Chapter 6

The Search for Educational Effectiveness

As we have seen, educationalists have been searching for improved instructional techniques for decades, and have investigated many different approaches. However, the general result has been that most innovations have resulted in about the same level of performance as that obtained using traditional approaches. This is frequently reported, in statistical terms, as 'no significant difference' or NSD. Some investigations have looked at the effects of specific media, or even specific modes of instruction, while others have looked at broader approaches which may incorporate several different media and/or particular techniques, such as mastery learning.

Here I use the term *mode*, in the sense that Rowntree (1982) defines it, as the kind of stimulus presented to the student. According to this scheme five modes are available, including human interaction, realia (real things), pictorial representations, written symbols and recorded sounds. However, I prefer the use of a general *interactive* mode term, rather than one specifically designated as human interaction. This broader term includes both human interactions and machine interactions, and comes closer to Rowntree's intended meaning.

Rowntree makes a distinction between a **MODE**, the kind of stimulus presented to the student (eg. written symbols, pictures) and a **MEDIUM**, the vehicle carrying the stimulus mode (eg. for written symbols: books, posters or films are media vehicles; and they may be equally the media for the picture mode). Another term used by Rowntree is **SOFTWARE**, which is defined

thus: when a transmitted message uses a MODE that requires a tangible **MEDIUM** of presentation (eg. a film) the result is a piece of SOFTWARE. The software may require a piece of **HARDWARE** to display it:

eg.	written symbols	microfilm	microfilm reader
	MODE	**MEDIUM**	**HARDWARE**

[Content: Ed.Tech. [Software: Ed.Tech. Biliography] microfilm]

The stimulus modes are:

1) **Human Interaction** (verbal and non-verbal)
2) **Realia** (real things, people, events)
3) **Pictorial Representation** (still and moving)
4) **Written Symbols (words**, figures)
5) **Recorded Sound** (speech, music, natural noises)

HUMAN INTERACTION

This is the mode that becomes available for communication, according to Rowntree, whenever two or more people are aware of one another's presence, and begin to respond consciously or unconsciously to one another's messages. The spoken word is the dominant element but sometimes non-verbal elements will be dominant — facial expressions, eye-contact, gestures. Here the message is largely affective and emotional. The intensity of the inter-action will depend on the presentation medium. In a lecture, there may be little inter-action, especially if the audience is large and the lecturer does not encourage participation from the students. There will be more opportunities for inter-action if the medium is the tutorial, with tutor and student responding directly to one another's verbal and non-verbal signals. Other media that include this mode are: discussion groups, seminars, project teams, demonstrations and telephone conversations. All such media combine cognitive and affective, verbal and non-verbal elements. Role-playing and simulation games provide a great deal of human inter-action, with students acting out a model of some real-world situation. The essentials of a real-life situation are built into the structure of the game and the student learns by having to operate with them. Simulation does not always require human inter-action. A computer may be used to simulate patients' responses for medical students or the movement of an aeroplane for

a trainee pilot; it may be used to simulate scientific phenomena which would take weeks to produce in the laboratory. Rowntree comments that education has concentrated on the presence of professionally certified teachers to provide the necessary human inter-action in the classroom and has underestimated the benefits that could be gained from the inclusion of parents, classroom helpers and above all, the students themselves. A fact that was crucial in the development of mass education in the Lancastrian or monitorial system, where the teacher taught the older pupils (monitors) and they in turn taught the younger ones. This emphasis is currently undergoing a revival in the form of Keller Plan or PSI courses. This mode is considered to be a primary mode, students seem to need a human response to their efforts, and Rowntree attributes the high drop-out rate in many correspondence courses to the lack of human inter-action. Other media, such as radio and television can demonstrate human inter-action, but they can only involve the student in a vicarious manner. This may be valuable to the student working on his own in a distance learning situation but it does not provide the same stimulus as direct contact.

REALIA

This is pronounced RAY/ARLIA, according to Rowntree. It concerns real things, events, animals, people. The child learns from real things as early as he learns from human inter-action. Textures and sounds, the smell and taste of food, all build up what Gagné calls signal learning and stimulus-response learning from the moment of birth. As the child grows up he is exposed to a wider range of realia: complex toys, visitors, pets and all that comprises the immediate environment. Research shows that an unstimulating early environment causes physical, measurable deterioration in the anatomy and chemistry of the brain. In school the child meets systematically arranged contact with realia: sand and water, Cuisanaire rods, visits to farms, factories the countryside. And, still later, more sophisticated realia to be found in the laboratory or on field trips. According to Piagetian psychology, direct observation of things and events is the source and sustenance of all understanding; but, as the child gains in experience, so he works less with realia and more with vicarious and symbolic experiences. Unfortunately, teachers frequently forget the need for preliminary experience with realia and may hurry the child on to symbolic experiences before he can, quite literally, know what he is talking about.

PICTORIAL REPRESENTATION

This mode comprises pictures and diagrams, realistic or symbolic, still or moving. Photographs, drawings, graphs, maps all are representations of reality

and sometimes reality is too big for the classroom (the solar system, a factory) or too small (the nucleus of an atom) or too slow (the development of an embryo) or too fast (the movement of clouds before a storm) or too inaccessible (the inner workings of a nuclear reactor) or even extinct! In each case pictures may be used as substitutes for the real thing. Reality can be controlled by using pictures, we can edit out details, focus on the relevant material. And much else is possible: 1) speed up processes, with time lapse photography 2) slow down processes, with slow motion techniques 3) observe dangerous processes in safety 4) emphasise and eliminate by selective editing 5) picture the invisible using diagrams and animation 6) reconstruct past events. Rowntree argues that models are best thought of as three-dimensional pictures and have the same basic characteristics, but this inclusion of models and replicas in the pictorial category leaves out the essential manipulative and kinaesthetic experiences that form such an important part of the usefulness of any model. There is much to be gained from the use of pictures and the associated editing of reality, but how far is the student's experience impoverished by this lack of contact with the three-dimensionality, colour, smell, taste and feel of the real specimen? That really depends on the anticipated outcome of the learning experience and the price of acquiring so much information at second-hand necessarily means that it will be incomplete. A great many media can be used to present the pictorial mode:

1) prints of paintings, graphs, photographs can be produced for individuals to handle
2) prints may be made on a larger scale for display as posters or charts
3) pictures may appear in books, films, slides or as overhead transparencies

WRITTEN SYMBOLS

Written symbols have evolved from the other modes of representing and inter-acting with the world. Writing began to develop 5,000 years ago first as a picture language and later as a truly symbolic system. Rowntree quotes Plato as an example of how some Luddites resisted this technological innovation:

> ...this discovery of yours will create forgetfulness in the learner's souls, because they will not use their memories; they will trust themselves to the external characters and not remember them-

> selves... they will be the hearers of many things and will have learned nothing. *(The Dialogues of Plato)*

Clearly history has been on the side of writing, which is still, in spite of many recent innovations, the most respected of media. Written symbols make for the powerful storage of ideas, which in turn leads to transformations and the generation of new ideas and concepts. We are in many ways totally dependent on the written word and find that it not only makes ideas more memorable but also that it is essential for us to actually understand complex communications, such as lectures, which are only partially understood at the time of delivery. Research on the components of the Audio-Tutorial approach to learning biology revealed that, although the system was designed to give students the opportunity to listen to audiotaped lectures, the students actually preferred to have the transcripts for study, rather than the tape-recordings. This does, however, presuppose the ability to read.

Written symbols can be presented by a variety of media:

1) the most obvious is the ubiquitous book.
2) slides, films, videotape recordings, OHP transparencies make extensive use of a variety of written symbols.
3) there are written materials produced by the teacher and responses written by the student.
4) all in all it is difficult to think of a medium that does not include written symbols as an integral part.

RECORDED SOUND

The final mode in Rowntree's scheme is the recording of evanescent, ever-moving sound. A process which allows it to be edited, speeded up, slowed down for analysis, and repeated endlessly. With the capturing of sound on tape or disc perhaps we are moving away from the print based culture, with its demands for literacy, to an oral culture of the type that Plato insisted led to a greater facility and reliance on memory. It can be used in many teaching situations, in language laboratories, in music rooms and as an integral part of simulation presentations. This mode is represented by several media which are exclusively devoted to sound recordings, such as audiotape recordings and gramophone records. It is also represented by media which use it in conjunction with recorded images, such as television and film. There are talking books and talking pages and

digital synthesizers for voice and music presentation, though these may be a problem for Rowntree's classificatory system.

Rowntree's scheme does allow the teacher engaged in the process of selecting media to concentrate upon the major, common features before making a choice of one or another. However, I feel that he has missed one of the major features that deserves to fall into the mode classification. Well, he hasn't missed it entirely, he has the mode **HUMAN INTERACTION**. It is an interesting category, but the two words **HUMAN** and **INTERACTION** do demonstrate an interesting divide: it appears that this category assumes interaction whenever a human teacher or instructor is present, but then demonstrates that a lecture may not have interaction or feedback and that in many situations the level of interaction is very variable. Now in media analysis we may be interested in looking at the difference between live lectures and filmed or videotaped lectures. If there is no feedback or interaction in the lecture then one predicted outcome would be that there would be no difference between the different media. This is a common result in research studies. So, we have a situation in which teachers may provide as little interaction as the passive film or video. Conversely, the computer can be programmed in such a way as to simulate the extensive interactions of the tutorial system. I would suggest, therefore, that we remove the HUMAN term and concentrate upon the INTERACTIVE aspect. The **INTERACTIVE MODE** would include such media as: tutorials, games, computer simulations, simple teaching machines, discussion groups and computer enquiry systems, but would probably exclude lectures or, at least, a majority of lectures.

In addition to modes and media there is the broader category which may be termed methods or approaches. Here a variety of different media may be incorporated, together with a particular emphasis on the style of teaching. For example, the Audio-tutorial approach to biological instruction places great emphasis on individualised instruction in a multi-media environment including audiotape, slides, movies or video, a variety of printed materials and experimental apparatus, together with opportunities for human interaction. Most of these media are also used in traditional approaches to biology teaching. The distinguishing features are individualised learning and formative evaluation.

COMPARATIVE STUDIES

There are few comparisons dealing specifically with instructional modes because most media and methods tend to include several different modes. However, one area, pictorial representation, has received considerable atten-

tion in the form of comparisons between illustrated and non-illustrated teaching materials.

Much of the available research has dealt with comparisons between a particular medium (or method/approach) and the traditional way of teaching the subject. For many media comparisons this consists of the new medium being used to deliver most of the course content, for example, through the medium of television or video. This is then compared with the usual way of teaching the material, which may be chalk and talk or may include alternative media eg. teacher plus overhead projector.

Similarly, new methods are compared with those used prior to the new development. This could include comparisons of essentially the same instructional media used in conjunction with different teaching styles or methods of organisation, as is the case when the Audio-tutorial approach is compared with a traditional biological sciences course.

BOX SCORES OR EFFECT SIZES?

Early research studies tended to report comparative statistics which gave no indication of the size of differences, if any, between the types of instruction. Conclusions tended to be based on the presence or absence of a statistically significant result. When groups of researches were reviewed there was a tendency to use a 'box score' tally approach, frequently resulting in a small number of studies favouring the innovation, a similar number favouring the traditional approach, and the vast majority showing NSD.

Criticisms of this approach to summarising research have been accommodated by the new meta-analytic methods of formulating generalisations (Glass et al., 1981). Meta-analysis is simply the statistical analysis of a large collection of results from individual studies for the purpose of integrating findings. It seeks to determine the effect of a specific treatment, influence or intervention from a large variety of individual studies on a particular subject. Of course, the quality of the individual studies is of crucial importance and selection criteria must be stringent. The meta-analytic procedures yield effect size estimates which are converted to 'percentage of standard deviation gains' due to the more powerful treatment, if any.

The effect size (ES) is a measure of the educational importance of any performance changes produced. It is generally estimated as the average test score difference between treatment and control groups divided by the standard deviation of the control group. In education we are not simply interested in differences in a statistical sense, we wish to know when such differences are educationally significant. An ES of 1.0 means that the innovation increases the

performance of the group by an amount equal to one standard deviation unit of the control treatment. This would take the average student from a position in the middle of the traditional group to the position occupied by the top 20% of that group. This is a large effect and is educationally significant. An ES of 0.2 is a small or trivial effect, whereas an ES of 0.5 shows a moderate effect, produced by a treatment which certainly merits further investigation.

MODES, MEDIA AND METHODS.

Whatever the method of reporting the results, general media comparisons and studies pertaining to their overall instructional impact have yielded little that warrants optimism and Clark provides a typical commentary on this state of affairs:

> The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition. Basically, the choice of vehicle might influence the cost or extent of distributing instruction, but only the content of the vehicle can influence achievement. *(Clark, 1983)*

Comparisons of new methods give more room for optimism. Some, but not all, demonstrate consistently superior, educationally significant levels of performance when compared with traditional methods. Similarly, the main line of what may be termed *pictorial mode* research looks encouraging. These results can, I believe, offer guide-lines for the development of successful teaching strategies, but they may be in conflict with *a priori* perceptions of the essential ingredients for effective instruction.

PICTORIAL MODE.

Illustrations may be said to form a very significant part of the pictorial representation mode. They are the very essence of visual-based instructional media and methods. The pictorial mode of instruction applies to many different media and it is often assumed that it must aid recall, comprehension and understanding. However, the early researches did not support this assumption (Miller, 1938; Vernon, 1953), leading Samuels (1970) to conclude that pictures do not facilitate comprehension as much as had been supposed.

Later research, reviewed by Levie and Lentz (1982), disagreed with Samuels. When an *information-analysis* approach was adopted, Levie and

Lentz found an ES of 0.55 in favour of illustrations. In this case, the research concentrated on the learning of illustrated text information from illustrated text versus text alone. Their further analysis of Dwyer's (1978) research studies demonstrated that illustrations provide moderate benefits (ES=0.58) when a drawing test is used, but are less beneficial for more verbal tests (terminology ES=0.28; comprehension ES=0.09).

Levin et al. (1987) reviewed the research on illustrations (including texts which were presented orally to children) according to their functions:

> **Decoration:** This is the function associated with text-irrelevant pictures. In particular, when illustrations are selected to make a textbook look more attractive (rather than to support or supplement critical text information), then a decoration function is being served.
> **Representation:** These pictures serve to reinforce major narrative events. Illustrations that tell exactly the same story as the words are prototype representational pictures, and pictures that overlap substantially with the text also fit the definition.
> **Organization:** Organizational pictures provide an organizational framework for a text, giving it greater coherence. For example, illustrated maps frequently are used to make geographical relationships more transparent. How-to-do-it diagrams serve a similar function with respect to what are called procedural texts, such as how to assemble something. Passages that basically list distinctive features of several characters or objects also lend themselves to a more coherent organization via pictorial representation — bringing to mind the overused "one picture is worth a thousand words" aphorism.
> **Interpretational:** Interpretational pictures clarify difficult-to-understand passages and abstract concepts within passages. These illustrations are similar to organizational pictures, but deal with more complex and difficult concepts eg. technical terms and their associated characteristics. Such pictures are supposed to add comprehensibility to text which they accompany.
> **Transformational:** These represent a contrast to the previous types of illustration. They are unconventional in that they are conspicuously absent from traditional texts. They are designed to have a direct effect on memory by targeting the critical

> information to be learned. They do this by (a) recoding it into a more concrete and memorable form, (b) relating in a well-organized context the separate pieces of information, and (c) providing the student with a systematic means of retrieving the critical information. These have been dubbed the "three Rs" of associative mnemonic techniques. Prose passages which have large amounts of factual information that would be difficult to remember lend themselves to transformational techniques.

He found that the effects for decorational illustrations were near zero, but that representational, organisational and interpretational illustrations produced substantially the same ES of 0.75, with transformational illustrations having a very large effect (ES=1.5). Transformational illustrations have a direct effect on memory by targeting the critical information to be learned, the representation frequently embodying disparate elements in a coherent (though possibly bizarre) whole. Educational media make extensive use of representational, organizational and interpretational illustrations. However, the general application of transformational illustrations is probably rather limited.

These experimental results clearly demonstrate the value of the pictorial representation mode and, as illustrations are an essential part of all visual-based media, the research is a vindication of visual-based instructional theory.

VISUAL-BASED INSTRUCTIONAL MEDIA.

Visual-based instruction is a term which can be applied to a variety of different media (filmstrips, films, television etc.). Such educational media can be seen to make learning more concrete and relevant by bring the real world into the classroom through the use of a variety of still and moving pictorial displays. They are seen as the antithesis of traditional verbal methods.

FILMS AND FILMSTRIPS

As we have seen, in studies in different age groups and for different subjects, films and filmstrips generally have showed no significant differences when compared with traditional chalk and talk, or talk plus relevant illustrations.

> Most studies do not reveal reliable differences between instruction by films as compared to conventional methods, over a wide range of subject matter, age ranges, abilities, and conditions of use. *(Campeau, 1966)*

Looking closer, studies also showed that expensive full-colour movie presentations were, in fact, no more effective than crude black and white still pictures (Twyford, 1954; May and Lumsdaine, 1956).

TELEVISION

Television was introduced in the early 1950s and it was hoped that, by putting the best teachers on the screen and using television as a window on the world, tv would prove to be more effective than traditional methods. By the mid-1960s there was sufficient evidence to show that, again, there was no real benefit, in terms of effectiveness, from the new medium in a majority of more than 200 research studies. Chu and Schramm (1968) found that in 73% of studies there was no significant difference between traditional and television methods.

Cohen et al. (1981) have reviewed the visual-based instruction research, which included still projection, film, multi-media, closed-circuit television, educational television and video, using meta-analysis techniques. The outcome is predictable from previous results with an average ES of 0.15. A moderate ES of 0.41 was observed for the use of video as a source of feedback for teacher training or skill acquisition.

PROGRAMMED LEARNING METHODS

At about the same time that TV was entering the educational arena a new method also appeared. Programmed learning was rooted in behaviouristic psychology and soon became the most evaluated method in the history of education. A wide variety of media was employed to implement this method, ranging from simple linear teaching machines to group programmed learning via television. Programmed texts were also popular and the method has also been applied to the computer medium. Unfortunately, it didn't live up to early expectations and by 1964 the cumulative evidence showed that it could be used for many age groups covering almost any aspect of education and that students did indeed learn as much as traditional methods, but not much more, although there could be savings in learning time (Schramm, 1964).

The latest evidence suggests that small but positive ESs will generally be found. For higher education this is in the region of 0.24 (Kulik, Cohen, and Ebeling, 1980); but for secondary schools it is only 0.08 (Kulik, Schwalb, and Kulik, 1982). Some subjects benefit more than others: surprisingly, social sciences show a moderate ES of 0.6 whereas maths produce a small negative ES (Hartley, 1977).

COMPUTER AIDED INSTRUCTIONAL METHODS

The computer is the main medium in such methods, potentially delivering all modes of instruction, except realia. The medium can be used in a variety of different ways, ranging from basic drill and practice routines to more sophisticated interactive modes such as tutoring and simulations.

Computer aided instruction, the great hope of the 1960s, failed to deliver consistent educational benefits, probably because it was only seen as a convenient medium for the implementation of programmed learning techniques. Mid-1970s reviews concluded that only small differences were to be expected from CAI.

> At secondary school and college levels CAI is about as effective as traditional instruction. *(Jamison et al., 1974)*

The picture remains the same for more recent reviews, with small ESs for most of the educational uses of computers. In higher education these included tutoring, simulation, managing and use of computers for programming, with substantially the same small ES of 0.25 (Kulik, Kulik, and Cohen, 1980). For secondary schools an average ES of 0.32 was obtained (Kulik, Bangert, and Williams, 1983), although interactive simulations gave a promising ES of 0.49 and tutoring an ES of 0.36. These figures have been confirmed in the latest meta-analysis from Michigan (Kulik and Kulik, 1988)

THE AUDIO-TUTORIAL METHOD.

Postlethwait's system evolved from the use of audiotaped lectures for remedial instruction. In its developed form students work independently, listening to the audiotape and following instructions which may include carrying out experiments, reading articles or watching multi-media displays. There is regular formative evaluation of student performance and although this may include a diagnostic element, there is not a mastery requirement. It has proved to be a very popular method of instruction in a wide range of subjects. The first major review of research was favourable, showing more than 60% of studies favouring AT when compared with more traditional teaching (Fisher and MacWhinney, 1976). These results are indicative of the false impression that some comparative statistical approaches convey. Later reviews pointed out the small performance difference anticipated from AT implementation (Kulik and Jaksa, 1977) and when meta-analytic procedures were applied to the research data this was confirmed, with a small ES of 0.25 (Kulik, Kulik and Cohen, 1979).

METHODS OF GROUP ORGANISATION.

Accumulated evidence also shows that various methods of grouping and teaching, ranging from tutorials to lectures and two-way telephone discussions, fail to produce significant instructional benefits. Dubin and Taveggia (1968) summarised a total of 91 studies from 1924 to 1965 which compared such approaches to learning with more traditional methods. The results led them to title two of their chapters *The Sound and Fury, Signify Nothing* and *There Are No Differences*! Later meta-analyses have shown a moderate ES of 0.4 for the effects of individual tutoring (Cohen, Kulik and Kulik, 1982) but have shown only a small average ES of 0.1 for the effects of ability groups (Kulik and Kulik, 1982).

Effects were near zero in the four programs designed especially for academically deficient students: such students learned as much in mixed-ability classrooms as they did in homogeneous classrooms. Finally, effects were also near zero in the 33 studies that compared effects of multi-track versus mixed-ability classrooms on unrestricted populations. (Kulik and Kulik, 1982)

The same trivial average ES was found for studies comparing individualised systems of instruction (Bangert, Kulik and Kulik, 1983) and for class-size effects (Walberg, 1984).

MASTERY LEARNING METHODS

THE PERSONALISED SYSTEM OF INSTRUCTION

The Personalised System of Instruction (PSI) was pioneered by Fred Keller, a psychologist who was impressed by Skinner's work with his teaching machines and programmed texts and realised that positive consequences (good grades, feelings of achievement etc.) are more effective facilitators of learning than negative consequences (boredom, failure etc.). Keller Plan specifies objectives and provides reinforcement for their successful achievement, as well as giving more opportunities for personal interaction than traditional systems. This is achieved by the provision of proctors (student tutors) who monitor student progress and ensure mastery of each teaching unit.

LEARNING FOR MASTERY

Bloom's Learning For Mastery (LFM) is derived from Carroll's model of school learning (1963) which relates mastery to two major variables in learning:

1. Time needed in learning, which depends on student aptitude, the quality of instruction and the student's ability to understand instruction.

2. Time spent in learning, which depends on the time allowed for learning and the student's perseverance in learning.

Although not all the variables in Carroll's scheme can be readily altered, Bloom maintains that some can, particularly the quality of instruction and the time allowed for learning. Diagnostic, formative evaluation is a crucial element in this method. Students who fail to master study units are provided with additional tuition which may consist of a variety of different instructional media. Bloom emphasises that this method can be applied within the usual weekly time-scale of schools and does not require large-scale change.

MASTERY RESEARCH

From the earliest research reviews there has been a tendency for PSI to outperform traditional methods. An early review demonstrated that 38 of the 39 studies conducted showed a better final exam performance for PSI. In 34 cases the difference was statistically significant, giving an average ES of 0.66 (Kulik, Kulik and Smith, 1976). A later meta-analysis looked at 61 studies and found an average ES of 0.5, with 35% less variation in the performance of the PSI group (Kulik, Kulik and Cohen, 1979). A crucial feature is the high mastery criterion. Relaxation of this criterion leads to a decline in final test performance. With mastery at 70-80% the ES is 0.4, but with mastery set at 100% the ES is 0.82 (Kulik, Kulik and Bangert-Drowns, 1986). Block and Burns (1977) found a high average ES of 0.8 for LFM studies and a combined PSI and LFM retention analysis revealed an average ES of 0.7.

These methods are certainly producing significant educational effects and this has led Walberg (1984) to comment that:

> .... the psychological components of mastery learning rank first and fourth in their effects on educational outcomes: Skinnerian reinforcement or reward for correct performance has the largest overall average effect - 1.17 standard deviations; instructional cues, engagement, and corrective feedback have effects equal to approximately one standard deviation. Separate syntheses of mastery programs in science show an average effect of .8.

The emphasis on feedback and correctives, so essential to the mastery programmes, may also account for the discrepancy between assigned and graded homework. Walberg (1984) indicates that homework that is com-

mented upon and graded has nearly three times the effect of homework that is merely assigned, giving an ES of 0.79.

CONCLUSIONS CONCERNING FUTURE DEVELOPMENTS

I have summarized the ESs associated with the different researches in Figure 6.1. In order to make the data more intelligible I have divided the studies into groups, according to the size of ES.

Figure 6.1: Modes, Media and Methods: Summary of Effect Sizes

	Effect Size	
Small Effect Sizes (Range 0.1-0.3)		
Programmed learning (Secondary)	0.08	*
Individualized instruction	0.1	*
Ability groups	0.1	*
Visual-based instruction	0.15	**
Programmed learning (Higher)	0.24	**
Audio-Tutorial	0.25	***
Computer Assisted Instruction (Higher)	0.25	***
Assigned homework	0.28	***
Computer Assisted Instruction (Secondary)	0.32	***
Moderate Effect Sizes (Range 0.4-0.6)		
Tutoring	0.4	****
Video feedback	0.41	****
Computer Simulations	0.49	*****
PSI	0.58 †	******
Large Effect Sizes (Range 0.7 and above)		
LFM and PSI (retention test)	0.7	*******
Illustrations	0.75	********
Graded homework	0.79	********
LFM	0.8	********

† average

* represents the size of effect in tenths of a standard deviation

Using these figures it is necessary to consider and resolve some of the conflicting sets of data before attempting to formulate a general position for future developments in instructional techniques.

MODES AND MEDIA

Visual illustrations are of central importance when considering the effects of visual-based teaching media. Why then are significant educational effects observed for the pictorial mode studies but not for visual-based media? The answer is that pictorial mode effects are more powerful than media effects because the mode studies compare two fundamentally different ways of presenting information: uni-modal and bi-modal. For example, Dwyer compares a verbal only presentation (uni-modal) of the structure and functioning of the heart with a combined verbal and pictorial presentation (bi-modal). When the illustrations are removed student performance will, not surprisingly, be adversely affected, particularly when tests incorporate a visual dimension.

Cognitive psychology is beginning to supply an explanation for this. There is now strong evidence that information is stored in two separate but interconnected systems within the human organism: a verbal system and an image system. Media which involve bi-modal presentations, addressing both storage systems, will be more effective than uni-modal media, particularly when the tests are also bi-modal.

There is evidence that the human information system compresses incoming information, reducing redundancy. Illustrations which are compressed forms of reality and therefore less demanding of the processing system, appear to be stored and retrieved more efficiently. Hence, simple line illustrations are found to be as effective as more complex, realistic representations.

Media research has frequently made the mistake of comparing like with like in terms of modes. Thus, a lecture illustrated with blackboard illustrations is compared with a televised lecture with more elaborate illustrations. The outcome is the same in both cases because, although the pictorial mode is a necessary condition for the activation of the iconic memory storage system, transparencies, television graphics, printed illustrations or blackboard drawings are all sufficient for this activation to take place.

Of course, not all concepts are readily illustrated with pictorial representations, in such cases a word is worth a thousand pictures, and accompanying illustrations may even have a negative effect!

MODES AND METHODS

The results for the different methods also present an interpretive challenge. A mode analysis may also be appropriate here. I would argue that the interactive mode, which includes machine simulations of human interactions, provides the key to the success of those methods which are more effective. The essence of this mode is that it provides opportunities for feedback. The nature of that feedback is crucial. It can vary from the simplest indication, without explanation, that an answer is incorrect, to the full diagnostic interactions with a proctor that are found in PSI. The primary purpose of the diagnosis in mastery learning methods is to ensure complete understanding of the taught material. The most effective methods of instruction seem to include these diagnostic interactions combined with mastery conditions .

On this basis, programmed learning methods which simply report success or failure, providing minimal interactive features, no diagnosis and no mastery conditions, are not very effective. Similarly, computer based methods which show all the hallmarks of early programmed learning methods, are likely to be no more effective. It is interesting to note that the computer is most successful when interactively simulating real world events or tutoring.

Although nominally a tutorial approach, Postlethwait's AT method uses a non-interactive medium (audiotape) to provide the tutoring. This proves to be inadequate in terms of improving student performance because the level of learning is not checked at this stage. Weekly testing and grading sessions do not appear to be effective in raising student performance, probably because the emphasis is misplaced, with grading of students taking precedence over mastery of course units. LFM and PSI combine diagnostic interactions with high mastery criteria and consequently show impressive, educationally significant benefits. However, the large effect produced by graded homework can only be partially explained on the basis of diagnostic interactions.

RAISING STANDARDS OF PERFORMANCE

These results indicate that the technology for substantially enhancing learning is available and can be delivered using a variety of different techniques. Keller Plan uses traditional media vehicles, human tutors and print materials, to implement an interactive mastery approach; it represents a simple and effective method for raising student performance. Bloom's Learning for Mastery offers a similar approach, within a classroom context. Effective computer programmes, which simulate human activities and are efficient at handling mastery requirements, are also available. What seems to be crucial is the application of the technology of education rather than the provision of

technology in education. Unfortunately, the latter frequently is given priority when non-educational agencies are involved, the ill-informed decision-makers being seduced by the superficial appeal of new hardware approaches.

Finally, recent curriculum development proposals in this country, ostensibly aimed at raising standards of performance, seem to place considerable emphasis on increased testing. However, they fail to acknowledge that testing, which is not diagnostic and related to remedial strategies aimed at ensuring high levels of mastery performance, will merely continue to produce the same cumulative deficits and failure, the same low standard of performance, as before. If we wish to raise standards, this is not the way.

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