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Media, Mental Skills and Learning Tasks: The Interplay of Research and Instructional Design

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Research in the area of educational media has gone through a number of identifiable stages which have been documented by several scholars (e.g. Levie and Dickie, 1973; Torkelson, 1977). Since it is a major purpose of research in our area to develop theory that can direct decisions made by instructional designers, the principles and practice of instructional design have followed a parallel evolution. At present, another major step in this evolution is being taken by researchers. This stems from the realization that human abilities are far more malleable than has hitherto been believed, and that many of the mental skills that were thought to remain immutable over a person's lifespan can be developed and even trained. It follows from this that certain of the problems traditionally attributed to "individual differences" can be overcome. If the past is anything to go by, this development, and others associated with it, will have profound implications for the practice of instructional design.

The purpose of this article is threefold. First, it will briefly trace the evolution of the thinking in our area about what factors influence learning. This is, in effect, the evolution of instructional design principles, because the key to instructional design is an understanding of how these factors can be controlled in a way that is beneficial to learners. Second, the question of human abilities, which lies at the heart of the matter, will be addressed. This will involve a review of research on aptitudes and an examination of some recent cognitive theory to do with training in mental skills. Finally, it will be suggested that knowledge of the learning task in interaction with a number of other factors is a powerful determinant of learning. The general thesis of the article is that cognitive psychology is beginning to reveal the great complexity of learning, and that to be effective, instructional designers must take cognizance of a wide variety of factors known to influence learning that have mostly been ignored up until now. The article focusses specifically on the design of instruction that is in some way mediated, though the discussion will of necessity sometimes have to range more widely.

Instructional Design in Retrospect

It used to be thought that the only factor that influenced learning which was worth consideration by instructional designers was the form in which information was delivered to learners. In our area, this pretty much meant the media that were selected or created to deliver the message. This rather limited view arose from the equally confined outlook of researchers. The onset of the media age in the early fifties was stamped with an optimism based on the belief that the "new media" were superior to "traditional" forms of instruction. Researchers were charged with the responsibility of confirming this supposition. The research paradigm that this charge gave rise to is usually referred to as "media comparison", where media of all types were compared to classroom instruction, and to each other. Usually, no differences were found, and for every study that showed one medium to be better than lecture or another medium, another study would show the opposite. This much has often been acknowledged, and with hindsight is little cause for surprise. Writers often neglect to mention, though, what this implied for instructional design. The only factor that designers had any control over — the medium itself — was shown not to affect learning at all. The reaction of many designers was to go on mediating instruction anyway, producing nice-looking but ineffective materials. The legacy of this practice is still with us today.

The persistent finding of "no difference" between mediated and traditional instruction soon led to the realization that what influenced learning was not the medium per se, but specific characteristics of each medium that were particularly appropriate to various types of learning (Allen, 1967). This led to an analysis of media characteristics, and experimentation in which these characteristics were varied. For instance, researchers no longer compared film, say, to slides. Rather, they compared realistic pictures to line drawings, motion to still visuals, and color to black-and-white pictures, where realism, motion and color are characteristics of visual media generally. It was at this level that some information useful to instructional designers began to emerge. Many of the principles of design presented by Fleming and Levie (1978), and the conclusions stated by Dwyer (1972, 1978) reflect the "media characteristics" approach to research and design. The conclusions that color can be used effectively to highlight important information, and that line drawings are more effective than realistic pictures in teaching certain types of identification are typical examples. They are also medium independent, since color and line drawings can be used in film, television, slides, posters, textbook illustrations, and so on.

Yet still expected results sometimes did not occur. Another factor was brought into consideration to account for this. This was the suspicion that the different media characteristics that were varied by designers might impinge on different learners in different ways (Snow and Salomon, 1968). The research paradigm shifted once again, and now took account of the learners' abilities to learn from different types of mediated materials. This approach is generally known as "Aptitude treatment interaction" (ATI), and is dealt with in detail by Cronbach and Snow (1977). The general thesis of the ATI approach is that, while line drawings, for instance, might prove to be more effective than realistic pictures for low ability learners, the reverse might be true for more able ones. This "interaction" between learner ability and treatment factors led instructional designers to design different forms of materials (and instruction in general) for learners of different ability. This often proved difficult to do, and was not always cost-effective. A further difficulty arose from the fact that the number of learner-aptitude media-characteristic and subject-matter permutations is enormous. So while some generalizations from the research are possible, most of them are little more than statements of the obvious (see Allen, 1975).

Recently, certain other limitations of the ATI paradigm have become apparent. This is leading to a reconceptualization of media research and instructional design.

Beyond Aptitude Treatment Interaction

It is best to illustrate the fundamental problem with ATI research by means of an example. In a study of the effect of diagrammatic organization of content on learners' ability to structure a conceptual domain to do with biological food chains (Winn, 1980), it was expected that verbal ability would interact with diagrammatic and textual treatments in such a way that the diagrams would help low-verbals. The rationale for this assumption was consistent with Salomon's "supplantation" hypothesis (Salomon, 1979), which states that instruction that supplants mental skills in which learners are weak will help them learn. In other words adding structural diagrams to text would help low-verbals, because the content is expressed in a form with which they will have less difficulty. The results showed the opposite to be true. It was found that high-verbals who had seen the diagram did better than high-verbals who had seen the text, while there was no difference for low-verbals. The ATI was the reverse of what was expected. This phenomenon has subsequently been found in two other studies (Winn, 1981a; Winn, in press).

A viable explanation of these results is found in Salomon's alternative "activation" hypothesis (1979), which proposes a different role for materials. In this case, they activate skills in which learners are adept rather than supplanting those in which they are weak. In our case, the diagrammatic treatment would have activated mental processes that the high-verbal subjects possessed, but which were lacking in the low-verbals. There are two things to consider that arise from this. The first is that presenting information in non-verbal form will not necessarily help low-verbals learn better. There are several possible reasons for this, the most likely being that, in the studies mentioned above, the diagrammatic treatments tended to be more information-dense and redundant which would take away from low-verbals any advantages granted by the non-verbal presentation. Second is the puzzle created by the fact that verbal ability predicted learning from non-verbal materials. This is a more complex question which has been addressed by several researchers.

If the results reported in these studies are to be believed, it seems that the test used to measure verbal ability in fact measured something else. This is, of course, a question of the construct validity of the verbal test. And it is precisely the construct validity of aptitude tests that has recently come into question. There is plenty of evidence, a lot of
it summarized by Cronbach and Snow (19
chapter 9), that many of the aptitude
commonly used by media specialists in
search, or in diagnosis of learner ability
to making design decisions, do not mea
what they claim to. Let us return to test
verbal ability for an example. It has
shown convincingly (Hunt, 1978; H
Frost and Lunneborg, 1973; Hunt, L
neborg and Lewis, 1975) that certain tests
verbal ability measure general cognitive
cessing ability, particularly speed. In the
periments of Hunt and his colleagues, ve
ability was found to be positively corre
to the speed at which subjects were ab
make accurate judgements about the
of statements describing simple
displays (e.g. "the cross is above the sta

If aptitude tests do not measure what
claim to, how are researchers and desi
to proceed? This is a question that has
received attention. Of greatest interest a
tempts to identify what Snow (1980)
called "aptitude processes". These are
general aptitudes. Cognitive speed is on
ample that we have already menti
These fundamental processes can be
tified in two main ways: by rationalizin
processes from what is known about
abilities aptitude tests do measure (Ca
1976); and by studying test-taking beha
in order to deduce what cognitive proc
those who do well employ (Lohman,
1978; Snow, 1980). Whichever metho
used, what emerges is a description of
mental skills that people need to posse
order to perform various learning
These skills are described in terms of
cognitive processes and not general apti
and abilities.

Reducing aptitudes to more fundam
constituents has had some quite remar
advantages for research and design, in
tion to overcoming the problem of the
struct validity of aptitude tests. Not
among these is the matter of training l
ers in the mental skills they need in ord
learn a particular task. Aptitudes have u
ly been thought of as being pretty stable
a person's lifetime, and therefore un
able. However, the processes that und
aptitudes are not as stable, and are not
ant to attempts to train learners in thei
A good example of this appears in a stu

Thorndyke and Stasz (1980) on map learning. In a first experiment, these researchers had subjects learn the information presented on a map of a fictitious country until they obtained perfect scores. Subjects then described in detail the mental strategies they had used in order to learn the information. By comparing the mental strategies to the number of trials each subject needed in order to reach the criterion, the most useful strategies were identified. These skills included using imagery, mentally partitioning the map into sections, and rehearsal. In a second experiment, the useful skills were taught to one group of subjects, non-helpful skills to a second group, and a third group was taught no skills at all. As might be expected, the group that had been taught useful skills outperformed the other two groups. Other studies where relevant mental skills were successfully taught to learners have been reported by Weinstein (1978), Weinstein et. al. (1979), and Dansereau et. al. (1979).

The implications of these studies for instructional design are far-reaching. Indeed, you may have already realized that the Thorndyke and Stasz study was a fine illustration of how research (the first experiment) can be applied to practice (the second experiment). The main implication is that it is no longer necessary to devote as much time and effort to identifying strong and weak learner aptitudes, and developing instruction accordingly. Nor is it necessary to develop different sets of instructional materials for learners of different ability. What is more relevant is to identify those mental skills that learners need to apply in order to learn what they have to, and to train the learners in those skills. This is rendered all the more feasible in light of the growing number of techniques that are available for conducting task analysis in terms of the cognitive processes learners need to employ in order to complete a given task (Resnick, 1976; Greeno, 1976, 1980; inn, 1978). Thus, task analysis gains in importance over learner analysis in the design process, an approach that has been named appropriately the "task first" approach by Rhetts (1974).

Factors That Influence Learning

We are now in a position to ask the basic question that has been implied since the beginning of this article: What factors controlled by instructional designers influence learning? We have seen the fallacy of believing that only the type of medium influences learning. We have seen how certain characteristics of media influence learning directly, or in interaction with the learner aptitudes. We have also seen how the basic mental skills that underlie these aptitudes influence learning. In addition to these factors (the form of the medium, media characteristics, learner aptitude, and specific mental skills), there is another important factor that has not yet been mentioned. This is knowledge of the learning task by the learners.

The logic of giving knowledge of task prominence in our list of factors that influence learning stems from the reasoning that the appropriate media characteristics cannot be attended to, nor can the right mental skills be brought to bear, unless the learner knows in advance what is to be done with the information that is presented. This has been borne out in two recent experiments (Winn, 1981b), which studied the roles of knowledge of task, instructions to use certain mental skills, and the form the materials in learning patterns and sequences made up of lines and letters. Subjects were shown either lines or letters one at a time at various locations on a screen, and had either to recreate the figure or pattern that the lines or letters created, or to remember the sequence in which the lines and letters appeared. They were told whether to recall patterns or sequences either before or after the lines or letters had been presented. In addition, some subjects received instructions to form images, while others were instructed how to chain one element to the next. Results showed that subjects who had been cued to the task before presentation outperformed those who had been cued afterwards, and also that instructions on how to process the information helped subjects learn. It was also found that sequences were easier to recall than patterns if the elements in them were letters, but that the reverse was true if the subjects were shown lines. Various interactions occurred among the three factors, which suggested that the form of the materials and instructions to process the information in a particular way was before they saw the materials. In other words, without knowledge of task, learners were not influenced by factors that would otherwise be important for designers to manipulate.

These two experiments are just the beginning of what is hoped to be a fairly lengthy and detailed study of how these, and other factors (e.g. mental ability) interact and affect learning. What is important, though, is that already it appears that the form of the materials is a factor second in importance to knowledge of task, and maybe even to processing instructions. What this means is that instructional designers must not under any circumstances confine their decisions to considerations of what form materials should take. Of more importance is making clear to learners what is expected of them, and giving them instructions on how to go about processing the information that they are given. Instruction should therefore include guidance on how to learn as well as content to be learned. On the other hand, the designer's task is made somewhat less difficult by the knowledge that learners are often cognitively flexible enough to be trained in the mental skills they need. It is quite likely that, in many situations, taking the time to train skills will be more cost-effective than taking time to develop several alternative forms of instruction for learners of different ability. This latter suggestion has yet to be confirmed empirically. However, intuitively there appears to be truth to it.

In sum, the great complexity of learning that research is slowly uncovering reveals the learner to be more intellectually flexible than was once believed. This has certain advantages for the instructional designer, who can adapt the learner to suit the instruction rather than adapt the instruction to suit the learner. That is not to say that individualization is not recommended. It says, rather, that there may be circumstances that make it easier for the designer, and for the learner, if the new alternative is tried. The repertoire of the designer is increased in this way, to include the "task first" as well as the traditional "learner first" approaches. Maybe research will reveal situations where a "medium first" approach is the best, though this seems unlikely. In any event, our increasing knowledge of learning is beginning to offer designers a choice of instructional strategies that can be used to attune instruction more appropriately to tasks and to learners. This can only be to the good of designers and learners alike.

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Planning Instructional Change

Marvin E. Duncan and Ronald K. Bass

Change, whether planned or unplanned, usually brings with it confusion and discomfort. Planned change, however, results in less confusion and less discomfort while providing more efficiency and more productivity than unplanned change. In planned change, the initiator of the change idea has a thorough knowledge of the situation to be changed. The "real" problem and not simply symptoms of the problem are analyzed and clearly identified before attempts to change the problem situation are begun. Proposed changes must be developed and implemented, and an evaluation of these changes must be made in order to determine whether the organization functions more effectively and more efficiently than it functioned prior to the implementation of changes. The content of this paper is intended to be a guide to planning instructional change rather than a universal prescription for all change. It is the purpose of this paper to assist the reader in bringing about desired instructional changes by utilizing a systematic approach for making a smooth transition from the existing situation to the desired situation.

Identifying a Problem

It is paramount that the change agent ask and respond to two pertinent questions before attempting to bring about change. Both questions may be answered before a thorough identification of the problem is made, depending upon the knowledge the change initiator has of the client system. However, answers to both questions usually come about after problem identification. The first question which must be answered is, "Do I as change agent have some influence as to whether or not the situation will be changed?" If you have no influence in the situation, forget it! Continuation will bring only internal discomfort, mental frustration and anguish, or possibly dismissal. The second question is, "Am I concerned to the extent that I am willing to put forth the time and effort to bring the change idea into fruition?" If the answer to the latter question is yes, proceed. If the answer is no, stop fooling yourself since you are not committed to the proposed idea.

Ronald G. Havelock (1970, p. 12) writes that a successful change agent needs to develop a viable relationship with the client system prior to attempts at identifying the problem. A detailed description of the entire problem situation is not needed at this point. Rather, establishing a wholesome working relationship with those for whom the change is intended and with those who make decisions relative to the proposed change is a necessity. After the above has been accomplished proceed with identification of the problem. Care should be taken to avoid "finding a solution." This will more than likely result in the change agent reacting to symptoms rather than to the problem. The problem appears obvious in many situations. Usually, as Havelock (1970, p. 60) points out, the obvious is merely a symptom of the problem. Perhaps the most successful method of identifying the problem is by asking questions about the situation until common patterns among symptoms are recognized. Once the problem has been identified, determine the cause of the problem. Eliminating the cause means eliminating the problem. Consider the example below:

Your office mate comes into the office with wet clothing. The problem appears obvious. It is raining. However, the rain may not be the real problem. It may not be raining. Your office mate could have gotten wet by:

1) *walking under a sprinkler system.*
2) *walking too closely to a vehicle using water to clean the streets or*
3) *being doused with water by an individual*

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