confusion about what it is, how it should be taught, the benefits it offers to young people and especially the requirements concerning the information processing capability of the student accessing such a domain.

As Kimbell, Stables and Green observe when defining the task associated with technology:

> "These features of the activity are (largely) under the control of teachers, but there are some things that are not. The most significant here are the *individual differences* (their italics) amongst pupils and this raises the problem of differentiated activity" (Kimbell, Stables, Green, 1996 p17)

Kimbell et al further observe "Designing is – in a sense – concrete thinking, and it is no coincidence that in practice designers frequently talk of themselves as 'thinking with a pencil'" (Kimbell et al p30) and they continue "In short, Design and Technology not only enhances the thinking and decision-making powers of young people, it also enhances their conscious awareness of those thought processes." (Kimbell et al p31). Implicit in this observation is the notion of metacognition – 'thinking about one's thinking'.

The APU study became increasingly interested in the development of technology capability and a new project, Understanding Technological Approaches, was established in 1992. The rationale behind this project was to explore models of practice in technology. A number of 'facets of performance' central to the development of children's capability were identified (Kimbell et al 1996 p48) and these are listed as follows:

- investigating
- planning

- modelling and making
- raising and tackling design issues
- evaluating
- extending knowledge and skills
- communicating

Further analysis of these performance criteria reveals that in order for the student to achieve to a high degree in each of these facets of performance the student requires a high degree of information processing capability.

For instance, the notion of *modelling* requires the student to engage in analogical reasoning which in itself depends upon being able to perceive similarities between pairs of relationships. This requires the creation of mental images which have to take into account all the various attributes of the object. These mental images make it possible to connect different objects or parts of the object by comparing their attributes so that differences can be noted and similarities identified. Such processes may become automatic in some adults and children but research suggests they remain beyond the scope of many (Shayer and Adey 1981).

The notion of *investigating* requires students to draw on their own experiences, to access information from a multitude of sources and to test the feasibility of their ideas incorporating notions of a 'fair' test. This in itself requires the manipulation and evaluation of compound variable systems. Thus utilising a Piagetian model, an early concrete operational thinker will register what happens in a practical investigation but for interest to be maintained after the first obvious observations, needs a seriative or simple associative model to help make sense of further observations. A late concrete operational thinker will include seriation and classification as tools of perception in finding out what happens, but needs to be provided with a concrete model by which to structure experimental results. Such a student will find interest in making and checking cause-and-effect predictions.

The early formal operational thinker on the other hand will find further interest in beginning to look for 'why' answers and following out consequences from a formal model which itself needs to be provided. Such a thinker can see the point of making hypotheses and can plan simple controlled experiments but is likely to need help in deducing relationships from results and in organising the information so that irrelevant variables are excluded at each step.

A late formal operational thinker will find interest in generating and checking possible 'why' explanations, takes it as obvious that in a system with several variables, 'all other things must be held the same', whilst varying one thing at a time and can plan such investigations and interpret results.

Consideration of just these two 'facets of performance' highlights the level of information processing capability required by the student if that student is to achieve at the highest level in technology.

Feuerstein et al (1979) have identified a number of information processing deficiencies which they call 'The nature and locus of cognitive impairments', from which to analyse typical learning errors and allow for the implementation of a programme which would direct students' attention selectively to different aspects of the domain under question. That students exhibit such cognitive impairments is supported by earlier research in the UK which suggests that such deficiencies are not localised within a small selection of the UK school population but are experienced by the vast majority of the UK school population (Shayer and Wylam 1978).

Many commentators have assumed that the construct of concrete and formal operations is of value only within the domain of science and mathematics. However Adey and Shayer observe that Inhelder and Piaget had no doubt that they were describing modes of thinking that influenced every aspect of a person's cognitive life even though the problems that they used to investigate adolescents' schemata were based within a mathematico-scientific context (Adey and Shayer 1994 p25).

They also observe that "the validity of such an assumption is questioned by the work of..." and cite a number of authors who have used the Piagetian account of formal operations as a basis for investigating higher level thinking in domains other than science and mathematics. (p135-148)

We entertain a similar viewpoint to Adey and Shayer with regards to technology capability in that we believe the Piagetian account is a useful model as a means of characterising higher order thinking. We view the deficit model proposed by Feuerstein et al as another useful model on which to help us analyse certain specific types of learning errors. Indeed, we take the position that the most important determinant in controlling learning in any domain is the general data-processing capability of the mind. We acknowledge the importance of existing fields of knowledge and sets of procedures of different domains but believe that no amount of training or experience within a domain will lead to expertise unless a person has the fundamental intellectual infrastructure required to master concepts and procedures of any domain of knowledge. This may run countercurrent to the ideas of such notable theorists as Gardner (1983), Light and Butterworth (1992) who suggest that concentration on the semantic and strategic knowledge bases of each of the domains of knowledge is more productive in terms of cognitive development than attempts to teach general thinking skills, but our own experiences as teachers and educationists of long standing suggest otherwise.

Cognitive intervention methodology
Instrumental Enrichment

(Feuerstein et al 1979)
Feuerstein describes successful versus unsuccessful approaches to learning in terms of a number of cognitive functions and deficiencies that are organised according to an input-elaboration-output model of the mental act. The source of these deficiencies is thought to be inadequacies of Mediated Learning Experiences (MLEs). MLEs can be thought of as subtle processes in which adults emphasise, interpret, extend and embellish the environment so that the child builds up an internal model of the world in which disparate aspects of experience are meaningfully related (Blagg 1991).

In the Feuerstein approach, the teacher is replaced by a mediator, whose task is to help the learner learn. The task is not aimed at placing a specified body of knowledge into the learner's head. The mediator's intention is NOT to help the learner to solve the problem posed by the stimulus. It is rather to understand, with the learner, the process whereby the learner learns. The learner is involved in a three-step learning process. In the first step the learner receives the stimulus or instrument which has been especially designed to make it 'possible for the learner and mediator to gain insights into the learning process. In the second stage the learner processes the information. In the third stage the learner decides upon a response, and is assisted by the mediator. This three step process constitutes the Mediated Learning Experience.

The designs of the instruments are one of the distinguishing, features of the methodology. They are not designed to teach a specific knowledge or a special skill; rather they are designed to help both the mediator and the learner discover what is happening during the learning process. They are joined in an attempt to learn 'how the learner learns' and to 'improve the process'. MLEs have their origin in Vygotsky's psychology.

Instrumental Enrichment (IE) is a context-independent intervention. According to Adey and Shayer, IE has been shown to deliver large effects on psychological tests of here-and-now thinking ability, on Piagetian tests, on cognitive functions and on various tests of fluid intelligence (Adey and Shayer 1994). However, the same authors observe "Yet no evidence exists in the literature of an accompanying subsequent increase in school achievement by students who have experienced this or other context-independent interventions and this tends to cast doubt on the psychological models used." (Adey and Shayer 1994 p129)

A very comprehensive evaluation of the IE clement of the Lower Attaining Pupil Programme (LAPP) (1981-1988) was conducted by the then Chief Educational Psychologist of Somerset, Dr Nigel Blagg. The net conclusion of the evaluation was that there were no differences whatsoever between IE and control classes on any of the product or ability measures used (Blagg 1991). The LAPP programme was used with students aged 15+ to 16+ and the evidence from the evaluation suggested that the students undertaking the programme were already disaffected from normal school routines. Further evidence suggests that the IE feature of the LAPP programme suffered from 'management of change' problems associated with all innovation as highlighted by Fullan (1991).

Mervyn Mehl (1985) developed a new style course for his first year physics university medical students based on IE. However, his instruments were firmly established within "the language of the tutorial discussions between student and teacher" (Adey and Shayer 1994 p52). The results of his intervention were dramatic in reducing the 'failure rate' of his students. They needed to pass at the end of the year if they were to continue in medical school. He helped to reduce the failure rate from 50% to 20%, achieving an average effect-size on the physics exam of over 2 standard deviations. Evidence here that a context-dependent intervention was successful in raising achievement.

Adey and Shayer observe that a context-dependent intervention by Strang, replicating Mehl's work, but with a below-average Year 9 class, yielded gains of 1.15 standard deviations in a school achievement test in chemistry, with the experimental group achieving a mean score of 59% against 38% mean score for the controls (Adey and Shayer 1994 p54). They conclude "it can be seen that very large effects on the results of instruction can be obtained by applying some of the principles of an intervention to analysing students' learning difficulties and modifying teaching strategies accordingly" (p54).

Somerset Thinking Skills

(Blagg et al 1988)
This is an intervention programme which lies mid-way between the context-independent and context-dependent approaches. It has been designed for use with a broader ability band of students than the original IE approach on which it is based. Individual instruments can be selected and used within specific domains. The teacher is replaced by a mediator as described above. Although the literature does not yield evidence that such an intervention leads to increased school achievement, evidence emanating from a longitudinal study of one school in Newcastle suggests that the use of this intervention programme has produced an improvement in school achievement. We intend to produce evidence that such a programme has also produced an effect in our study.

Cognitive Acceleration through Science Education (CASE) (Adey et al 1989)

CASE has been comprehensively reported on by its authors (Adey and Shayer 1988; Adey, Shayer and Yates 1989; Shayer and Adey 1993; Adey and Shayer 1994). We do not intend here to repeat the excellent detail provided in those works.

CASE is a context-dependent intervention which purports to raise the general level of thinking and reasoning skills of students. Here there is strong evidence that both near and far transfer effects have occurred with the report that effects were apparent in science, mathematics and English language, establishing a case for the notion that general thinking skill improvement can be achieved through a context-dependent intervention.

The CASE methodology is based on what the authors call the 'five pillars of CASE' (Adey and Shayer 1994). These are:

Concrete preparation – to help the student become familiar with the task; with the technical terms; with the apparatus, in order for the student to access into the task. In other words the mediator (teacher) helps the task to 'come alive', so that the learner is helped to discriminate between what is and is not important – what to note and what to ignore. During this phase of the CASE lesson, the mediator helps the learner to inhibit impulsive responses as well as to increase the learner's focus and attention. This is analogous to the notion of mediation of meaning and mediated regulation and control of behaviour as used in the IE programme. (Lidz 1991)

Cognitive conflict – This is when the learner's existing mental schema is thrown into disequilibrium by new data or observations that do not fit into it. This then creates the conflict situation that is the necessary prerequisite for a subsequent re-formulation of a new, more comprehensive schema. (Desforges 1995)

Construction – This is the process that follows the cognitive conflict phase whereby equilibrium is re-established through the development of a more powerful and effective way of thinking about the problem. The mediator helps the learner reach beyond the current level of functioning without becoming overwhelmed. This can be seen as helping the learner move through the Vygotskian notion of the 'zone of proximal development' (Vygotsky 1978 p84-91) by helping to create the optimal match between the learner's abilities and the situation in which the learner is involved. The learner initially requires help from the mediator, but is helped by the mediator to function independently by becoming aware of and maintaining focus on the goal or objective of the task, and determining effective strategies to reach the goal. The mediator does not give the learner the correct answer but instead conveys the idea that some choices may lead to positive outcomes and that what the learner does can make a difference to the outcome. As Lidz observes "This is the antithesis to a fatalistic attitude to passive acceptance." (Lidz 1991 p15)

Metacognition – Adey and Shayer interpret this as 'thinking about one's thinking', becoming conscious of one's own reasoning. Students are encouraged to reflect on the sort of thinking that they have been engaged in, to bring it to the front of their consciousness, and to make it an explicit tool which may then be available for use in a new context. This is achieved through the use of language and students are encouraged to present their strategies and ideas to the whole class in order for all to make use of them as a tool. This function allows the peer group to act as the mediator. The learner is then exposed to a successful strategy or performance from another learner and can then internalise it whereby it can then become part of the learner's repertoire to be used as a tool to help reach a desired outcome. This process of peer group mediation is of the utmost importance. More often than not, strategies suggested by the teacher may be too far removed from where the learner currently is to be assimilated and internalised effectively, whereas strategies suggested by a peer group member may well be nearer to the partially completed strategies of the learner. As Vygotsky eloquently suggests "Any function in a child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpersonal category, and then within the child as an intrapsychological category." (Vygotsky 1981 p163)

Bridging – The mediator connects current, tangible and perceivable experiences to events in the past or future that require visualisation and mental operations. Thus 'what if' type questions would be useful to move the learner beyond the concreteness of the immediate experience. This is analogous to the notion of mediation of transcendence as featured in IE.

CASE utilises the models of Piaget, Vygotsky and Feuerstein. The Piagetian model is useful for diagnostic purposes and equating the task to the capability of the student in order for the student to obtain access. The Vygotsky and Feuerstein models can be thought of as the classroom driving force.

The main aim of this paper is to report a preliminary investigation into the relationship between the teaching of a two-year cognitive intervention programme through the technology domain and technology achievement as measured through school examinations.

In this study we were interested in the effects of forcing students to process information more effectively through their study of technology. Would such an approach actually improve their information processing capability? Would such an approach allow for near transfer effects into the technology domain? Would such an approach allow for far transfer into other domains?

Method

Subjects and design

As this project was unfunded we had to operate within the constraints of the existing school policy and practice.

The subjects in this study were 120 Year 10 students (15+) attending a girls comprehensive school in an inner London Education Authority. The students were randomly placed in eight all ability classes according to the normal school practice and policy. Three experimental classes (45 students) and five control classes (75 students) were identified. The new head of design and technology had targeted this year group in order to try to raise achievement of a group of students in a domain which had not previously performed as effectively as had been expected.

This teacher would be taking the three experimental groups designated 10.1, 10.2, 10.5. Two other teachers would have the responsibility of teaching the five control classes. Unfortunately we were unable to establish a control group being taught by the teacher of the experimental groups. Furthermore, the two teachers of the control groups were Newly Qualified Teachers (NQTS) and had only recently completed their training as technology teachers.

The adopted model

The model that was adopted for the study utilised principles from CASE (the five pillars), from Instrumental Enrichment and from the Somerset Thinking Skills project. The essential feature of the study was to concentrate on enhancing the students' thinking, reasoning and problem solving capability with the teacher acting as a mediator and director of the activities and of the discussion that occurred.

The development of a shared language between mediator and student and student and student was, we believe, critical to the success of the development of thinking within each lesson. This required much questioning of the 'what, why, how' type, both in whole class discussion and with individuals and small group work. The students were encouraged to make their ideas and strategies used throughout the lesson explicit to co-workers and others in the class. Approximately 20 minutes was left at the end of each lesson to allow for group presentations and questions.

Diagnosis of student deficiencies within technology at the school suggested to us that use could be made of some of the Piagetian reasoning patterns used in the CASE project i.e.

- control and exclusion of variables
- classification
- ratio and proportionality
- logical reasoning

and information processing strategies as designed for the Somerset Thinking Skills project, i.e.

- gathering and organising all relevant information
- recognising and defining problems
- generating alternative approaches to problems
- monitoring and checking progress
- evaluation through reflection and consideration
- communicating by selecting appropriate forms
- transferring by exploring ways in which objects, events and problems can be inter-related.

The activities or instruments used were initially selected from CASE and from the Somerset Thinking Skills project along with activities that we designed. These were mapped into the Technology GCSE curriculum. Delivery of each instrument would occur once every two weeks. One experimental group, designated group 10.2., received twice as many intervention lessons as the remaining experimental groups. The reason for this was that this group had opted to do a graphical communication extension option which allowed for further intervention.

An important component of this study would be teacher mediation. The head of department was untrained in the delivery of such a programme and it was necessary for this teacher to undertake an intensive training programme prior to the beginning of the study and then be supported in the classroom during the study. Evidence suggesting that in-class training and support is the most effective type of training for teachers (Joyce and Showers 1988; Hamaker 1994) provided a model whereby the teacher could be trained and supported, especially in the initial stages of the study. Unfortunately, long term support could not be sustained as initial funding to support the teacher in the classroom was withdrawn when the local Training and Enterprise Council, which had agreed to part fund this aspect of the study, went into receivership. However, the school science department had introduced CASE into their curriculum in 1993 and this allowed for further training and support for the head of department within the school itself.

Tests and measures

All students completed a Piagetian Reasoning Task – the Pendulum (Shayer and Wylam 1978) as a pre-test. This test served as a general measure of the intellectual level of the student. Research (Shayer and Adey 1981) has shown that such tests have substantial predictive power for students' school achievement. This would be readministered at the end of the two year intervention as a post-test and would serve as a measure of enhanced fluid intelligence. GCSE examination results would then be used to monitor overall effects in technology in order to gauge whether near transfer effects had occurred. GCSE results in science, maths and English would also be collected to monitor possible far transfer effects. It was also decided to monitor any effects after just one year of the programme. The Pendulum test would be readministered after one year and raw scores on mock GCSE examinations would be used to monitor any short term transfer effects. A student questionnaire would also be administered at the end of the intervention to evaluate possible student motivation effects. The test instruments are not elaborated here, but information on them can be obtained from the authors.

Results

Table 1 shows the results for the experimental versus the control groups on the Piagetian Reasoning Task reported as a mean residual gain.

A residual gain analysis was performed in order to utilise all of the information that we collected on all of the students. The individual Piagetian scores for each student on the post-test are plotted against the scores on the pre-test for just the control groups. When a linear regression is computed the line is placed so that the sum of the vertical differences – called the residuals – between any point and the line is zero. Tile regression line is a running

Pearson correlation coefficient for pre-test/post-test data = 0.82

Pooled σ for control group on post-test = 1.023

Control mean = 0.00   Experimental mean = 0.66 (sig $p<0.005$ N = 42)

group	pre-test mean	SD	post test mean	SD	mean Residual Gain (SD units)	Sample N	t test	sig (one tailed)	group
10.1	6.43	0.739	7.01	0.761	0.68	12	2.23	<0.025	exp
10.2	6.92	1.284	7.55	0.902	0.83	15	3.26	<0.005	exp
10.3	6.21	1.028	6.29	1.027	0.15	19	0.20	ns	con
10.4	6.96	1.353	6.72	1.001	-0.03	14	0.15	ns	con
10.5	6.12	0.910	6.67	1.045	0.54	15	1.86	<0.05	exp
10.6	6.52	0.770	6.23	0.76	-0.17	13	0.37	ns	con
10.7	5.87	1.465	5.93	1.185	-0.19	14	0.38	ns	con
10.8	6.64	0.879	6.57	1.049	0.19	14	0.65	ns	con

Table 1: Residual gain analysis for control versus experimental scores utilising Piagetian Reasoning Test pre/post data

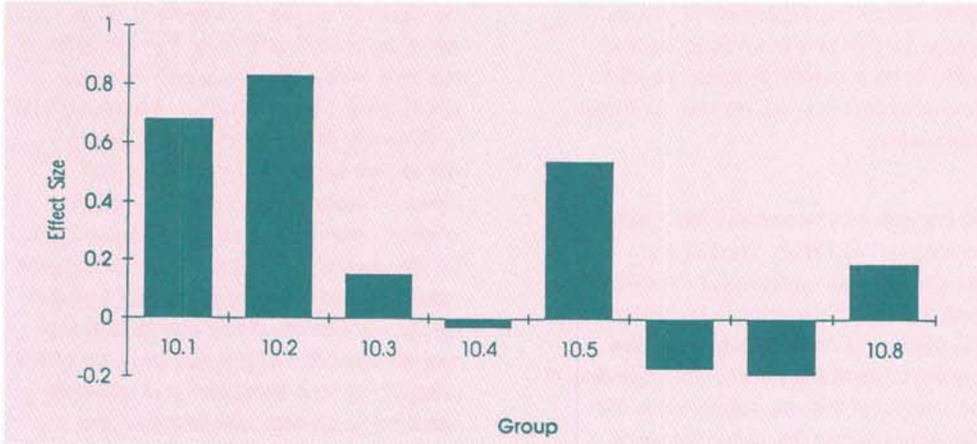

Figure 1: Residual gain for Piagetian scores

average put exactly through the whole data-set, and enables the information to be summarised in two parameters: the slope of the line and a constant on the predicted axis, in the above case the post-test score axis.

The individual Piagetian scores for the experimental groups are then placed on the same figure for comparison with the controls using the same regression line as for the controls. On average, if the experimental classes have had comparable teaching to the control classes the sum of their residuals around the regression line should be zero like the controls'.

The mean residual gains for each class are shown in Figure 1.

Inspection reveals that all three experimental class residuals are positive. The mean of the experimental class residuals is 0.656σ (expressed in standard deviation units of the control class). Thus, we are seeing an effect on this test battery.

Inspection of the individual experimental classes reveals that class 10.2 is showing a larger effect when compared to the other two experimental classes. This class received twice as many intervention lessons as the other two experimental classes.

A similar analysis was performed on the technology mock examination raw scores. The individual raw mock examination scores for technology are plotted against the Piagetian pre-test score. The results are shown in Table 2.

The mean residual gains for technology are shown in Figure 2.

On average the three experimental classes are showing a significant effect (0.34σ) compared to the control classes albeit an effect half as large as was observed on the

Table 2: Residual gain analysis for control versus experimental scores ustilising pre-test Piagetian test scores and mock tecnology test scores

Pearson correlation coefficient for PRT pre-test/mock technology scores = 0.63

Pooled σ for technology scores = 15.98

Control mean residual 0.00

Experimental mean residual 4.91 = 0.34 (σ units) (sig $p<0.05$ N = 41)

group	mean tech	σ	res gain	res gain (sd units)	size N	t test	sig	exp/con
10.1	48.2	10.4	6.78	0.43	11	1.39	<0.1	exp
10.2	49.7	17.4	4.84	0.31	15	1.16	<0.25	exp
10.3	35.1	12.6	-7.19	-0.45	16	1.8	<0.05	con
10.4	50.6	16.9	5.22	0.33	13	1.19	<0.25	con
10.5	45.2	19.3	3.62	0.23	15	0.89	<0.25	exp
10.6	42.1	17.7	1.28	0.08	13	0.28	ns	con
10.7	36.9	10.8	0.76	0.05	13	0.18	ns	con
10.8	45.1	18.4	1.88	0.12	11	0.60	ns	con

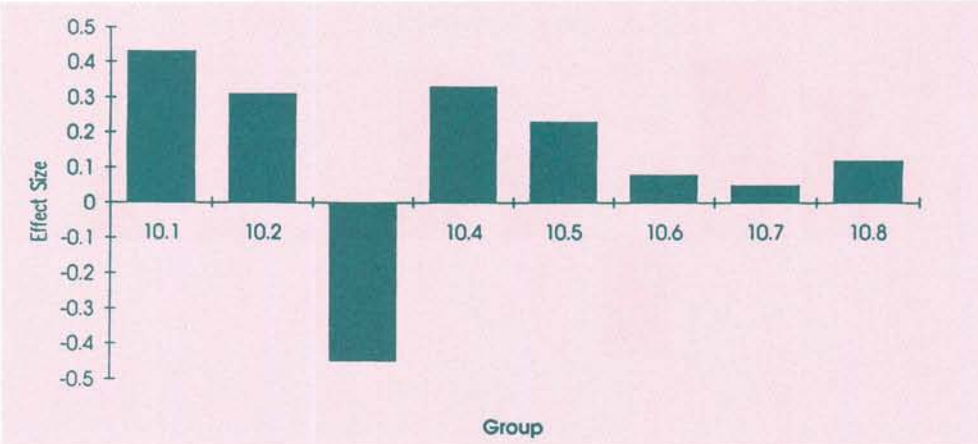

Figure 2: Residual gain for mock technology

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Piagetian post-test scores. Nevertheless the effect is statistically significant.

Inspection of the individual group results suggests that whilst the effect is not substantial, they compare well with effects obtained from the control classes.

It can be seen that control class 10.3 is showing a significant negative effect which is being further investigated.

Control class 10.4 is showing an effect comparable to the experimental classes but this class contained some very high achievers. Inspection of the raw data reveals that the Piagetian pre-test mean for class 10.4 is 6.96 (σ1.35), which when compared to the normative data curves established by Shayer (Shayer and Wylam 1978) reveals that this class is approximately operating at the 76th percentile level and are thus an above average group for their age range. Similarly, class 10.2 contains high achievers with the Piagetian pre-test mean 6.92 (σ1.28) suggesting that this class is operating at the 74th percentile level.

In order to try to compensate for the fact that classes 10.2 and 10.4 contained students with a high information processing capability which could skew the data, a residual gain analysis was performed on the raw data after the removal of those students who had scored 7.5 or above on the Piagetian pre-test from all of the data, both experimental and controls. (A score of 7.5 or above on this test suggests that such a student is well into formal operational thinking).

The results of this analysis are presented in Table 3 with the original technology residual gains as a comparison.

The mean residual gains are shown in Figure 3.

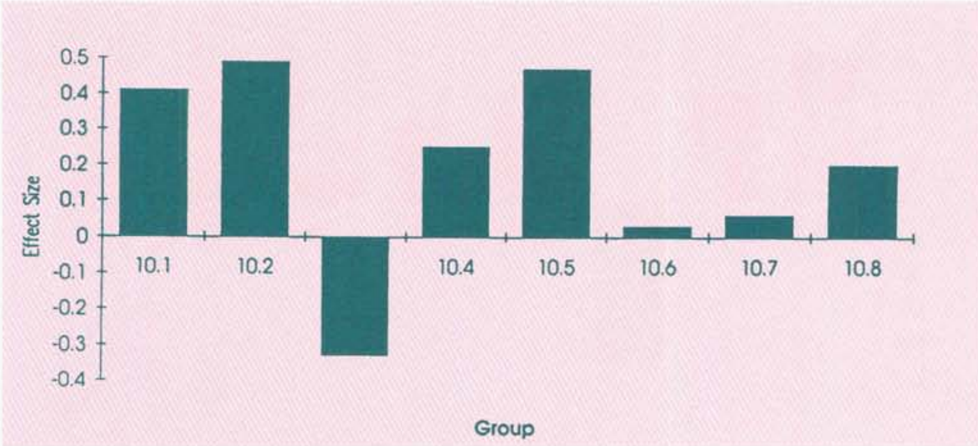
A comparison of the experimental with the control groups suggests that the overall effect for the experimental groups is now much larger than was previously shown and is statistically significant. All three experimental classes are showing residual gains almost twice that of the nearest control Group. Group 10.2 has shown the

group	PRT res	tech res	new mean residual gain (sd) units	size N	t test	sig	exp/con
10.1	0.68	0.43	0.41	10	1.39	<0.25	exp
10.2	0.83	0.31	0.49	11	1.16	<0.10	exp
10.3	0.14	-0.45	-0.33	14	1.8	<0.25	con
10.4	-0.03	0.33	0.25	8	1.19	<0.25	con
10.5	0.54	0.23	0.47	14	0.89	=0.05	exp
10.6	-0.17	0.08	0.03	12	0.28	ns	con
10.7	-0.19	0.05	0.06	11	0.18	ns	con
10.8	0.19	0.18	0.20	8	0.60	ns	con

* Effect sizes for the Piagetian scors and original mock technology scores are included as a comparison

*Table 3: Residual gain analysis for control versus experimental scores utilising Piagetian pre-test scores and mock technology scores after the removal of high achievers**

Figure 3: Residual gain for mock technology after removal of high achievers



largest gain. This group received twice as many intervention lessons as the other two experimental groups, although this gain is comparable with group 10.5.

Analysis of corresponding data for mock examinations in science, mathematics and English language did not yield any effects. Thus we have no evidence of any far transfer effects at this time.

Conclusion

Whilst the intervention programme in technology is designed to operate for two years, we feel that the results after just one year suggest that a story is beginning to emerge which we want to share. We believe that we have some evidence, albeit limited, that we were right to attempt such a study. As Nickerson et al observed:

"If (teaching thinking) cannot be done, and we try to do it, we may waste some time and effort. If it can be done, and we fail to try, the inestimable cost will be generations of students whose ability to think is less than it could have been" (Nickerson et al 1985 p324).

Our preliminary results are not yet conclusive. We asked ourselves three questions at the start of the study. We believe that in a very short time frame there is strong evidence to suggest that two of the questions have been answered in the affirmative, namely that we believe it is possible to improve the information processing capability of the students. The gains on the Piagetian test battery suggest that the experimental groups have raised their level of thinking considerably when compared to the control groups. This could be due to the inexperience of the NQTs as compared to the experienced head of department. We recognise this as a weakness in the original design of the study. However, as reported, we were unable to operate other than the school desired.

Nevertheless, group 10.2 received twice as much intervention and their gains are considerable on the Piagetian test battery, suggesting that the effect is due to the intervention.

The literature suggests that such intervention programmes are better suited to students in the earlier years of schooling. There is little evidence that programmes delivered to 15 and 16 year olds do enhance the thinking and reasoning skills of such students.

Blagg has reported in his study of the IE component of the LAPP programme that there was "No evidence of FIE having any positive effect on pupils' work study skills with respect to map reading, interpreting graphs and tables, or using reference materials. Indeed, there was a slight suggestion of a negative transfer effect with the FIE pupils' performance on the RW1 test (map reading) appearing to deteriorate over time (significant at the 5% level). These results were not predicted as the Richmond Work Study Skills Tests were judged to represent a set of reasonably close transfer tasks" and he continues "Finally, no evidence was amassed to suggest enhanced cognitive development among the

FIE pupils relative to the controls as assessed by changes in their pre- and post-CSMS Test Profiles, which investigated pupil competence on a range of Piagetian reasoning tasks." (Blagg 1991 p 71)

We believe that the instruments that we used can be judged to represent a set of reasonable close transfer tasks in technology and we also utilised the CSMS Piagetian reasoning task – The Pendulum. FIE was a context-independent programme. Our study is a context-dependent programme. Whilst we acknowledge that the Blagg study was a comprehensive evaluation of the FIE component of the LAPP programme utilising a number of different test batteries and that our study is an interim evaluation of a two year programme, utilising far fewer test batteries, nevertheless, we believe that our results suggest that a context-dependent intervention is showing near transfer effects.

What is of great interest to us is the suggestion from these results that in Year 10, it could be possible to raise student achievement and that this can be achieved within a two year GCSE programme. We hope that by September 1996 we will have further evidence to show that such programmes really can raise achievement, especially within the technology domain.

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