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EXCELLENCE IN INSTRUCTIONAL DEVELOPMENT

REACTIONS TO A SYMPOSIUM

RESEARCH, THEORY AND INSTRUCTIONAL DEVELOPMENT:
A VIEW FROM THE TRENCHES
Robert M. Diamond

TEACHING, THEORY AND INSTRUCTIONAL DEVELOPMENT:
FRUIT FLY OR LEMMING?
Ivor K. Davies

These two articles are written versions of the presentations given in reaction to the Excellence in Instructional Development: A Symposium conducted at the Miami Beach AECT Convention. Each reactor was asked to respond from his own frame of reference—the opinions expressed are those of the reactors and do not reflect, necessarily, the opinions of the editors of the Journal.

RESEARCH, THEORY & INSTRUCTIONAL DEVELOPMENT:
A VIEW FROM THE TRENCHES

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For practical purposes, this paper, reacting to the Excellence in Instructional Development Seminar, will discuss first the relationship between research and theory and the day-to-day existence of the instructional developer, and then conclude with some comments on the papers themselves. The earlier discussion also provides a framework upon which many of the specific reactions are based.

Research, Theory, and Practice
The real world of instructional development is not easy. The developer* is constantly caught between what he or she knows should be done and what, in reality, can be done. The developer must deal, on an almost daily basis, with time pressures, budget limitations, the inac-

*For the purpose of this paper, the developer is defined as the individual responsible for directing and coordinating a team of content specialists and evaluators (if available) through the systematic design, implementation, and evaluation of courses and curricula.

cessibility of information, and the built-in biases and goals of everyone involved in the project. In addition, there are the priorities of curriculum committees, of departmental committees, and various administrators which, if overlooked, can almost guarantee failure of any project. Perhaps, in the long run, the most successful developers are those who see their projects implemented and surviving while knowing full well that what has been produced may not necessarily be the best possible course or curriculum but that it represents the best of what could be done under existing circumstances.
The instructional developer, however, cannot perform in a research vacuum. The developer must know what research says, must understand the strengths and weaknesses of various theories, and be able to defend the particular process or design model that is being followed. New approaches and theories must be discussed, analyzed, and understood. As developers, we must set aside some of our time to find out what is and what is not working elsewhere and why. We must not only understand the rationale behind different theories but also the implications of their implementation in the design process. The instructional developer must know the research and theory base on learning and on change. We must understand the various roles of evaluation, what it can do for us, and how, if we don’t have access to a professional evaluator, we can still build evaluation into our project.

However, as we do our research, we must realize that often what we are reading and hearing may not be all it appears to be for several fundamental reasons.

1. Many of the theories and models have not been field-tested or implemented and were designed apart from the practical world of instructional development.

2. Many of the models that have been implemented were supported by grants and research funds that will not be available to others hoping to use the same approach. There is a world of functional difference between “soft” and “hard” money projects. Many approaches that do work under experimental conditions become impractical because they require more time, more talent, and more money than we often have available to us.

3. Practical research studies in instructional development are scarce since it is extremely difficult to conduct classical experimental designs within the framework of regular course offerings. Of growing importance to our field are the “quasi” experimental approaches described by Campbell and Stanley and others.

4. Failures and problems associated with various approaches are rarely fully reported. How often have you visited a program that you have read about or discussed a particular model or theory with its major advocate only to find that key limitations or negative factors were omitted from what you have read or heard?

The Balance Between Research, Theory, and Practice

It is the understanding of existing research combined with experience that allows a developer, playing his or her hunches, to make the right decisions. During meetings with faculty, the developer does not have the time to explore alternatives exhaustively or thoroughly investigate all related research and writings. Decisions have to be made immediately and can rarely be delayed. However, if we’ve planned ahead, our actions will usually be the correct ones. Although most development meetings contain some surprises, the topics being covered and the goals of the session can be anticipated. Developers should enter every meeting with a clear idea of where it is heading under his or her direction, and, therefore, planning is essential.

If the session will include a discussion about the first units in a course or curriculum, the developer should already know and bring to the meeting extensive data about the students’ knowledge, attitudes, and priorities. If there are going to be prerequisite problems or if the potential for exemption exists, this must be on the agenda of the developer for very early discussion since these factors will have impact on the total course design. If objectives and evaluation are to be discussed, they should be considered and developed without intimidating the faculty member in the process. This is extremely important since many of the existing models, while they may generate hundreds of objectives, tend to antagonize the faculty as they are forced through the process. While the faculty must understand the design process being followed and be able to describe it in general terms, the less the developers discuss complex models and theories with the faculty the better. Most simply want to get on with the project and are not usually interested in the jargon, models, and theories of our profession.

The writings of Gagne, Markey, Snow, Merrill, and others are important to the practicing instructional developer. However, there is often a major difference between the ideal, where the design of every lesson follows the recommended procedures, and what we can realistically hope to do. Faced with the pressures of rapid implementation and limited as we are in both time and resources, I would like to propose the following working relationship between those approaches requiring extensive analysis and design and instructional development—Utilize the in-depth approaches when attempting to find out why certain elements aren’t working or why certain students aren’t learning. It is here that we will gain maximum payoff for maximum input. Across-the-board utilization of many theories and models is simply not cost effective.

Some Brief Comments on Specific Papers

Kaufman on Needs Assessment2 In this paper Kaufman briefly summarizes his approach to the area which identifies six categories of needs assessment and then presents, in some detail, a realignment of needs assessment into two major headings, internal and external. While he relates to the overall design process, he argues that although much of what we do approaches needs assessment from within the organization, external needs assessment is very important and obviously much more difficult to accomplish because it may be regarded as posing a threat to the fundamental purposes of an organization. While I do have some problems with the “external” — “internal” classification system proposed in this paper, I feel that the overall statement Kaufman presents on needs assessment is sound and clear. However, I feel more comfortable viewing needs assessment from the two fundamental decision areas in which these data are of major importance: establishing the priorities on which project selection is made, and in the design of the project itself.

In addition, we must remember that the goals and objectives of any program will depend on who is given the opportunity of having input into the system, and this is usually controlled by the instructional developer.

Gagne on Learning Hierarchies and the Training of Instructional Developers.3 Asked to discuss what kinds of skills and competencies should be aimed for in training specialists in instructional development and to describe how the concept of the learning hierarchy might be used in planning such programs, Gagne lists five general categories of learned capabilities and shows how the learning hierarchy would be used to identify essential prerequisite skills for any specific intellectual skill. Gagne recognizes that in his discussion in general because the specific tasks that an instructional developer may have to do are virtually limitless.
While I certainly agree with the concepts presented in this paper, I am concerned with how to fully implement this approach on a day-to-day basis without antagonizing faculty. Can we, perhaps using other procedures, achieve the same goal with less frustration and in less time? Finally, in any discussion of the training of instructional developers, I would like to see more discussion on the qualities that an instructional developer must have that can’t be taught. I’m increasingly convinced that it is certain human qualities that in the long run determine the success or failure of developers, and, therefore, our most important decision may not be in the design of our academic program but in how we select our students.

Merrill on the Concept Elaboration Theory. Merrill’s Concept Elaboration Theory is presented as an alternative to the Gagne-type learning hierarchy. Merrill concludes that Gagne himself does not specify that hierarchies are necessarily devices to sequence subject matter, but he points out that they have, nevertheless, been so used by others. Concept Elaboration Theory is a procedure for representing the content structure of complex subject matter, for determining an optimal sequence for teaching complex subject matter, and for determining an optimal presentation strategy for complex subject matter. The difference between these two theories might be illustrated as follows. If you were to teach someone a complicated task, you might begin by teaching him prerequisite skills first. After learning them in some order, the student would ultimately be able to perform the terminal task. This would be a Gagne-type approach. You might, however, approach the teaching job differently. You might teach a simple version of the task but one which still applies its underlying principle. You would then successively elaborate the simple version until the student learned to perform the terminal, much more complex task. Merrill feels that the Concept Elaboration Theory would give the learner overall understanding of the task much sooner.

While I agree philosophically with the approach being suggested, I am not sure if we can realistically hope to put this process into operation when we must deal on a daily basis with faculty. The process we use must be clear, concise, sequential, and equally important, humanistic. On a lesson-by-lesson basis, how detailed can we really be?

Markle on Teaching Concepts. Starting with some fundamental and totally supportable instructional design axioms, Markle discusses the concept of learning hierarchies and the process and problems associated with classification. The difference between a hierarchy of intellectual skills and a well defined "knowledge structure" is discussed with emphasis on the impact these differences will have on the design process. The job of the instructional developer, according to Markle, will be to identify the knowledge structure in various subject matter areas and to redesign materials so that they become more accessible to beginners in a new discipline.

While again I support the concept being presented, I find myself somewhat uncertain as to when it makes sense to place all the elements of a course I am working on in hierarchical order. Perhaps, as I mentioned earlier, we should take the time to do this when something isn’t working. One advantage the instructional developer has is being outside of the subject area is that he or she can ask key questions of the faculty that will evolve and help articulate the knowledge structure within the discipline.

Faust on Instructional Strategies. First, identifying the problem, then stating the objectives, and finally, selecting a mode of instruction makes eminent sense. All too often we find solutions seeking problems. In this paper, Faust emphasizes instructional strategies as they relate to meeting a single instructional objective. While also discussing the classification of objectives, the major portion of this paper describes a model of an effective instructional design approach which relates the classification of specific objectives to the instructional strategy which will be selected. Faust’s statement, “Each objective and each component are not treated as a completely new challenge requiring the invention of a completely new strategy,” should have been emphasized on several of our more highly publicized models. However, we should remember that, when cut too fine, the writing of objectives has caused many faculty to lose sight of why the course was taught in the first place.

Snow on Individual Differences and Instructional Design. In this paper, Snow writes that individual human differences are far more complex and fundamental than has been recognized. Where differences have been acknowledged, he feels that they have usually been used to select out people who did not conform to a mythical average. Snow points out that there is an interaction between individual differences and instructional conditions —ATT (aptitude-treatment interaction) —which can produce varying degrees of learning success or failure, depending on how appropriately instructional conditions are matched with individual differences. The individual differences Snow refers to include more than just general intelligence; they include other aptitude variables, such as General Achievement Motivation (achievement via independence or achievement via conformity) and Anxiety. Students, for example, who are able, conforming, and anxious seem to need more step-by-step structure in the progress of instruction, whereas students who are able, independent, and non-anxious seem to need less teacher structure of this sort. He concludes that instruction that takes these individual differences into account and which tries to accommodate them by appropriate learning conditions should produce greater learning success.

I’d love to have the time and resources to apply trait-treatment principles to everything I do; unfortunately, I don’t have either. This approach has helped us identify why certain students aren’t succeeding and has provided us with some excellent indications of what we can do to correct the problem. We must always, however, keep in mind that some students may never succeed and others will learn whatever we do. The final percentage of failure may, in the long run, rest on the resources available to us. We also must remember that as course design becomes more complex (many courses include lectures, seminars, laboratories, tutorials, and independent studies) the process of analysis also becomes more complicated.

Baker on evaluation. Not to have evaluation as an integral part of the development process is idiotic. Unfortunately, it happens all the time. Baker uses a dance metaphor to discuss formative evaluation (the hustle) and summative evaluation (the minuet). She argues that summative evaluation is too often merely a contrived exercise of limited practicality: when conducted by the organization itself, its results are likely to be suspect; when conducted by more objective outsiders, it may be perceived as threatening. Summative evaluation, she feels, is subject to political pressures; when requested, it is often intended to promote
or debunk some program. Formative evaluation, she concludes, has much greater practical value, is perceived as much less threatening, has a real effect on development, and is much less subject to political pressure.

While I generally agree with this paper, I believe that formative evaluation begins earlier in the design process than Baker suggests and includes those elements of needs assessment associated with project design. We have, for example, found it extremely important, long before a course or program is outlined or a student manual or instructional unit produced, to gather detailed information about our students. What skills and attitudes do they bring to our class? Are our assumptions about prior learning correct? Why are they there in the first place and where are they going? In addition, when our project is related to a specific profession, key questions must be asked of recent graduates, of practitioners, and of their employers. We must also determine in advance what criteria those who will judge the project are going to use to determine its success. These questions are all part of the formative evaluation process and their answers will not only provide the basis for many design decisions but also the basis for comparative data used in the summative stages of evaluation.

The instructional development process must represent a blend of research, theory, hunches, and experience. The coordination of these elements must rest with the instructional developer.


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**INSTRUCTIONAL DEVELOPMENT: FRUIT FLY OR LEMMING?**

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"His thought is not to give flame first
and then smoke,
but from smoke to let light break out.”
Horace

Instructional development is at a cross roads. In its search for excellence, the title of the symposium of papers published in the first issue of this journal, it has reached a critical point of inflection signalling a point of change in its history. The seven papers by Roger Kaufman, Bob Gagne, Dave Merrill, Sue Markle, Gerald Faust, Dick Snow and Eva Baker all portray this point, as well as indicate the influence of forces outside the field of instructional development. Indeed, they not only indicate the point of inflection individually, but even more markedly when they are viewed together as one portrayal of what the field is about. For this reason, despite their individual praiseworthiness, they merit more acclaim when viewed as a whole.

In his introduction to the symposium, the editor, Ken Silber, points out that the seven authors “have theorized about, researched, developed, and implemented the techniques we use today, and, hopefully, will be using in the future to develop instruction.” He goes on to argue that the authors represent a variety of interests and disciplines, and, in some cases, have differences of opinion. Overall, Silber says, the ideas represented in these seven papers on needs assessment; capabilities and learning hierarchies; content analysis; conceptual networks; instructional strategies; aptitude-treatment interactions; and evaluation—represent the cutting edge ideas in instructional development today. And, so they do. But we still have to deal with the issue of “Where do we go from here?”

The point of inflection which instructional development has reached, and
which these papers seem to illustrate, is critical not only in terms of the theories, paradigms and strategies available to, and valued by, developers, but also in terms of a continuance of, and hopefully increase in, the resources available to them. In other words, is instructional development to become either:

• A casualty in the seemingly endless swings of the pendulum in education, a passing fashion no less, or will it be able to renew and re-invigorate itself as an area of continuing substance and integrity.

• A diluted, and perhaps more palatable successor of programmed instruction (from which so many of its leaders, as well as its models and strategies appear to be derived), or is it to grow as a worthwhile discipline by developing methods of inquiry capable of making significant and elegant contributions to the prevention and solution of instructional problems.

To put it even more bluntly, does the Division of Instructional Development (DID) and the journal have a future, or only a past to exploit?

The seven papers making up the symposium suggest that there is, indeed, a rising sun on the horizon once again, but the evidence that they present may not be persuasive enough to convince people within the field let alone those outside it.

Convincing ourselves is easy, convincing others may be more problematic—yet it is the others, by and large, who will have to be convinced, if developers are going to stand any chance of obtaining the commitment that will be needed. This year, therefore, can be a time of self-assessment. A time when reflection may be more important than evaluation (narrowly conceived), a time to explore alternative options rather than continue to seek the "one best way," and a time to decide what instructional development can become rather than unthinkingly accept constraints imposed upon it by the force of events. It is the nature and the direction of ID's growth that we need to ponder.

Evolution and growth

Growth in any living organism, as well as in most areas of human endeavor like instructional development, tends to follow one or other of two basic growth curves [see Haldane, 1963; Salk, 1973].


This model is characterized by the S-shaped or sigmoid growth curve. Such a curve, see Figure 1, shows an initial period of little growth, followed by a long period of rapid but sustained growth, followed by a period when growth levels off or stabilizes at some optimal level. The S-shaped growth curve is best illustrated by the fruit fly (Drosophila), as well as by many micro-organisms and most populations. Many subject matter areas have tended to follow a similar growth pattern. Geography is one example, and a cumulative analysis of the literature of other disciplines is especially revealing, and of doctoral dissertations even more so.

[2] Model for fluctuating populations. This model is characterized by the W-shaped or sine growth curve. Such a curve, see Figure 1, shows short periods of rapid growth, followed almost immediately by regular and suicidal catastrophes. Such boom-burst cycles of growth are characteristic of the lemming (Lemmus), a small rodent found in Alaska, Siberia and Scandinavia, which commits suicide en masse in the sea, as well as of the snowshoe rabbit (Lepus americanus), mice, voles, jerboas and other Muridae (see Huxley, 1963). Many movements in Education have tended to follow this boom-burst, boom-burst, boom-burst growth cycle, particularly in the area of such basic skills as the 3 R's.

The basic dilemma for instructional development is that it has moved from a period of little growth into a period of rapid and sustained growth in a very small number of years. Regardless of the future, however, one point about growth, of importance to ID, still remains to be considered.

![Figure 1. Idealized Lemming and Fruit Fly Growth Curves](image-url)
Development During Periods of Boom and Burst. During any period of initial growth, when conditions are favorable and the number of people engaged in the new activity may be small, the intensity of selection may be very low. As the area undergoes rapid and sustained growth, and a peak is approached, a more rigorous selection of models, strategies and techniques will occur due to the pressure of competition. Ideas lacking in substance or usefulness will tend to be abandoned, whilst ideas which have been demonstrated to have utility and integrity will survive and prosper. As the boom bursts, however, only those ideas which prove most resistant to the forces which caused the turnaround will survive. In the subsequent period of unfavorable environmental conditions, survival or selection will depend upon the ability of ideas to resist the new negative features present in the environment. This will largely depend upon their ability to make a wider contribution, outside the area in which they were initially developed.

After the period of setback, in which some ideas will survive or lie dormant, a new cycle can start as conditions begin, once more, to favor a new burst of activity. During the period of initial growth and extra-ordinary flowering of models, strategies and techniques characteristically occur, with marked departures from previous norms and restraints. A high proportion of the ideas, however, may be "deformed" in some way, with the amount of the deformity depending upon the degree of variation. As growth continues, however, and conditions within the discipline become again more rigorous and competitive, extreme variants will tend to disappear. The methods of inquiry characteristic of the whole field, though, are likely to have a similarity with those of the previous cycle of growth, but will be, nevertheless, still recognizably different and distinct.

Instructional Development During the Last Century

Bearing the above discussion in mind, let us look at the history of needs assessment, specific objectives, content analysis and evaluation (for more detail see Davies, 1976). Although the field of instructional development has a history of but some twelve or fifteen years, many of the issues, models and strategies which are recognized, today, as peculiar-ly those of ID, predate it by at least one century. Needs assessment and objectives, for instance, were well developed concerns during the mid 1800s. They had a literature which still echoes in many writings today, as a result of the influence of Herbert Spencer, Johann Herbart and Gabriel Rosmini, Herbart's book The Science of Education, republished in translation by Beatrice Mulliner in 1898, is particularly noteworthy to developers today. The period was one of great interest, with its concern with identifying which knowledge was of the most worth, the problems of sequencing information, and the difficulties involved with designing instructional situations. By 1800, however, the boom had burst, and the pendulum swung in the opposite direction against a science of education. Despite her quotation from Browning:

"Sacrifice is offered for and to Something conceived of. An ignorance of means may minister To greatness, but an ignorance of aims Makes it impossible to be great at all."

at the masthead of her second chapter, entitled "The Aim in View," Mulliner still failed to remove the deep rooted suspicion. Clayre's reproachful words to Pestalozzi were flung at Herbartians, as the new scientists of education were called, and "Vous voulez mecaniser l'Education" became the death rattle of a lost cause. (Yes, Clayre is alive, well and with us still!)

In the lull following the boom of the mid 1800s, the idea of analysis survived in education, but at a low level of visibility. Then, during the first years of the present century, following the successful application of science to industry, together with the growth of 'popular' education for all, a new burst of interest occurred with the idea of improving education through the application of science. Encouraged by the work of Taylor and Gilbreth, and especially by their techniques of analyzing the requirements of jobs as they sought to identify the "one best way" of designing work, a new cycle of activity began. The cycle reached its full flowering in the 1920s, particularly as a result of the work and influence of Werrett Charters and Franklin Bobbitt. The importance of task analysis, or as they called it 'activity analysis,' and the importance of defining objectives in highly detailed terms loomed large. Charter's book Curriculum Construction, published in 1924, deals in detail with such topics as the: prestige of systematic knowledge; analysis of activities; limits of analysis; determination of objectives; selection of methods; sequencing subject matter; interaction of content, learner ability and interests, and developmental stage; and teaching methods.

Charters' seven stage model for development, even by today's standards, is a thought provoking sequence of development activities. Included in it are stages which: identify major objectives by analyzing people in life settings; analyze objectives by means of a matrix of ideals and activities; identify working units and order them in importance; raise to positions of higher order those ideals and activities high in value for children, but low in value for adults; identify those that are best dealt with in school, and those best handled out of school; collect the best known practices for handling ideals and activities; and arrange the material in an instructional order according to the psychological nature of children.

The major contribution of this period of development, however, is the weight that was given to the power of analysis, and the emphasis given to the importance of defining highly specific objectives. Charter's activity chart, for mapping objectives, has many advantages over the list structure that developers so commonly use today. (Although the idea was re-introduced by a large number of the contributors to Bloom, Hastings and Madura's Handbook of Formative and Summative Evaluation of Student Learning, published in 1971, it is still not characteristic of either the work of developers, nor is it to be found in the majority of their professional writings). Despite all the activity of the 1920s, as well as the many creative contributions, the systematic movement collapsed once more before the growth of progressive education. Franklin Bobbitt, in his introduction to his new book The Curriculum of Modern Education, published in 1941, wrote that he was "content to let it rest in peace."

The rest of the story is too well known to need re-telling here. Ralph Tyler, a former student of Charters, kept the lamp alight by taking the ideas behind specific objectives into the area of test construction. But with Sputnik, national pride was dealt a severe blow, and massive resources were made available to renew education. Some of these became
available to activities that were later 'captured' under the term of instructional development. Objectives were re-discovered, as if for the first time, and the importance of defining them in 'the one best way' inevitably overblown by over zealous initiates. Analysis, and the importance of systematic planning, once more became by-words, and seen as the only way of going. Others discovered the joy of drawing boxes with arrows.

The Allometry of Instructional Development

Although growth, regardless of which of the two models is followed, normally implies some sort of orderliness as far as the whole is involved, it does not necessarily imply that there is an orderly process of symmetrical enlargement of the parts making up the whole. Just as the Irish elk possibly became extinct due to the exaggerated growth of its antlers in relation to its body, thus impeding movement, so the parts of a subject area may grow out of all proportion to the whole, and threaten the continued existence and acceptability of the discipline. Allometry, which studies patterns of unequal or disharmonic growth, offers, therefore, a concept useful to the survival not only of living organisms but also to the integrity of such area of disciplined inquiry as instructional development.

In considering the application of allometry to instructional development, it is important to bear in mind the truism that conditions and forces that were advantageous to ID during the early stages of a growth cycle, may become neutral or even disadvantageous later on. Similarly, models and techniques that were important, if not essential, in the early years of a discipline's cycle of growth, may threaten the continued acceptance of the area unless some re-tuning or re-focusing takes place to bring them into line.

Two strategies of instructional development, both discussed in the symposium papers, which may have grown disharmoniously, in the current cycle, as well as during the one in the early years of this century, involve objectives and evaluation. This is, in no way, to be taken as a negation of the importance of these two activities, but only a recognition that to many of ID's clients they appear to be threatening and anxiety provoking. The very terms 'evaluation' and 'objectives' have become emotive slow-gans, beggars more fearful than what is really implied or involved. Even to developers, the activities associated with 'identifying objectives' and 'carrying out evaluation' have become such resource consuming tasks, that little time is left for other necessities like learner analysis—other than by means of some superficial treatment. It is almost as if, instead of helping to solve instructional problems, they 'colonize' them instead. Both evaluation and objectives, to use the analogy of Eva Baker, can in insensitive hands become rigidly stylized steps. Politically important, but—especially in the case of summative evaluation—too often offering little of real significance when measured against the enormous resources that may have consumed.

What is necessary is that instructional developers re-assess the basic paradigms and models of ID (turn ID into, as it were), re-tuning the whole process, as necessary. There is no 'one best way,' everything depends upon the needs of the task and the people who have to be served, and there is no reason to believe that every technique available to developers (including defining objectives) must always, without exception, be part of the mandatory practices of development. Furthermore, there are techniques which still need to be acquired or developed, techniques which recognize the importance of people as people and as individuals, each with their own intrinsic merit. Identifying the importance of different cognitive styles is a start, but there is still a long way to go. The lesson is an important one. It is in the ideas of instructional development, not in its mechanical achievements, that the real potential of the discipline is to be found. The allometry of some of its values, therefore, will repay analysis, at least from the point of view of the immediate future.

Two Contrasting Value Systems

But what of the future? Is instructional development to continue on the lemming curve, doomed to destroy itself yet again, as the pessimists would have it, or is instructional development able to assert itself and begin a new growth pattern on the fruit fly curve, as the optimists would have it, reaching new levels of excellence? The important thing is that developers are uniquely able to make the choice, since the pessimists are themselves evidence that there is a signalling device able to sound warnings of danger. The engineering approach, with its apparent attempt to 'mechanize' education, will simply not do. The serious question, only just beginning to be debated at a professional level, is whether ID can be content with an approach in which people appear to be but a variable to be manipulated, rather than as a given with a rich potential to be realized.

Essentially then, instructional development is facing a conflict between two contrasting value systems, each of which offers a different set of assumptions for development activities. Others have debated these value systems in instructional development (see Davies, 1973; McBeath, 1969) but the wider case for society has been put dramatically by Jonas Salk in his book The Survival of the Wisest, published in 1973. He argues that if people are to influence the course of their own growth, they must seek a critical moment (a point of inflection) to move from what he calls an "Epoch A" set of values to an "Epoch B" set of values. He points out that in the course of evolution, many more things have become extinct than have survived, very often because of the way that they have dealt with themselves. They brought about, almost inevitably, their own destruction. If Salk's model can be translated from the sphere of world problems, to the world of instructional development, then the problem facing ID can be restated. Is instructional development to continue with an Epoch A set of values, or is it to develop a set of Epoch B ones. The symposium papers suggest that ID is already making the change, for the values they appear to represent are predominantly those outlined in the Epoch B column of Figure 2.

Epoch A reflects a world of deterministic values, in which survival is the reward of the fittest. Independence is the prime motive, and the immediate goal is to seek for remedies. Competition is seen as a prescription for personal development, and the basic strategies involve a win/lose, either/or, types of response in the context of a world in which self-repression and outside restraints loom large. Epoch B reflect a world of possibilistic values, in which survival is the reward of the wisest—for in wisdom lies strength. Interdependence is the prime motive, and the immediate goal is prevention rather than cure. Cooperation is seen as a prescription for personal development, and the basic strategies involve double win, or inclusive "and," types of response in the context of a world in
which self-expression and self-restraint loom large [see also Bronowski, 1977.]

These ideas are appealing to a wider and wider group of professional people both in Europe and in the United States. At the end of last year an Epoch B group called together a meeting in Europe of journalists, economists and administrators from all over the world to discuss "Media Values for a New Epoch." No instructional developers appear to have been invited. The point, however, is that ID, too, needs such a debate, in order to consider "Instructional development values for a New Epoch." It is not necessary to regard Jonas Salk as a new world prophet, but rather (in the words of a colleague of his) "as an instrument maker who has offered us a useful instrument through which we can see the world in a new way."

**EPOCH "A" VALUES**

*Foreclosing on the possibilities by:*

Judging between what is right and wrong, good or bad, true or false.

Searching for the one best way of doing things, and believing that it can be found.

Searching only for remedies for existing instructional problems. Cure orientation.

Focusing on efforts, and the resources needed for efficient development. Stress is on the authority developers need.

Attending to far too many things in an attempt to attend to every aspect of the traditional ID model.

Emphasizing learner weaknesses and deficiencies, emphasizing what cannot be.

**Result: efficiency**

[i.e. doing things right.]

**EPOCH "B" VALUES**

*Opening up the possibilities by:*

Choosing between alternatives; neither of which is provably more nearly right than the other.

Searching for the best alternatives from which to choose, recognizing the needs of the task and the people involved.

Seeking for ways to help prevent instructional problems from occurring. Prevention orientation.

Focusing on the contribution that instructional development can make by gearing efforts to results. Stress is on responsibility and sensitivity.

Concentrating upon a few major areas where real professionalism will produce outstanding results. Stress is on priorities.

Building on learner strengths, emphasizing what can be and what ought to be.

**Result: effectiveness**

[i.e. doing the right things.]

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**Figure 2. Epoch "A" and Epoch "B" Values in Instructional Development.**

The seven papers of the symposium "Excellence in Instructional Development" represents ID's instrument makers at work, and they too offer us useful instruments through which we can discern an emerging new world of instructional development. Care must be taken, however, that in our haste to adopt new ideas, we fail to discern the value systems that they represent. Epoch A is for the lemmings, Epoch B is for the fruit flies. Which are we to be?

**Epilogue**

"Where are you going?" asked the lemmings.

"Oh, I don't know," said Bob the developer lemming.

"But you can't go, we have too much to do. Festival time is coming up, and we have to plan for the en masse migration to the sea. You can't go."

"Yes, I can," said Bob. "I don't have to help you."

"But you are a lemming. We have to help each other."

"You help one another," said Bob. "I'm not one of you. I am not a lemming any more."

"Well, what are you then?" the lemmings shouted. "Tell us."

"I don't know," said Bob, the developer, as he headed firmly away from the sea. "Maybe, I'll be a fruit fly!"

**Moral: Heaven helps those who help themselves.**

**References**


CONCLUDING REMARKS

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This symposium has presented the key issues and techniques of each step in the instructional development process as seen and developed by those in the forefront of the instructional development field. It has brought together, both at a DID session at an AEFT Convention, and in a DID publication, people who, and ideas which, are not usually directly available to DID/AEFT members.

There is little to add to what the presenters, and the reactors, have already said, but I would like to set forth one idea to conclude the symposium.

By design, each presenter addressed only one aspect of instructional development. Yet, according to any model of instructional development you choose to accept and follow, ID is more than a set of isolated steps. ID is a total process for solving instructional problems, and it is in the context of a total process that instructional development's power as a technique lies.

Many of the individual techniques discussed in this symposium have been, in the past, used in isolation, with less than successful results. There is ample evidence that the individual techniques, used by themselves, cannot solve instructional problems.

What does make the total technique of instructional development work, on the other hand, is systematic combination of these individual techniques into a total process—a total process which shows the relationships among the individual techniques as they are brought to bear on an instructional problem. Though there is some disagreement about the “correct” sequence to follow in doing ID, most developers would agree that needs assessment and learner analysis are necessary first steps in a successful development process. Further, they would agree that the information gained from these steps “feeds forward” to influence subsequent steps in the process. Most would agree that some sort of task/content/objectives analysis should precede the selection of the instructional strategy and media, and that these analyses provide information needed to make successful selections. Most would agree that formative evaluation can take place following any of the steps in the process, and should take place following the development of the first prototype, and that the information gathered from the evaluation “feeds back” to the other steps in the process.

The instructional development process, then, is more than a set of individual techniques. It is a systematic combination of these techniques in which the relationships among the techniques (e.g., feedback, feed-forward, sequence) are as important as the techniques themselves.

Viewing instructional development as a total, systematic problem-solving process, involving both separate techniques and the relationships among them, makes instructional development a synergistic process—one in which the whole, and its results, are greater than the sum of the parts, and their results.

If this is what makes instructional development the powerful tool it is, then we must all leave this symposium with more than a collection of seven individual techniques. As important as each technique discussed in this symposium is, it does not, alone, hold the key to successful instructional development. To make instructional development successful, we must not only understand each technique; we must also identify its relationships with the other techniques discussed. We must synthesize the techniques into a coherent, systematic whole, and apply them as a total process to solve problems.

If we can perform this synthesis, and total application, then the symposium will have been successful in providing us with the more potent tool we all need to become better instructional developers.
What Is The Design Science Of Instruction?

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Abstract

This paper is an attempt to identify what instructional science is and what instructional scientists do. First, prescriptive design sciences are distinguished from descriptive sciences in general, and instructional science is characterized as a prescriptive design science. Second, three major phases of instructional development are described (design, production, and validation), and three approaches for each phase are identified (artistic, empirical, and analytic). The design science of instruction is described as being the foundation for one of the three approaches (the analytic) to one of the three phases (design) of instructional development. Third, typical activities of people in instructional science are described. Like all design sciences, instructional science has three types of professionals: scientists, technologists, and technicians. The major activities of instructional scientists are the derivation and validation of prescriptive principles of instruction. Fourth, a four-stage theory-construction procedure is proposed as a particularly promising methodology for instructional scientists to conduct their activities of deriving and validating prescriptive principles and theories of instruction. Fifth, reference is made to recent work by one instructional science laboratory which uses this four-stage theory-construction procedure. And finally, the controversy over basic vs. applied research is addressed from the perspective of the previous analyses.

What Is The Design Science of Instruction?

The major products of the science of instruction are prescriptive principles of instruction. These principles allow instructional designers to prescribe instructional methods that are likely to be optimal for given sets of conditions, and they help instructional evaluators to identify methods that are not optimal for given sets of conditions. Therefore, the fundamental purpose of the science of instruction is to contribute to improving the quality of instruction.

A Science of Instruction vs. a Science of Learning B. F. Skinner (1954, 1965) pioneered and popularized a scientific approach to the study of instruction with his programmed instruction movement. For the first time, the emphasis was clearly placed on investigating instructional variables (i.e., how information is presented to the student) rather than on investigating learning variables (i.e., how learning occurs).

Jerome Bruner (1964) also helped establish the foundations of a science of instruction, except his was a more cognitive approach. A tremendous contribution was his distinction between the prescriptive nature of theories of instruction and the descriptive nature of theories of learning.

From another perspective, Herbert Simon (1969) elaborated a similar distinction by describing the common characteristics of prescriptive "design sciences" in all disciplines (e.g., business, medicine, engineering) and by contrasting them with the characteristics of their descriptive counterparts (e.g., economics, biology, physics—respectively). In this framework, instructional theory is clearly the prescriptive counterpart of learning theory. Robert Glaser (1965, 1976) also emphasized the importance of developing a prescriptive design science of instruction.

An important aspect of this descriptive-prescriptive distinction is that there is only one type of professional in a descriptive science—the scientist—whereas there are three types of professionals related to a prescriptive science—scientists, who discover principles, technologists, who use those principles to develop procedures or machines, and technicians, who use those procedures or machines to produce products. More will be said about these three types of professionals below.

The Context of Instructional Science

As was mentioned in the opening paragraph, the fundamental purpose of the design science of instruction is to contribute to improving the quality of instruction. A major aspect of this endeavor is instructional development, which can be conceptualized as having three major phases: (1) design, which is, for an instructional developer, what a blueprint is for a builder, (2) production, which is the using of the design to make an instructional program and (3) validation, which is the determination of the quality or validity of the final product.

Three Approaches to Each Phase Although design, production, and validation are essential phases of instructional development, none of these phases necessarily involves instructional science. Merrill (1975) proposed that there are three major approaches—artistic, raw empirical, and analytic—toward these three phases of instructional development, and that any one of the three approaches can be used on any one of the phases (i.e., design, production, or validation). However, only one of these approaches—the analytic approach—involves instructional science. (Note: these approaches are not mutually exclusive, and each is seldom used in pure form.) Figure 1 characterizes the three approaches.
The artistic approach is subjective and entails the use of intuition, taste, and experience for designing, producing, or validating instructional programs. A person using the artistic approach might say: "I am going to develop the instruction this way because it feels right."

The raw empirical approach is an extension of the artistic approach. It entails the use of both intuition and results (data) for designing, producing, or validating programs; but the results must be product-specific, and each product must be developed by trial-and-error: try something on the basis of intuition, and collect data to see if it works. A person using the raw empirical approach might say: "I had a feeling that the final product should be like this; but when I tested its quality, I found it was poor. Judging from the problems encountered, I think I’ll try these modifications and see if it will then be acceptable."

The analytic approach entails the use of prescriptive principles of instructional design, production, or measurement for doing each of the three phases of development; design, production, and validation respectively. The instructional developer follows procedures which are based on principles that have already entailed intuition for their derivation and results (research) for their validation. Therefore, intuition ("art") and results ("empirics") are of minimal importance for conducting any given phase of instructional development; data are usually still needed in the systematic validation of the final product—the third phase—but they are not needed to test the procedures of design, production, or validation. A person using the analytic approach might say: "Since the students have these characteristics and the subject matter content has these characteristics, the following instructional strategies should be used."

An artist or raw empiricist may in fact use some principles in his/her approach to any single phase. However, those principles are usually of "local" derivation; they usually have not been empirically tested; and they are often not made explicit by the artistic or raw empirical developer.

As was mentioned above, any one of the three approaches toward instructional development (i.e., artistic, raw empirical, and analytic) can be used on any one of the three phases (i.e., design, production, or validation). But the artistic, raw empirical, and analytic labels are often used to describe the commonly used approaches to the whole process of instructional development. Nevertheless, a label so used seldom applied accurately to all three phases. For instance, what is commonly referred to as the raw empirical approach to the whole process of instructional development usually entails an analytic approach (rather than a raw empirical approach) to the validation phase—that is, it entails a set of well-tested measurement techniques or procedures which are based on proven principles. Therefore, it is much more helpful to describe the approach used on each phase rather than to use one approach descriptor to refer to the whole process of instructional development.

For all three phases (i.e., design, production, and validation), we propose that the analytic approach is preferable to the other two approaches for the following reasons: (1) it saves time and money by reducing the need for revision, because the principles and procedures (of design, production, or validation) have been proven effective for specific conditions; (2) it saves money by allowing less-costly (easily-trained) technicians to do the development work by properly following some validated procedures.
and (3) it leads to more consistent high quality of the final products of each phase because it is based on knowledge (principles) accumulated on a much broader scope than personal experience — the most effective methods are more likely to be overlooked by the other two approaches.

Context
So where does instructional science fit into this broad picture of phases (i.e., design, production, and validation) and approaches (i.e., artistic, raw empirical, and analytic) of instructional development? Of the three phases, validation relies primarily on methods of measurement, and production relies primarily on methods of organization and media production (including print); only design relies on methods of instruction. And of the three approaches, the artistic requires primarily intuition, and the raw empirical requires primarily data (and intuition); only the analytic must be supported by a scientific base of prescriptive principles. Therefore, instructional science is the foundation of the analytic approach to the design phase of instructional development (see Figure 2).

Some instructional scientists (including Bunderson) interpret the scope of instructional science more broadly to include the analytic approach to the production and validation phases; however others (including Reigeluth and Merrill) view these phases as being supported by completely different types of principles which are derived and validated by other design sciences.

There is one major problem with the foregoing analysis of approaches. Although analytic approaches to production and validation are feasible because of the development of design sciences which support them, an analytic approach to instructional design is not yet broadly feasible because the young design science of instruction has not yet developed the necessary procedures for instructional design nor even derived the prescriptive principles from which those procedures can be developed. Therefore, there is a great need for highly capable people to be attracted and encouraged to help develop this important design science.

What is Instructional Science?

Instructional science, like all prescriptive design sciences, has three types of professionals related to it: (1) scientists, who discover principles, (2) technologists, who use those principles to develop procedures, and (3) technicians, who use those procedures to produce instructional products. The technician who uses procedures need not be the same person who developed those procedures or the one who derived and validated the principles upon which those procedures are based. These three roles are referred to as differentiated because each entails a distinct activity (or activities) which requires different types of abilities and training.

Figure 2 illustrates the differentiation of roles within the analytic approach by indicating the nature of the activities of each type of professional. The analytic approach is the only one that specifically uses principles and procedures based on those principles, hence it is the approach that permits a useful differentiation of roles. In either the artistic or raw empirical approach there may be novices who imitate the techniques of the artist or the empiricist: such a person is usually called an apprentice. However, he lacks the professional expertise to do the work by himself. Hence, there is a trainer-trainee relationship, but there is no true differentiation of professional roles because the apprentice is not a professional who does a distinct activity that requires different types of abilities and training from those of his trainer. An artist or raw empiricist may often have a differentiated professional staff, but that staff is composed of professionals in different areas (e.g., graphics design, layout, videotape production), rather than of professionals at different levels within a single area.

Instructional scientists, like artists and raw empiricists, use intuition; however, intuition is used to produce principles rather than products. Intuition is also used by instructional scientists to design research for testing hypothesized principles, and the results are used to subsequently modify the hypothesized principles if necessary. In addition, new principles and results influence intuition (hence the two-way arrows in Figure 1). Thus, an interactive triad forms the core of instructional scientists' activities, with prescriptive principles of instruction as the output.

Instructional technologists apply the scientists' principles to the development of instruction. Again, this entails the use of intuition; however, intuition is used to produce procedures for applying the principles in development projects, rather than to produce raw principles. These procedures should also be empirically tested, both for efficiency and cost as well as for the effectiveness of student learning from the resulting product. Thus, another interactive triad forms the core of the instructional technolo-

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Figure 2. The three approaches to instructional development can be used on any of the three phases of instructional development. Instructional science is the foundation of one approach to one phase.
gists' activities, with validated procedures for instructional design as the output.

Finally, instructional technicians (the developers for whom instructional scientists and technologists exist) use the technologists' procedures to produce instructional products. An instructional design technician must have a good knowledge of the "tools" of his trade—such as writing techniques, instructional design components and terminology, and the procedures of instructional design. His skills are mainly concept-classification and procedure-using. Intuition is no longer the most important requirement; hence competent instructional technicians can be trained relatively quickly and inexpensively. Also, at this level, research (generalizable results) effectively drops out, and specific evaluations are used to test specific instructional products. However, because these instructional products have been designed using empirically validated principles and procedures, the probability of success is considerably enhanced, and the extent of necessary revision is greatly reduced. Although both research and evaluation are concerned with empirically testing instruction, research does so on the principle and procedure levels (hence the concern with external validity), whereas empirical evaluation tests instruction on the product level.

In summary, instructional science is the foundation of the analytic approach to instructional development; and it entails intuition and research work as inputs and the derivation of prescriptive principles and theories (i.e., sets of interrelated principles) of instruction as its outputs. A major portion of instructional scientists' activities involves analyzing the components of instructional tactics and strategies as to their effectiveness, efficiency, and appeal under different conditions (primarily diverse student characteristics and subject-matter characteristics) in order to derive the prescriptive principles and theories of instruction.

Theory Construction Before the analytic approach to instructional development, with its cost-effective use of technicians, can become feasible, instructional technologists must develop procedures that encompass the use of principles and theories; and before technologists can do that, instructional scientists must derive and validate the important prescriptive principles of instruction and construct test prescriptive theories or models of instruction. A "top-down" deductive theory-construction procedure (Snelbecker, 1974) would appear to have the greatest advantages. This theory-construction procedure entails: (1) what Snow (1973) referred to as "D-Theory" (descriptive theory and taxonomic) construction, which is the identification, description, and classification of instructional variables, both on the "cause" side (i.e., the independent variables), and on the "effect" side (i.e., the dependent variables), (2) the formulation of some basic postulates (i.e., hypothesized principles) which relate those independent and dependent variables to each other through the specification of certain tactics or strategies under certain conditions, and (3) the use of these postulates to derive testable deductions, predictions, or hypotheses, and to test the validity of each postulate by systematic experimental testing of those hypotheses. Through this continuous process of postulate-generation and experimental testing, instructional science can develop and progress.

But the design science of instruction involves more than the description of separate cause-and-effect relationships. These cause-and-effect relationships are prescriptive and valuable, but they are identified and tested in laboratory-type conditions, i.e., conditions that are carefully controlled so as to eliminate confounding variables and isolate pure effects. Although these relationships may have significant effects in a certain direction under such laboratory conditions, it is likely that their significance may be reduced, and the direction of their effects may even be reversed, in real-world instruction due to the interaction effects of all the other (sometimes unnoticed) variables.

For instance, we hypothesize that an S-shaped curve represents the relationship between the quality of instruction and the effectiveness of that instruction (see Figure 3). Experimenters deliberately design the experimental treatments such that the variable(s) under investigation will increase the quality of the instruction from a to b rather than from c to d, so that the contribution of that variable to the effectiveness of instruction will be on the order of magnitude of w to x rather than y to z. In multiple regression (statistics) an independent variable has a much higher correlation with the dependent variable if it is taken alone than if it is adjusted for all other independent variables. The same is probably true of instructional variables in instructional science, such that the significance of any component of instruction is likely to be of a much lower order of magnitude in real, planned instructional settings.

![Figure 3. The relationship between the richness of instruction and its effectiveness.](image-url)
These limitations are serious and require that the theory-construction procedure entail a fourth stage: the testing of instructional strategy variables or components by selectively adding or removing them from whole systems or models of instruction. In such a process, it may be discovered that some uninvestigated characteristics, such as some content strategy or instructional management variables, may have a larger impact on instructional outcomes than the most significant of the variables already investigated. Interaction effects can also be more effectively investigated by such a process.

An Example of Theory Construction M. David Merrill and his associates have adopted the above-mentioned theory-construction procedure: (1) the development of a taxonomy of instructional variables. (2) the formulation of a few basic postulates that relate those variables to each other. (3) the empirical validation or repudiation of those postulates through the experimental testing of hypotheses derived from the postulates, and (4) the testing of variables in realistically complex models or systems of instruction.

Merrill and his colleagues (Merrill & Boutwell, 1973; Merrill & Wood, 1974, 1975a) have developed a broad taxonomy which identifies, describes, and classifies presentation strategy variables, such as attribute isolation, mnemonics, divergent examples, and type of representation. This was a particularly important step, considering that different instructional researchers and theorists often use the same label to refer to different concepts, and different labels to refer to the same concept. A lack of precision in the scientific language of instruction has greatly impeded the communication and interpretation of theoretical and research work.

Merrill and his colleagues (Merrill, Olsen, & Coldway, 1976; Merrill, Richards, Schmidt, & Wood, 1977; Merrill & Wood, 1975b) have also constructed some basic postulates that relate the instructional variables to each other and to the following three outcomes of instruction: its effectiveness, efficiency, and appeal.

Merrill, Olsen, and Coldway (1976) conducted a review of research literature to test eight of these postulates. No results were found which were contrary to hypotheses derived from any of the postulates, but "considerable support" was found for only five of the eight postulates, while "partial support" (due to the small number of relevant studies encountered) was found for two, and no relevant research studies were found for one of the postulates.

In summary, while much more work is still needed, the area of presentation strategies has received considerable theoretical development and experimental study. The authors are currently working on the development of a taxonomy of structural strategy variables, such as sequencing (ordering) and synthesizing (interrelating) a set of related segments of a subject matter. Reigeluth, Merrill & Bunderson (in press) represents a first step toward that goal.

Applied vs. Basic Research There has been much controversy recently over priorities for applied and basic research (Ebel, 1977; Glaser, 1977; Kerlinger, 1977). Understanding and communication on this issue are impeded by the lack of clear definitions of these terms. However, the foregoing analyses may help to clarify intended meanings for each of these terms.

On the basis of the descriptive-prescriptive characterization of sciences, one could define basic research as all the research activities in the descriptive sciences and define applied research as all the research activities in the prescriptive design sciences (both at the scientist and technologist levels). Or, on the basis of the scientist-technologist characterization of researchers, one could define basic research as all the research activities performed at the scientist level and define applied research as all the research activities performed at the technologist level. Figure 4 illustrates that the source of ambiguity or misunderstanding on the concepts of basic and applied research lies in the classification of research done at the science level in a prescriptive design science, in this case, instructional science.

Arguments could be made for classifying research in instructional science either way. However, it may be more valuable to classify it as a third, distinct type of research—one that may deserve higher priority than either of the other two types because of its unique combination of basic and applied characteristics.

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Footnotes

1 As an example of a principle of instruction: "The use of examples which are divergent on variable attributes reduces undergeneralization errors in a concept-classification task."

2 As an example of a procedure for instructional design: "If the subject matter content is a concept and the desired level of behavior for the student is using the definition to classify instances and noninstances, then examples which are divergent on variable attributes should be included in the instruction."
Prerequisites For Understanding: Implications For The Design Of Instructional Strategies & Materials

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Many times instructional materials and strategies fail or are only partially successful because of misunderstanding about the nature of comprehension. In this paper we will examine some of the factors involved in comprehension and see how these factors are related to the design of instructional materials. Although the points I intend to make are true of comprehensions in general, this paper will focus upon the understanding of language.

Typically understanding what another person says seems to be a smooth effortless, automatic process. People speak and we just know what they mean. Partly as a result of this ease of understanding words we are led to false conclusions about the way that words work in allowing us to understand other people and written messages. It seems natural to assume that we learn words and their meanings, and that when we later hear the words their meanings are evoked. Understanding, then, is just being aware of the meanings of words. Words function in language, the story goes, as symbols or representations of meanings. The word is heard or seen, its meaning is evoked, and understanding occurs.

As we shall see, this set of assumptions about the way words work is inaccurate and can be detrimental in the development of instructional materials. Words do not function as referents of objects or meanings, rather, words act as cues on the basis of which we construct meaningful interpretations of messages or interactions. For example, the words "How are you?" can mean a wide variety of things depending upon how they are said and the context in which they occur. Frequently, we assume "how are you?" is not really a question in need of an answer, but a form of greeting that can vary from friendly to cold politeness. In the situations where it is in fact a question it can have many meanings such as "Are you feeling better now" if you have been sick or "Can you continue" if we are doing something difficult, or a complaint if I haven't heard from you in a long time. In each case the meaning of the phrase is inferred on the basis of the listeners knowledge about what is happening between the speaker and himself and how this might relate to other interactions, or special knowledge he has about himself, the speaker or their relationship. The words do not evoke a given set of meanings, rather they act as cues to possible meanings. If you play the game of changing contexts, changing relations between people, and changing the demands of the situation, you can create a seemingly endless set of meanings for the phrase "how are you." How can this be so? How can words work if the possible meanings they have can be such a long list? How does the head keep a record of so many possible meanings for the thousands and thousands of words we know? The answer, as we shall see, is that the meanings are not stored. Rather, the meanings are created in the different situations. Words act as cues for this creation, they do not stand for a list of meanings which are evoked as the words are experienced.

Read the following words slowly with the knowledge that you will be asked to remember them in a few minutes: pillow, spread, bed, rug, slippers, yawn, book, pajamas, dress, light, robe, awake, alarm, sheet, blanket. Now write down as many of the words as you can remember. About 30% of my students who hear or read this list later remember the word sleep. Sleep, however, was not in the list of words. This is not a surprising result if we assume that the words led people to imagine or construct in their mind a situation or series of events that would occur in a bedroom. Many of these constructions could involve sleeping, or falling asleep, or waking up. If the act of sleeping was a part of the construction then it makes sense to remember or think you heard the word sleep. The words acted as cues on the basis of which you created possible or likely mental constructions. What you tend to remember is the construction, i.e., what your head builds, not just a copy of the list of words. Consider now what it means to have understood those words. The understanding was an active process, the creation of mental events. It is this active building of mental events which characterizes comprehension. What we understand depends upon the events we construct and what we learn is contained in these mental constructions.

Similarly, when we listen to people talk or when we read sentences and paragraphs we are rarely able to recall the exact words that were used. What we are usually very good at remembering is the meaning of what was read or said. In a cleverly designed series of experiments, Sachs (1966 & 1967) presented short stories to subjects. She stopped the story and presented new sentences to the subjects asking them if they were identical to sentences in the story or changed in any way. The subjects were unable to consistently detect changes in the form of the sentences. However, any change that effected the meaning of the sentences was detected 80% to 90% of the time.

For example, consider the following five sentences actually used by Sachs.

BASE (unchanged): A wealthy manufacturer, Matthew Boulton, sought out the young inventor.

SEMANTIC CHANGE: The young inventor sought out a wealthy manufacturer, Matthew Boulton.

ACTIVE TO PASSIVE CHANGE: The young inventor was sought out by a wealthy manufacturer, Matthew Boulton.

FORMAL CHANGE: A wealthy manufacturer, Matthew Boulton, sought the young inventor out.
LEXICAL CHANGE: A rich manufacturer, Matthew Boulton, sought out the young inventor.

The "base" sentence was in the original story. If forty seconds or more had passed since the subject heard the base sentence the passive/active, formal, and lexical changes were not detected at a level different from chance. In contrast, the semantic change was consistently detected as different. Sachs' subjects had knowledge of the meaning of the passages, but they had little knowledge of the exact words in the sentences or the form of the sentences. Much as they did with the word list you heard, these words also acted as cues for the mental constructions. Consequently, sentences which were consistent with the constructions of Sach's subjects were not detected as changed. Clearly, when we listen to or read words we do not learn copies of the words or sentences themselves, rather we learn the meanings that we construct.

Studies such as the Sachs' studies illustrate that the words somehow act as the basis for mental construction and that what we know or remember are these constructions. It is not the case that we remember sentences and repeat them back again so we can remember what they meant. We remember our constructed meanings and evaluate consequent events in terms of these constructions. The meaning that sentences have for us are the mental constructions we create when we experience the words.

Brunsford, Barclay, and Franks (1972) discuss a series of experiments which investigate the nature of these constructions. Consider the sentence "Three turtles were sitting on a log when a fish swam beneath them." Subjects who heard this sentence later believed that they had heard sentences which said the fish swam under the log. The event of the fish swimming under the log is implied in the original sentence and would therefore, be in our mental constructions about the sentence. It is important to note, however, that the event is not described in the sentence or contained in the meaning of the words in the sentence. The event of the fish swimming under the log is implied given what we know about turtles, water, logs, and fish and how these objects can interact. It is not contained in the meanings of the words. If we have the appropriate knowledge we can use the words as cues to build a mental construction. What is contained in these constructions goes beyond the meanings of the word used.

In a related experiment Johnson, Bransford, and Solomon (reported in Bransford and McCarrell, 1975) found that after hearing the following sentences "John was trying to fix the birdhouse. He was pounding the nail when his father came out to watch him and help him do the work." Subjects frequently believed that they had heard a sentence containing the word hammer. Again, note, that hammer is implied only if you have the appropriate knowledge. In other times or cultures, "rock" could have been implied by a similar sentence. Hammer is implied for us because of our knowledge about tools, birdhouses, etc., and it is not in the meaning of the words in the sentence.

To review, understanding is not an awareness of given meanings which we store and bring to mind when the word is experienced. Rather, words act as cues allowing us to create semantic constructions on the basis of knowledge we have about the words, the situation, the objects involved, and the possible interaction of these factors with each other. As the above examples have shown the content of the construction is more than what is contained in the meanings of words. The content of the construction depends upon what the listener contributes, it is not predetermined by meanings which are evoked when the words are heard.

To this point we have discussed evidence suggesting that words act as cues to allow us to build mental constructions. Now I would like to turn to a consideration of the factors necessary for this construction to occur. John Bransford and his colleagues have conducted a series of experiments investigating some of the limitations upon people's ability to understand and recall verbal material. Consider the sentence "The trip was not delayed because the bottle shattered. The haystack was important because the cloth ripped. The note was sour because the seam was split." At first, these sentences sound like nonsense and are difficult to remember even a few seconds after they are heard. McCarrell, Bransford, and Johnson, reported in Bransford & McCarrell, (1975), that subjects were extremely poor at recalling sentences such as these and found them exceedingly difficult to understand. However, the same sentences were not difficult to remember or understand when preceded with appropriate context cues: (christening a ship) The trip was not delayed because the bottle shattered. (parachutist) The haystack was important because the cloth ripped. (accordionist) The note was sour because the seam was split. When the sentence occurs in a context that provides the listener enough information to create a semantic construction, understanding and memory are easy. When the conditions are such that the necessary information is not present, exactly the same words seem terribly difficult to understand and remember. If understanding was simply a matter of having words evoke meanings, the sentences would be equally understandable with and without the contextual cues.

The contextual cues are effective only if we have appropriate knowledge. It is possible for someone to know the meaning of the words in the sentences and not have knowledge of christenings. In that case the meanings of the words would not be a sufficient condition for understanding the sentence even if the contextual cue (christening) was present. Understanding entails the successful creation of semantic constructions. If we are unable to build these constructions understanding does not occur. Relevant background knowledge is required to build the constructions. Knowledge of the words in the sentences is no guarantee that the sentence can be understood by the listener.

Finally, consider the following paragraph.

"The procedure is actually quite simple. First you arrange things in different groups. Of course one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step, otherwise you are pretty well set. It is important not to overdo things. That is, it is better to do too few things at once than too many. In the short run this may not seem important but complications can easily arise. A mistake can be expensive as well. At first the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for this task in the immediate future, but then one can never tell. After the procedure is completed one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is a part of life."
This paragraph was used in an experiment conducted by Bransford and Johnson (1974). Subjects showed poor comprehension and very little ability to recall the words in the paragraph. The problem in understanding this paragraph is not a problem of word meanings. We all know all of the words in the paragraph. The difficulty in understanding this sentence is a problem of creating a semantic construction which fits the paragraph. Read the paragraph again with the knowledge that it is about the task of washing clothes. Now the same words can provide you with a completely different experience. Notice how you are constructing situations, objects, and relations in your mind. For example, what is the mistake that could be costly? This demonstration shows that the meaning of the words, the meaning of the sentences, and the meaning of the paragraph depend upon the listener being able to construct a semantic interpretation. When the listener fails at this task, the prose seems to have no meaning. It is not sufficient for understanding that we have relevant knowledge. All of us have enough knowledge about washing clothes to understand what the paragraph is about if we know what part of our knowledge is relevant to understanding the paragraph.

Implications for Instructional Design

In the first part of this paper we saw that to understand, a listener has to actually build semantic constructions. When we interfered with this building even simple facts were not grasped or remembered. Instructional materials will fail if they do not lead the learner to build relevant semantic representations. To build these representations the listener must have the necessary background knowledge. Unless you had knowledge of Christenings you could not build an appropriate representation for “The trip was delayed because the bottle shattered.” Similarly, unless you had knowledge of parking laws and penalties you could not understand, “The car was gone because he didn’t have change.” In addition to needing appropriate background knowledge, the listener must know what aspect of his knowledge is relevant to the problem at hand. In the washing clothes example we all have the background knowledge necessary to build the appropriate constructions. However, we are not aware of what parts of our knowledge were relevant.

Consider the instructions for filling out your income tax forms. These instructions work, in that, if you follow them carefully you will be able to complete the task. However, following the steps in the instructions does not give you much information about what you are doing or why. The steps involved in doing a task need not give you any understanding about what you have done. It is important to keep the differences clear between instructions on how to do a task, such as assembling a toy or piece of furniture, and instructions which allow you to understand what is involved in the solution of a problem or similar problems.
Consider the scissors in figure 1. (This figure is taken from Bransford and Mccarrell, 1976). Suppose you are assigned the task of developing instructional materials to teach people to correctly identify each of the five types. One procedure would be to develop criteria or defining characteristics which when mastered would allow the learner to correctly identify each type of scissors. Typically, characteristics such as size of blades, size of handle, shape of blade, shape of handle, shape of blade tips, and weight, might be used. The learner would then be required to learn the six defining characteristics of each type. Once the characteristics of each type had been acquired the learner would have a foolproof set of procedures for identifying the five types of scissors.

What is wrong with such a set of procedures? It is clear that this system once learned would in fact allow the successful identification of the scissors. There are, however, a number of problems with such a set of procedures. It is clear that this system once learned would in fact allow the successful identification of the scissors. There are, however, a number of problems with such a set of procedures. First, the task of memorizing the six characteristics of each type seems complicated and difficult. Five characteristics for each type must be memorized. This means six for each of five scissors types, i.e., 30 items to be memorized. The real problem, however, is that most of us do not have background knowledge that relates to the criteria we have selected. We are hard pressed to build semantic constructions based upon size of handles, size of blades, etc.

These characteristics seem artificial in that it is difficult to organize them or group them in terms of things we already know. Even when memorized the list of characteristics has little relation to other experiences or situations we might encounter. They are simply a set of unrelated facts which don't make sense in terms of the rest of our knowledge of the world. In such a list, facts are easily forgotten and confused with each other. Another way to say all of this is that the learner cannot understand the scissors types. He is left with the tedious task of memorizing the six defining characteristics of each of the five types of scissors.

An alternative would be to develop instructional materials which would lead the learner to use his existing knowledge to build constructions concerning the five types of scissors and their relations to each other. For example, we could develop materials leading the learner to infer or discover the relation of the structure and function of the scissors. The heavy scissors with the lower blade flush to a surface and an unusually large finger hole are for cutting cloth. They are heavy for cutting heavy material, the blade and handle are designed to allow them to slide along a flat surface as you cut, and the large finger hole allows more fingers and therefore stronger pressure to the cutting blades. Now look at the other types: which might be safe for small children? How would finger holes be helpful to children? Which scissors would be good for cutting hair? Why? Now the learning of the different types seems sensible, easy, and straightforward. This is because we have selected criteria that are appropriate to our background knowledge. We all have knowledge about material, about what is necessary for something to slide along a flat surface, how pointed tips could be harmful to children, etc. Your existing knowledge is useful and you know which parts of your knowledge are relevant. Now, the task seems so easy as to be almost automatic. But if you look carefully, you will see your head at work building constructions which entail the relations that make sense of structure and function. The understanding is not automatic, and is only possible because of the existing knowledge you have. If you were from another culture and did not have the relevant knowledge you would once again be in the position of memorizing unrelated facts.

So much of what we teach people is learned as isolated facts that don't relate to the rest of their knowledge. I have interviewed children who had recently finished a 6th grade science curriculum. When asked about cells, they seemed to have learned a considerable amount. They knew about cell walls, cell nuclei, and the division of cells. However, when asked about where cells were, and what things had cells, they looked at me with a blank stare. "Do you have cells in your body? Do plants have cells?" They didn't know the answers to these questions and had not even considered them before they were asked. Clearly, they had no idea which part of their knowledge was relevant to the information they had been learning about cells. They had not used relevant aspects of their existing knowledge to build constructions about cells. They had memorized facts which were meaningless and irrelevant to them. The second set of characteristics we discussed is easy to make sense out of in terms of familiar objects and events in the world. Sharp points could be dangerous to children so the children's scissors have blunt tips. Small children are not well coordinated so the finger holes are large. Similarly, it is easy to imagine the importance of thin sharp blades for cutting hair. If the blades were dull they might pull the hair, if the blades were thick it might be difficult to cut the hair close to the ears. The building of these constructions is not difficult and seems sensible and natural. We have relevant background knowledge, and we are aware of what part of our knowledge is relevant. Now the task of building semantic constructions is once again easy and almost automatic.

We have seen that (1) understanding is a problem solving type of activity which entails constructing semantic interpretations. (2) To be successful at this task the listener must have appropriate background knowledge and (3) must know what aspects of his knowledge are relevant to the task of understanding. Knowing the meanings of the words is not a sufficient basis of understanding. The problem is not simply a vocabulary problem. Rather, the problem of understanding is one of providing sufficient conditions for the construction of semantic representations. To be successful, instructional strategies and materials must lead the learner to use her knowledge to develop these mental constructions.

Finally, consider the following definition of "constitution" which is typical of that found in eighth grade social studies texts. A constitution tells what a government can do: what the parts of the government are, and what work each part will do. An eighth grader can memorize this definition without too much trouble and read a chapter on constitutional government. Having completed these two tasks, the student could appear to understand the term constitution. However, it is unlikely that the semantic constructions necessary for understanding were actually built by the students. The definition does not provide cues which lead the student to use his existing knowledge to create relevant semantic constructions. The words "tells what a government can do" do not automatically bring examples or instances of events
covered by the constitution to mind. To understand, however, the student must in fact create mentally or deal with such instances. The meaning for the student is not in the words, but in the semantic construction he builds. Consequently, the students can learn the definition, read a chapter on history, pass related tests, and still have almost no knowledge of what a constitution is that is relevant outside the classroom. If asked about the following situation, most students would have difficulty seeing its relevance of the constitution. Suppose you got a job after school and then discovered that an older person who had worked there just as long as you and was doing exactly the same job, was getting twice as much as you. Can the employer do this? Is it legal? How could you find out? Learning the definition itself does not lead to the creation of the semantic constructions necessary for understanding.

An alternative instructional strategy to learning the definition, reading a chapter, and taking a test, is to design materials which lead the student to use his knowledge to create related semantic construction. For instance, the student might be directed to existing knowledge he has of rules in games, clubs, family situations, etc., as a source of relevant knowledge. What if the pitcher on the other team wants to stand five feet in front of the mound? Is it fair? How do we decide? This knowledge forms a basis upon which to create semantic constructions about the constitution and its functions.

Students could then be lead to build such constructions in many different ways such as: (1) considering interesting or relevant examples of individual, group, or governmental rights, (2) actually participating in the formation of a set of club rules or classroom rules, (3) or hypothetically solving important personal or group problems in terms of a state or city constitution. The list of possible alternative strategies is endless. What is important is that they lead the student to create the semantic constructions necessary for comprehension. They are not organized simply in terms of the subject matter, rather, they take into account the students existing knowledge and his task of creating semantic constructions. (For a more in depth account of the nature of comprehension and implications for instruction see Wilson, in press; and Shaw and Wilson, 1976).

References


An Alternative For Task Analysis In The Affective Domain

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Abstract

Application of commonly-used task analysis procedures to the affective domain leads to difficulties with instructional design, specification of intermediate objectives, and completeness of analysis. Analysis of objectives in six domains is presented as an alternative. Basing analysis on cue sensitivity, without directly stipulating stimulus conditions, can serve as a useful technique in domains other than the cognitive.

Of the three domains of learning commonly employed by instructional developers to map their objectives, the affective domain is perhaps the least well understood. In many development projects enormous effort is expended on task analysis and the specification of objectives for cognitive and psychomotor learning, but analysis in the affective domain is left to a few hopeful statements that "the student will value the concept of..." or that he or she "will spontaneously seek further information on..."

This approach to the affective domain typically focuses on feelings about stimulus objects or concepts presented in the cognitive and psychomotor domains. While we would all like students to have good feelings about what they learn, many tasks demand a more complete affective analysis. Objectives which focus directly on the stimulus conditions and desired responses (the most familiar form of the behavioral objective) are particularly difficult in the affective domain. There are at least three main reasons for this.

First, instructional design from such objectives is difficult. The values and attitudes which underlie an objectives list are acquired slowly, as a cumulative result of a number of elements in the environment—not all of which are within the control of the instructional designer. The precise correspondence of objectives, instructional episodes and outcome measures which marks good instructional design in the cognitive and psychomotor domains usually is not practical in the affective domain.

An example may illustrate the point: to an experienced instructional developer, a high-level cognitive objective (in the terms of Bloom's Taxonomy) readily suggests the parameters for design of a learning environment which will lead most learners to mastery of the objectives. The same is not true for a high-level affective objective such as, "faith in the power of reason and in methods of experiment and discussion" (Krathwohl, Bloom and Masia, 1964, p. 182).

A second major difficulty is that specification of intermediate objectives for affect is frequently difficult. As Wight (1971) points out, the need for practical objectives calling for realistic conditions, observable behaviors and feasible performance criteria frequently leads even the most conscientious developer to lose track of the affective goal in a sea of only marginally relevant detailed objectives. Suppose, for example, that the general instructional goal is, "The medical student shall show respect for the dignity of the patient;" what Krathwohl et al. (1964) might call a Generalized Set. Then it becomes necessary to (1) determine the behaviors which indicate respect of the patient and (2) write a series of objectives which specify how, under each combination of patient characteristics and circumstances, the student is to behave. The problem is that within realistic limits, it is virtually impossible to write a sufficient number of detailed objectives to ensure that the student will reliably generalize to the broad range of novel situations he or she will have to deal with in the real world. There are too many patient characteristics, too many situational factors and too many ways of demonstrating respect for any practical set of conventional behavioral objectives to adequately map the general goal. Each of the series of objectives would have to be of the sort:

Given a female patient, in her late thirties, who is well-dressed, college educated, in no immediate distress, and who is being interviewed by the student for the first time, seated in an outpatient clinic office, during normal office hours, where there is adequate privacy, ... the student sits him/herself so that his/her eyes are on the same level as the patient's, within a criterion of ± 1 foot, and...

However many intermediate objectives of this sort one writes, the analysis inevitably has an air of triviality; the general goal defies analysis in this way.

In the particular example chosen, one common way around this problem has been to group patients into "types;" seductive, dying, angry, etc. and then to provide rules for behaving with each type. This is only a partial solution, however, since students will still have difficulty generalizing to patients that do not fit neatly into whatever classification scheme is employed.

In some styles of objective writing (e.g., Gronlund, 1970), such extreme detail in specification is left implicit. Even there, however, the principle is the same: the objective must specify the link between each stimulus condition and the corresponding response.
A third difficulty with task analysis in the affective domain is that the domain itself is incomplete. "Affect" is usually equated with "feelings" or "emotions." While these factors are unquestionably important, they do not constitute (when taken together with the cognitive and psychomotor domains) a complete mapping of learning outcomes. Foskay (1975) has identified six domains, summarized in the first two columns of Table 1. While the familiar cognitive, psychomotor and affective domains may be identified among them, Foskay calls for consideration of types of learning not easily described within the more familiar three-part framework. Social learning is identified as a separate category because all learning environments (even the autotutorial) teach lessons about social structures. These lessons concern relationships with others and moral and ethical principles. Thus, while the student learns about geometry, he or she also learns about teacher and student role expectations, the moral and ethical principles of the classroom environment, and so on. The lessons of this domain are difficult to specify in strictly cognitive, psychomotor and affective terms; most commonly, they are not specified at all. The aesthetic domain is included because the learner responses mentioned (formal, technical, sensuous and expressive) are qualitatively different from those of the cognitive and affective domains. Attention here focuses on the learner's ability to judge his own experience of an object or situation, rather than on the qualities of the external stimulus itself. The spiritual domain refers at one end to the sense of astonishment over the phenomena of the world and of man; at the other end of its continuum might be the kind of transcendental response found in intense experiences of all kinds: meditation, love—even combat.

Specification of objectives within these domains is a process more complex than that to which developers are accustomed. Clearly, the emphasis given to analysis in each domain would vary according to the goals of instruction. It would be ludicrous, under most circumstances, to analyze the spiritual implications of mastering the manipulation of a cash register. It might not be irrelevant, however, to structure an introductory computer course so that students who feel that the computer is a threat to their humanity can identify and evaluate their beliefs. Similarly, a goal such as "showing respect for the patient" probably necessitates analysis in all six domains.

An Alternate Method of Analysis

Techniques for task analysis in domains other than cognitive (intellectual) and psychomotor (physical) are not well developed. As explained above, analysis of expert performance into the familiar stimulus condition + response + performance criterion format (Mager, 1962) seems impractical, if not misleading. When defining competencies in domains other than cognitive and psychomotor, it is hard to write objectives which specify performance in terms of specific stimulus conditions: except in simple cases, the complexities of the situation will defeat even the most exhaustive analysis.

It may be that the basic problem is with the way in which stimulus conditions are specified. In cases where it is impractical or misleading to describe observable stimuli, the developer may be able to leave students to identify stimulus patterns on their own, without detailed instruction.

Empirical work done in counseling psychology seems to suggest the effectiveness of this mode of analysis. Working from different perspectives, three authors (Carkhuff, 1969; Kagan, 1978; Smith, 1973) have devised empirically validated ways of examining, analyzing and designing instruction in different areas of human relations. Each has developed techniques for identifying observable cues to feelings and emotions. In any given situation, the specific cues are unique; in spite of this, it has proven possible to teach students to identify the cues reliably, and to respond to them in prescribed ways. In effect, the task analysis has focused on cue sensitivity and general prescriptions for responding to the interpreted cues. The complex recognition of stimulus patterns involved in cue interpretation usually is not described in detail, and instruction is by means of positive and negative exemplars. In spite of this, the skills appear to generalize reliably to novel situations where the specific cues and responses are completely different.

This approach is more process-oriented than is traditional task analysis. An objective constructed according to this technique would not focus directly on the stimulus characteristics and the appropriate response. Instead, the objective would be phrased in terms of sensitivity to cues and processes by which an appropriate response to these cues can be formulated. Little or no attempt would be made to identify specific stimuli (or patterns of stimuli) which call for specific responses. Instead, students would be called upon to identify (and perhaps to label) the patterns themselves. They would then formulate their responses and be taught how to judge the quality of their decision-making. Again, the experience in counseling psychology cited above suggest that this can be done most efficiently by use of examples and nonexamples; the underlying concepts do not appear to be amenable to full verbal definition—though they may be verbally labeled.

Applications to Instructional Development

The modes of analysis presented here provide a way for the instructional developer to analyze and design instruction for certain complex tasks. In addition to identifying the cognitive and psychomotor components of tasks, it may be appropriate to identify emotional, social, aesthetic or spiritual components as well. Where objectives for these domains would be cumbersome or misleading, if written in the conventional way, they may instead be written in terms of cue sensitivity and appropriate types of response. For example, if the goal is for students to "show tolerance of others' religious beliefs," than it might be appropriate to write objectives such as:

The student shall identify the similarities and differences between beliefs of a practicing Catholic and a practicing Jew, presented in short first-person statements. (Cognitive)

The student shall formulate and label novel examples of conversational responses which a devout Moslem would probably find religiously offensive or agreeable. (Social)

The student shall spontaneously respond to a sacred object from a religion other than his/her own by identifying some characteristics of the response provoked by the object in those who practice that religion. (Aesthetic)

The student shall identify and describe his feelings toward one who believes in a faith other than his/her own. (Emotional)

The student shall (1) formulate his/her own posture for meditation, (2) evaluate the appropriateness of the position in terms of its "feel," and (3) evaluate its
implications in terms of the relationship of mind and body, within any system of belief of his/her choosing. (Physical, Spiritual)

Except for the cognitive objective, each of the above calls for the student to increase his or her sensitivity to particular types of cues. However, the precise nature of the cues is left unspecified, because to do so would be too complex a task, or because the cues themselves are not verbally describable (though they may be verbally labeled). Each objective also includes information about the way in which the response to the cues is to be formulated. In general, instruction formulated for these objectives would probably include many positive and negative exemplars, with modeling and prompting where feasible. It is likely that verbal definitions of the underlying concepts would be of limited utility.

Additional examples of objectives formulated in this way are presented in column three of Table 1.

Conclusion

The alternatives offered here are not intended to lead to the conclusion that all task analyses are inadequate unless performed in the six domains presented, and by the method discussed. As argued by Davies (1973), a task analysis must include a variety of techniques chosen because of their appropriateness to the problem. It is hoped, however, that these techniques will prove of value when the developer is not satisfied by the results of a more conventional analysis.

There are many unanswered questions. For example, it has yet to be determined how the social, emotional, aesthetic and spiritual domains might be organized; it may well be that hierarchies are not appropriate. In addition, evaluation of objectives in these domains obviously requires techniques unfamiliar to most developers. Finally, experience with the analyses described here is too limited, at this point, to assess their efficiency or effectiveness in comparison to established techniques.

References


Table 1: Domains of Learning (After Foshay, 1975)

<table>
<thead>
<tr>
<th>DOMAIN</th>
<th>DEFINITION</th>
<th>SAMPLE OBJECTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Intellectual</td>
<td>Similar to Bloom's Cognitive Domain.</td>
<td>Given data on the growth pattern of a city, the student shall formulate an original hypothesis explaining that pattern and judge the explanatory power of his hypothesis.</td>
</tr>
<tr>
<td>The Emotional</td>
<td>Feelings, emotions and emotional development.</td>
<td>When reviewing a videotape of a role-playing situation, the student shall identify the internal cues which permitted him to judge his emotional state at various times during the experience.</td>
</tr>
<tr>
<td>The Social</td>
<td>Development of social organization; moral development.</td>
<td>When confronted with a moral dilemma involving a simulated or real patient, the student shall (1) identify the nature of the dilemma in the vocabulary of this course and (2) identify the need for involvement of others in the decision.</td>
</tr>
<tr>
<td>The Physical</td>
<td>Psychomotor skills; development of physical self-concept.</td>
<td>On the basis of internal cues (e.g., &quot;feel&quot;), the student shall evaluate a novel dance step of his/her own invention.</td>
</tr>
<tr>
<td>The Aesthetic</td>
<td>Formal, technical, sensuous and expressive response to an object of contemplation.</td>
<td>When presented with a novel sculpture, the student shall identify and express his/her own response to the sculpture, and evaluate the nature of the response using the concepts of this course.</td>
</tr>
<tr>
<td>The Spiritual</td>
<td>Relating to the search for ultimate meaning.</td>
<td>The student shall identify and interpret cues in his/her patient's behavior which communicate the patient's sense of the meaningfulness of life.</td>
</tr>
</tbody>
</table>

Note: The sample objectives are drawn from a variety of "levels" within each domain, and thus are not of comparable complexity.
Prototype Development Of
A Self-Instructional Program
In Media Selection

Elaine A. Weiss

Introduction

The purpose of this study was to develop and test a self-instructional program in media selection, for use by teachers, librarians, and media specialists. The program was developed by applying design criteria from systems approaches to instructional development. This article will describe the instructional development model used to generate the instructional program, the development procedures utilized, and the results of the study.

The Model

The study used a systems model to design the self-instructional program. There are several advantages to using a systems approach to instructional design. They include: the specification of learning objectives; identifying and selecting alternative ways of meeting these objectives; and feedback, in the process of developmental testing, to validate the design. Articulation of the development process, as in this study, allows for both replication of the process and, hopefully, some insights into the reality of instructorial development. The flowchart in figure 1 illustrates the instructional development model used in the design of this program.

Development Procedures Utilized

The problem was to develop a self-instructional program in media selection which would be appropriate for graduate students in a variety of educative fields. The proposed program was to constitute the entire curriculum of a five-week course on media selection, offered each semester at Teachers College, Columbia University. The course was scheduled to meet once a week, for two hours each session.

Three goals were developed for the course:

1. To acquaint students with the literature on media selection
2. To familiarize students with the information sources available for media selection
3. To help students develop a set of criteria for evaluating instructional media

The program objectives were derived from a study of the competencies identified in the literature on media selection. A wide variety of sources were consulted in an effort to develop course objectives which reflected the needs of the field. Among the most helpful were the competencies identified in the JIMS study, and the AASL School Library Manpower Project. An ERIC search under the descriptor “Media Selection” identified four existing self-instructional programs in media selection. A review of these programs was made to determine the necessity of developing a new program for the identified setting; however, none of the programs met the needs of the identified target population at Teachers College. In the process of deriving the objectives, an extensive bibliography on media selection was compiled, and eventually incorporated into the course. The following objectives were developed:

1. Match the type of information useful in media selection with the appropriate information sources.
2. Discriminate between examples and non-examples of behavioral objectives.
3. Match instructional media with descriptions of their characteristics.
4. Name at least one strength and one limitation for each of the instructional media reviewed.
5. Name criteria to be considered when selecting any medium or media mix.
6. Develop an evaluation form for any medium which applies criteria developed in objective 5.
7. Discriminate between the Kemp and Goodman models of media selection.
8. Match an instructional objective to the most appropriate medium or media mix, and defend the choice in writing.

Once the objectives were developed and refined, test items were developed which were congruent to these objectives. The test, which consisted of matching, completion, and essay questions, was administered to learners as both a pre- and posttest. A criterion level of 80% was set for program mastery. In addition, data gathered from a comparison of pretest and posttest scores was used in the revision cycles of the development process. To further aid in the revision of the program, an attitude questionnaire was administered to learners upon completion of the course. A draft of the questionnaire was first submitted for review to a colleague in the Department of Measurement and Evaluation at Teachers College, and revised according to her suggestions. There was no formal validation of the questionnaire. It was felt that, since the purpose of the questionnaire was to gather data for revision only, face validity was sufficient.

Although the final form of the program was intended to be self-instructional, the first prototype to be developed and tested was teacher-directed. The prototype used a lecture and discussion format, and constituted the entire curriculum of the course. This instructional strategy was purposely chosen to give the investigator valuable data for revising the ma-
terials. In a teacher-directed course, the teacher is in direct verbal communication with the learners during the entire time of instruction. The investigator made use of this close contact with the learners to gain additional feedback on the course content and structure, above and beyond the performance measures described above. It was this "on-the-spot" feedback that provided much of the information necessary for transforming the course from a teacher-directed to a self-instructional format.

Developmental Testing

The self-instructional module was developed, tested, and refined in three cycles. Each cycle included:

1. administration of a pretest, to determine which objectives the learners could meet prior to the program
2. presentation of the instructional materials to the learners
3. administration of a posttest, to determine which objectives the learners could meet as a result of the program
4. evaluation and revision of the objectives, performance measures, content, and instructional strategies based on an analysis of pretest and posttest scores and feedback from the learners

The performance of these four steps constituted one complete cycle.

Cycle 1: The prototype presented in cycle one was in the form of a teacher-directed course, as stated previously, to gather data on content and instructional strategies before developing the final self-instructional module. This prototype was presented to a class of fifteen graduate students at Teachers College, Columbia University. Field notes were recorded for each lecture, to identify issues and concerns which might be of value in developing the self-instructional program. Students were pre- and post-tested, and an attitude questionnaire was administered on the last day of class. Figure 2 shows a comparison of pretest and posttest scores, by program objective. An analysis of this data indicated the need for numerous revisions. None of the students had reached the 80% criterion level set for mastery of the course (see figure 5). It was clear that changes would have to be made. Among these were:

1. Changes in course objectives. Four objectives were eliminated, and three new ones were added. All students had passed Objective 2 on the pretest, so it was felt that it was unnecessary to include this objective in the course. Objectives 4, 6, and 8, while valuable in terms of their content, were difficult to measure in a classroom setting. Therefore they were eliminated as terminal objectives. An additional objective was included to supplement Objective 1, as this was an area in which the students experienced confusion. And two more objectives were added in the area of media selection literature, based on student responses in class and on the attitude questionnaire. The new objectives read as follows:

1) Match the information useful in media selection with the appropriate information sources.
2) Identify key features of specific selection tools.
3) Match instructional media with descriptions of their characteristics, using Kemp's summary of characteristics of audiovisual materials as a referent.
4) Name five criteria to be considered when selecting any medium or media mix.
5) State Gerlach and Ely's basic rule for media selection.
6) Discriminate between the Kemp, Goodman, and Allen models of media selection.
7) List Diamond's five factors in the media selection process.

2. Changes in performance measures. Student responses on the pre- and posttests occasionally indicated some confusion with specific items. These items were subsequently clarified. In addition, essay items were changed to either multiple-choice or completion format, for ease of scoring and analysis.

3. Changes in instructional strategies. The decision to transform the course into a self-instructional module was confirmed by an analysis of the data. Lecture-discussion format was replaced with library assignments, self-study worksheets, and hands-on experiences with information sources. A totally self-directing module was developed, which included a list of program goals and objectives, instructions on how to use the materials, and work-sheets to accompany specific library assignments. Materials were placed on reserve in the Teachers College library, and worksheets were corrected and returned to the students within 24 hours of the time they were turned in.

Cycle 2: The self-instructional module was presented to a class of eleven graduate students at Teachers College. After the students took the pretest, they were given copies of the module and told that they had five weeks in which to complete the materials. Students were free to proceed through the module at their own speed, within the five-week limitation. They were encouraged to call upon the instructor for individual help if the materials were unclear or if other problems arose. Several students took advantage of this offer, and offered constructive criticism. This feedback was particularly helpful in identifying unclear instructions within the module. At the end of five weeks, a posttest and an attitude questionnaire were administered. Figure 3 shows a comparison of pretest and posttest scores, by program objective. Although an analysis of the performance measures indicated the need for some revisions, the most interesting data emerged from the attitude questionnaire.

Student responses clearly indicated that, for the most part, students were unhappy with the self-instructional format of the course. All but one student indicated a preference for an instructional strategy which included discussions. Although the majority of the students found the course well-organized, they felt that the work was neither challenging nor interesting.

Only half the students reported gains in learning (although posttest performance clearly contradicted this report) and only half said they would recommend the course to other students. When asked to name the single weakest feature of the course, students generally indicated that they felt deprived of the opportunity to share their discoveries and questions with the instructor and their peers in a classroom setting, and resented being "shunted off" to the library. These responses were particularly surprising, in the light of the fact that 100% of the students had passed the posttest (see figure 5). Clearly, although the instructional setting was successful insofar as mastery of objectives was concerned, the program had not met all the needs of the students. It is interesting to note that, had the design decisions been based on performance measures alone, this discovery and the subsequent revisions would have never been made. Instead, this unexpected finding led to a major revision in the final prototype of the module. The decision was made to change the totally self-instructional na-
ture of the course, since student response to this strategy was so clearly negative. The course curriculum was still based on the module. In addition, however, two discussion groups were scheduled during the five weeks, to give students an opportunity for group interaction. The agenda for these two group meetings was incorporated into the module, along with specific library assignments as prerequisites for the meetings. Several minor revisions were also made in the organization of the module, including:

1. The addition of a matrix, showing the relationship between course objectives, assignments, and reference pages in the module. This was included because the instructor received numerous telephone calls throughout the five weeks from students who were unclear about course assignments. A frequent source of this confusion was the relationship between the list of course objectives and the items on the task sheets. It was felt that a matrix would alleviate this problem.

2. The inclusion of a bibliography on media selection (one copy of such a bibliography had been placed on reserve in the library, but students expressed a desire for their own reference copies);

3. More introductory material, to clarify each of the library assignments;

4. Answers to the worksheets were posted, to make the library assignments self-correcting.

Cycle 3: Cycle three was presented to a group of eight graduate students at Teachers College. Students were pre-tested, and copies of the module were distributed. As in cycle two, students were permitted to proceed through the module independently. However, the two group meetings, with their prerequisite library assignments, lent some structure to the students' use of the module. The class met twice as a group during the five-week course, and attendance was high (seven students) for each meeting. At the end of five weeks, a posttest and attitude questionnaire were administered. Figure 4 shows a comparison of pretest and posttest scores, by program objective. A comparison of figures 3 and 4 reveals that, objective-by-objective, posttest performance was slightly higher for cycle 3. In addition, student response on the attitude questionnaire was highly favorable. Students found the library assignments to be extremely valuable in meeting course objectives, and enjoyed the self-instructional portions of the course, as well as the group discussions. The data from cycle 3 indicated that this final prototype met the demands of the original design criteria, i.e., to develop a course on media selection which was appropriate to the needs of graduate students at Teachers College. As a result, no further revisions were made in the module.

Conclusion

This article has attempted to describe the process of implementing an ID effort on a small scale, in a typical and believable setting. Although the ID literature is replete with comprehensive planning and development models, the fact remains that the majority of instructional development is carried on by overworked faculty members, in cramped offices, within under-funded departments. Nonetheless, the end results are often satisfactory, and occasionally spectacular.

Bridging the gap between general principles and the constraints of the real world is something we rarely learn until we are out there doing it. If so much of the ID work currently being done is on this small scale, then there is value in publicizing and articulating examples of it for the benefit of others in the field. Three implications for other instructional developers emerged from this study. First, when the final format of a course is to be self-instructional, there is a lot to be said for beginning with a teacher-directed course. Prototype testing conducted in this format provides valuable baseline data for subsequent revisions; data which would otherwise be unavailable to the developer. In this case, useful information was gathered on the entering skills of the students; confusing issues in the course content; and amount of time required to master the objectives. If the first prototype had been self-instructional, designed without benefit of this data, many more design decisions would have of necessity been based on intuition rather than fact, and the resulting product would have been weaker.

Secondly, student confusion on how to use the module during the second cycle carries a clear message to potential designers of self-instructional materials. The research on self-instruction revolves around the presentation of content, e.g., number and type of feedback items; response mode; pacing; and step size. But an equally important factor is the clarity of the instructions to the learner on how to use the materials. A self-instructional program is only effective if its users understand how it works. And the longer it takes a learner to decipher directions, the less time is spent on actual instruction. Thus developmental testing of self-instructional materials should include an evaluation of the instructions, as well as the instruction. Finally, it is strongly recommended that developmental testing include an analysis of student attitude, as well as test performance. As this study clearly showed, posttest gains alone do not necessarily indicate that student needs have been met. The instructional developer has a responsibility to design instructional materials which not only promote learning, but which are acceptable to the students. If learners emerge from an instructional sequence educated but hostile, we have let them down.

References

1. Many "systems models" appear in the ID literature: their common elements are an explicitly stated and systematically applied approach to the solution of an instructional problem.

2. Eg., the NICEM Indexes, the Westinghouse Learning Directory, and RPIE reports.


Figure 1: The Instructional Development Model

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Figure 2: Comparison of pretest and posttest mastery of course objectives, Cycle 1
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Figure 3: Comparison of pretest and posttest mastery of course objectives, Cycle 2 (n=11)

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Figure 4: Comparison of pretest and posttest mastery of course objectives, Cycle 3 (n=8)

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<tr>
<td>III. Self-Instruction/ Group Discussion (n=8)</td>
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Figure 5: Comparison of pretest and posttest mastery in three development cycles *mastery level was set at 80%
Basic Considerations For Implementing Instructional Development Programs In Higher Education:

Some Suggestions From The Literature

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January 5, 1978

The intent of this article is to provide a framework for considering issues related to instructional development programs in higher education. Instructional development is, in reality, a young movement. Popham (1974) wondered about its future, asking whether instructional improvement efforts will become an integral part of effectively functioning institutions of advanced learning or whether instructional development programs in higher education will disappear as a fad. In part, the answer to that question may lie in the ability of administrators planning and managing instructional development programs to learn from the efforts of their colleagues in other settings. The focus here is on organization and implementation rather than on instructional design procedures or models. No attempt is made to review or discuss theories, research evidence or procedures used to design and evaluate instruction. Consideration of these issues is beyond the scope of this article.

This article focuses upon providing guidance for practitioners of instructional development. This guidance is derived from a synthesis of prevailing views in the literature. Sixteen guiding principles are proposed for organizing and implementing instructional development programs in higher education.

Advice for Implementing Instructional Development Programs

In 1968 Haney, Lange, and Barson provided instructional developers with a set of heuristics for doing instructional development based on years of experience and accumulated wisdom. Instructional developers who followed these suggestions were grateful for the guidance. In 1974, Holodaw developed a comprehensive set of procedural guidelines for instructional development based on interviews with developers from various settings. This impressive effort also relied on collective judgement and wisdom to provide direction for those of us laboring daily to improve instruction through systematic development efforts.

In an attempt to provide still more insight about how to organize and implement instructional development programs, a set of "guiding principles for implementing instructional development" has been derived from an extensive review of the literature on change and instructional development (Durzo, 1976a). Because the literature in these areas exists in a number of widely scattered sources (some of them "fugitive documents" captured only by the ERIC System), it is important to synthesize the "recommendations" from the literature to make this collective wisdom and experience easily available to instructional developers across the country.

The guiding principles presented here should be taken for what they are--tentative conclusions, tentatively held. None of them is based on experimental research. Unlike the area of instructional design, where much sound experimentation has been done, experimental manipulation has not yet been helpful in providing insight into the organization and management of development programs. The issues and settings are too complex to be easily amenable to experimental manipulation. Qualitative field research methodologies such as participant observation (e.g., Dodge and Bogdan, 1974; Lutz and Ramsey, 1974) may provide a useful perspective on the issues raised by these guiding principles. Until such research bears fruit, the accumulated judgment and wisdom represented in scholarly articles, papers and books must serve as the foundation upon which the practice of instructional development is based. Taking these guiding principles into account when doing instructional development does not guarantee success, but it can reduce the initial frustration resulting from unseen pitfalls and false starts.

Guiding Principles for Instructional Development

References included in this section indicate that the particular works cited support the tone and direction of a given principle, though the specific wording used here may not appear in any of them.

1. The institutional climate should encourage and support innovation. Presidents and other high administrative officers must actively support innovation. Importance must be placed on the teaching-learning process.

Unless there is high-level support for an instructional development program, the
program will operate in a "one-down" position without a clear mandate for academic change. Faculty will perceive the lack of support and may be reluctant to become involved with the agency. The "clout" necessary for changing institutional practices (e.g., registration systems, summer pay for faculty) will be hard to come by, thus negatively affecting the potential contributions of the agency.


4. To have maximum impact on an institution's programs, select a few high-priority projects with a high prospect for long-term stability.

An instructional development agency should identify the institution's top academic priorities and choose projects which reflect them. The goal should be to complete a few major projects which have widespread impact rather than to support numerous small projects which will have little overall impact on the nature of the institution's academic program. In addition, every possible attempt should be made to assure the long-term stability of projects chosen. A key step is to select projects from departments where the staffing and enrollment patterns are relatively stable and the political climate is free from divisive problems which would eventually doom projects to failure. Another method of providing stability is to involve more than one faculty member in a project. This assures that other faculty members will be able to carry on with it even if one key person leaves the institution. Finally, the agency should structure the conditions for support of the project so that after the developmental stage is completed, the institution will continue to support the new course as a part of its normal academic program.


5. Assistance and support should be made available for development and implementation of academic innovations. Some organization or structure should be established to advocate and support innovation.

In order to provide both a catalyst for change and support for instructional innovation, some type of instructional development agency or support program should be established. Instructional development is a complex activity requiring considerable effort in both the design and implementation phases of the process. In order to maximize the likelihood of successful innovation, it is useful to provide faculty with: (1) assistance during the conceptual development of the solution and, (2) technical support for the design and implementation of materials and activities (e.g., evaluation assistance, production capabilities, development of record-keeping systems).


6. Program changes in one area of an organization may necessitate corresponding changes in other areas.

Academic change does not occur in a vacuum. A change in one department's basic course may also necessitate corresponding changes in all of its advanced courses, or in related courses in other departments. In addition, a developer may find that proposed course design requires significant changes in certain institutional procedures such as the registration system, use of independent learning facilities or room scheduling. To ignore the potential impact of instructional development efforts on other areas of an institution is to court disaster. Developers must always take a holistic view of proposed changes in order to anticipate their system-wide effects. Developers must attempt to identify and solve potential problems before they occur.

Baldrige, 1975; Benne & Birnbaum, 1969; Durzo, 1976 a; Diamond et al., 1975; Gross et al., 1972; Rogers, 1968.

7. To facilitate the development process, an instructional development procedure should be adopted and followed.

There are many different instructional development procedures or models used by agencies across the country. Each represents a particular method of applying a basic systematic approach to the development of instruction. Little research exists to guide an agency in selecting or developing a model, but the advice from the literature is clear. An instructional development procedure should be adopted and followed in order to facilitate the development process and assure communication among the individuals involved.

real problems which are important to the faculty member(s) involved.


11. Assistance should be provided in both the initiation and implementation stages of the change process. Both stages must be planned and executed thoroughly.

One important lesson from the literature on change is that the change process consists of two phases: (1) the initiation phase during which a person decides that a change is needed and begins work on the proposed solution, and (2) the implementation phase during which the innovation is actually carried out. An effective change support effort must recognize the existence of these two phases and develop assistance strategies appropriate to each. For example, a workshop concerned with college students’ reading problems may be an excellent initiation strategy to convince faculty of the need for change, but may be ineffective in assisting them to develop and implement necessary solutions. Durzo, 1976 a; Greenwood et al., 1975; Gross et al., 1971; Heathers, 1974; Lindquist, 1974; Miles, 1964; Pincus, 1974; Pressman & Wildavsky, 1974; Zaltman et al., 1973; Zaltman et al., 1977.

12. Include evaluation. Pilot trials, evaluation and experimental demonstration of innovations are both useful in accomplishing planned change and necessary to the development process.

Authors writing about educational change have described the importance of pilot demonstrations or trials in helping potential adopters of an innovation decide about its suitability. Moreover, the practice of pilot-testing a new program is central to the systematic approach to instructional development. Pilot demonstrations not only provide the developer and faculty the opportunity to “work out the bugs” in a design, they also enable other potential adopters to analyze the innovation. Consequently, a pilot demonstration of a PSI mathematics course will provide useful feedback to the development team and may also generate interest among other faculty in trying PSI in their courses. Evaluation is also important to assist the institution in judging the overall worth of instructional improvement efforts. Without adequate evaluation, it is not possible to describe accurately what was accomplished. Instructional changes, attitude changes, program effectiveness and efficiency, student learning, and faculty attitudes should all be examined as a part of the evaluation process.


13. Faculty must be willing to innovate. Initiative and support of the faculty is crucial to attempts at change and innovation.

The organizational structure of higher education places faculty in the role of autonomous professionals operating with the freedom to choose both the content and methodology of courses they teach. Consequently, there is little merit in “forcing” faculty to innovate. Faculty must perceive the need to change before they will engage in instructional development. They must have psychological “ownership” of the ideas and procedures underlying the courses they teach.


14. Time should be provided for faculty to engage in academic change and innovation.

With teaching, research, scholarship, advising, committee, and community responsibilities all consuming time, there is little “creative energy time” left for faculty to do instructional development. The traditional responsibilities of a faculty member are built into his or her typical academic year with little time to spare for educational innovation. To expect faculty to do development enthusiastically on an “over-time” basis is unrealistic and should be avoided if possible. Every effort should be made to provide faculty with released time during the academic year and/or summer stipends to do development.

Brickell, 1967; Clark & Guba, 1966; Diamond et al., 1975; Dietrich & Johnson, 1967; Durzo, 1976 a; Euard, 1975; Gaff, 1975 a; Hannah, 1966; Kief-
15. Faculty who engage in academic change and innovation efforts should be rewarded.

The institution should reward faculty for quality teaching and sincere attempts at innovation. Rewards such as campus recognition, faculty teaching awards and the like are a step in the right direction, but they are not enough. The most effective reward is official recognition by the institution in terms of promotion, tenure, salary, and other marks of status. Instructional development agencies should play a role in redesigning institutional reward structures so that faculty may benefit in a concrete manner from their attempts at innovation.


16. To produce long-term change, pay careful attention to the development of faculty members' skills in instructional development.

Producing meaningful, long-term academic change requires that faculty be effectively involved in the instructional development process. Attention should be paid to the development of faculty members' skills in doing instructional development on their own. The majority of opinions in the literature suggest that an important goal of any successful program should be for faculty to learn to become instructional developers in their own right. Various workshops and training sessions have been advanced as ways to achieve this objective. However, little data about the long-term effectiveness of these approaches are available. Hammons (1975) reported that short-term workshops by themselves have not proven to be effective in producing long-range change. He suggested that certain follow-up activities be included in order to maximize the impact of workshops. In addition, he listed a set of guidelines to be followed in developing workshops which are intended to help faculty improve their skills and knowledge about the teaching-learning process.

Abedor & Gustafson, 1971; Belby, 1974; Briley, 1971; DeBlois & Alder, 1973; Durzo, 1976 a; Faris, 1970; Gaff, 1975 b; Group for Human Develop-


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Hierarchical & Information Processing Task Analysis: A Comparison

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Brigham Young University

In a recent article, Merrill (1976) outlined an information processing approach to task analysis. He proposed that many of the concepts and techniques used by information processing theorists could profitably be applied to the problem of task analysis in the design of instructional materials. This approach to task analysis was described as being most appropriate for the analysis of tasks which were algorithmic in nature. An algorithm was defined as a procedure or sequence of operations for solving a problem or performing a task which is guaranteed to produce the correct results. A brief comparison between the information processing approach to task analysis and Gagne's (1962) hierarchical approach was also presented:

"The hierarchical task analysis procedure and the information processing analysis both reveal a structure of skills or operations having an ordered relationship to each other. However, the nature of this ordered relationship is considerably different. A hierarchical task analysis will reveal a structure of 'intellectual skills' such that the learning of one skill is prerequisite to the learning of higher ordered skills. Thus, the purpose of hierarchical analysis is to determine an ordered relationship of learning prerequisites. In contrast, an information processing analysis describes the way an algorithmic task is performed and reveals the information processing relationships between operations where the output of one operation is required as part of the input for succeeding operations. Thus, a hierarchical analysis reveals the prerequisite learning stages leading to the terminal behavior while an information processing analysis specifies the performance sequence of the suboperations of the terminal behavior [p. 10]."

Merrill further suggests that some tasks, especially mathematical tasks, may have both types of relationships. An instructional designer may find it advantageous to analyze such tasks using both techniques in order to obtain a broader understanding of the actual nature of the task and its subskill relationships. Gagne and Briggs (1974) state that deriving a learning hierarchy is not an easy matter and that mistakes can be made unless one attends to the necessity for thinking out all of the component mental operations used by the learner when he solves a particular problem. However, Gagne and Briggs do not provide any guidelines or procedures for making these component operations explicit. One of the purposes for conducting an information processing task analysis is to explicitly identify the component or sub-operations of a given task. Recently, Gagne (1977) has also recommended that an information processing analysis be conducted prior to deriving a learning hierarchy.

The author has found that many instructional designers in attempting to conduct a hierarchical analysis actually use an information processing approach and end up with an information processing analysis. However, they interpret the resulting analysis as if it were a hierarchy and make certain erroneous assumptions about prerequisite learning requirements. These erroneous conclusions apparently are a result of not being aware of the distinction between prerequisite learning relationships and output-input performance relationships. Conducting both types of analysis on a given task would help avoid this type of erroneous conclusion.

The purpose of this paper is to present a more detailed comparison of the infor-
mation processing and hierarchical task analysis procedures by examining the results of analyzing a specific task using both approaches.

Analysis Diagrams

The specific task which will be analyzed using both task analysis procedures is that of subtracting whole numbers. A diagram showing a hierarchical analysis of this task has been published by Gagne and Briggs (1974, page 114) and is reproduced in Figure 1. A flow chart of an information processing analysis of the procedure or algorithm for subtracting whole numbers is shown in Figure 2. This flow chart reveals the component mental operations involved in performing the task.

The specific steps of the subtraction procedure or algorithm may be divided into operations and decisions. The operations are represented by the rectangular shaped boxes in the flow chart while the decisions are represented by the diamond shaped boxes. The decision points are labeled with capital letters while the operations are labeled with numbers. The seventh operation is broken down into four suboperations which are labeled 7a through 7d. The lines and arrows indicate the order in which the various operations and decisions must be executed.

For some subtraction problems, the same series of steps may be performed several times during the solution of the problem. These iterations are referred to as a loop. A loop is a series of steps that lead you back to where you started from. Examples of loops in the subtraction algorithm are steps A, B, 2, C, and 3, and steps 5, D and 6. All steps of an algorithm are not necessarily used in solving a given problem. For example, if we were to follow the steps of the algorithm to solve the problem 7 minus 5, only steps 1, A, B, 2 and C would be used. For a problem such as 47 minus 25, these steps would be used a second time after executing step 3 and going around the loop. In solving any given problem only a specific set of steps are executed. These specific steps might be considered as a path through the algorithm. If we assume that subsequent iterations around a loop do not create a new path, the number of paths is finite. These paths may be identified; and given problems may be categorized according to the path that is used in solving the problem.

Figure 1. Learning hierarchy for subtracting whole numbers.
(From Gagne & Briggs, 1974, p. 114).

Figure 2. Information processing analysis flowchart for subtracting whole numbers.
The unique paths through the algorithm can be represented in terms of a directed graph where the decision steps are represented by points and the operation steps are represented by arrows or arcs (Scandura, 1973b). Figure 3 shows the directed graph for the subtraction algorithm and identifies 11 unique paths through the algorithm. The numbers on the arrows in the graph correspond to the numbers of the operations in the flow chart while the points in the graph correspond to the decision points and start-stop points in the flow chart. Note that only one point is used for adjacent decision points and only one arrow is used for adjacent operations. Thus decision boxes A and B are represented by one point and operation boxes 7a-d are represented by one arrow. Examples of problems which require the steps of a given path for their solution are shown in the column to the right of their corresponding paths. For example, path P3 would be used in solving the problem 647 minus 25 while path P8 would be used in solving the problem 607 minus 469.

Comparison

The boxes in the learning hierarchy shown in Figure 2 can also be related to a specific set of subtraction problems. For example, box 12 represents all of those subtraction problems which involve simple subtraction in successive columns without bringing down. This set of problems would correspond to those which can be solved by following path P2 of the subtraction algorithm (See Figure 3). The righthand column of Figure 3 shows the boxes of the learning hierarchy which correspond to the paths of the subtraction algorithm. The correspondence between the boxes in the learning hierarchy and the paths in the algorithm is not one for one. For example, problems corresponding to boxes VII, VIII and IX in the learning hierarchy can all be solved using path P7 from the subtraction algorithm. The subskills related to boxes VII, VIII, and IX in Figure 1 all involve exactly the same operations and decision points. They only differ in terms of the order in which certain steps of the path are executed or the number of times a loop is executed. For example, the skill "subtracting when a single borrowing is required" (box VII) requires only one execution of the loop which includes operations 5 and 7, while "subtracting when successive borrowing is required in adjacent columns" (box IX) requires several consecutive executions of the same loop. "Subtracting when several borrowings are required in non-adjacent columns" (box VIII) requires that each execution of the same loop be separated by the execution of other steps in the path (operations 2 and 3).

Scandura (1973b) has suggested that an algorithm may be broken down into simple enough steps so that every subject in a given population would be able to perform each step of the rule in an all or none fashion. He has further hypothesized that each path through the algorithm may be performed in an all or none fashion. Each path effectively partitions the domain of problems which may be solved using the algorithm into a set of mutually exclusive equivalence classes. Based on these assumptions, Scandura concludes that success on any item from one equivalence class implies success on all other items in the same class. According to this logic and the analyses of the subtraction algorithm.
shown in Figures 2 and 3, it should be possible to combine the subskills of the learning hierarchy shown in boxes VII, VIII and IX into one subskill.

Scandura (1973b) also suggests that the paths of an algorithm can be partially ordered according to difficulty. The most direct path (P1) would be the least difficult while paths which include the steps of another path would be more difficult. This ordering of the paths according to difficulty is not necessarily linear since some paths (e.g., P5 and P6; and P9 and P10) may not be ordered as to difficulty. Paths 5 and 6 include the same number of steps but each include one step which is not included in the other. The ordering of the paths in Figure 3 from path P1 through path P11 corresponds very closely to the ordering of the subskills identified in the learning hierarchy in Figure 1 from subskill 1 to XI. This correspondence should not be too surprising. According to Resnick and Ford (1976) positive transfer is expected to occur from simpler to more complex tasks in a learning hierarchy because the simpler tasks are included in or are components of the more complex tasks. This parallels directly the rationale used to order the paths through the algorithm (Scandura, 1973b).

It should be possible to reduce the total number of equivalence classes for a given algorithm if we assume that paths are equivalent which contain the same new steps but differ only by the inclusion of steps which have been included in a previous less difficult path. For example, paths P4, P5 and P6 could all be collapsed into the equivalence class defined by path P7. Paths P4, P5, P6 and P7 all include the same new steps (5 and 7) but only differ in that steps 2, 3 and 4, which have previously been included in path P3, are added one at a time in paths P4, P5, and P6. Similarly, paths 8, 9 and 10 could be combined into one equivalence class represented by path 11. These combinations would reduce the number of equivalence classes from 11 to 5 (Paths 1, 2, 3, 7 and 11).

Although the information processing or algorithmic analysis yields similar results to the hierarchical analysis, the algorithmic analysis requires greater precision and forces the analyst to specify in an explicit manner what is meant by a particular skill. For example, the actual steps involved in double borrowing specified by subskill X in the learning hierarchy are explicitly identified in path P11 of the algorithm. The identification of various paths through the algorithm also shows explicitly how one skill may be subordinate to another. The algorithmic analysis also reveals that certain skills are part of the same equivalence class and therefore may not need to be separately identified.

A revised learning hierarchy (Figure 4) has been developed based on the algorithmic analysis shown in Figures 2 and 3. In order to facilitate comparison, the Roman numerals which correspond to the boxes in the learning hierarchy in Figure 1 and the path numbers which correspond to the paths in the algorithm have been included in parentheses following the corresponding box numbers in Figure 4. Thus, Box VII in Figure 4 corresponds to the box labeled III in Figure 1 and path P3 in Figure 3. The oval shaped boxes in Figure 4 correspond to the decision points in the algorithm shown in Figure 2. Thus, box III in Figure 4 corresponds to box VI in Figure 1 and decision point B in Figure 2. Box V in Figure 4 corresponds to step 7C in Figure 2. This step is shown explicitly as a box in the diagram of Figure 4 since it probably should be considered as an entering behavior for certain students. The skills represented by oval boxes in Figure 4 could be deleted if it is assumed that the target population has these concept identification skills as entering behaviors. They are included here to show their relationship to the other analysis diagrams. Although the hierarchy in Figure 4 is based on Figures 2 and 3, it is a very useful diagram because it synthesizes the information gained from the algorithmic and path analyses and shows the learning prerequisite relationships.

**Additional Algorithms**

One of the implicit assumptions of hierarchical task analysis is that there is only one procedure for accomplishing any given task. In contrast, information processing task analysis implicitly assumes that there may be many procedures for
performing the task. It is very possible that students who are able to perform a
given higher level task without being
able to perform all of the subskills con-
sidered prerequisite, as revealed by a
particular hierarchical analysis, may
actually be using an alternate algorithm
which does not require those particular
subskills. For example, a slightly differ-
ent algorithm for subtracting whole
numbers than the algorithm shown in
Figure 2 may be found in Scandura
(1973b, page 200). A radically different
algorithm for subtracting whole numbers
based on an “equal additions” procedure
is shown in Figure 5. The algorithm in
Figure 5 will provide the correct solution
equally as well as that in Figure 2. How-
ever, the algorithm in Figure 5 does not
include the traditional borrowing pro-
cedure nor does it require the loop for
double borrowing across zero. Rather
than borrowing one from the top
number in the column to the left (as in
Figure 2) the algorithm in Figure 5 adds
one to the bottom number in the next
column. Readers who are unfamiliar
with the algorithm in Figure 5 should
walk through both algorithms using the
same problem such as 3,607 minus 825.

It should be obvious that a hierarchical
analysis based on the algorithm in Figure
5 would be considerably different than
the one shown in Figure 1 or Figure 4. A
learning hierarchy for subtracting whole
numbers based on the algorithm in Fig-
ure 5 is shown in Figure 6. There are
three significant differences between the
hierarchies shown in Figures 4 and 6.

These differences are directly related to
the differences between the algorithms
in Figures 2 and 5. Note that the subskills
represented by boxes VII and IX in
Figure 4 are not found in the hierarchy
shown in Figure 6. The subskill repre-
sented by box IX in Figure 4 is not re-
quired in the new algorithm. The sub-
skill represented by box VII in Figure 4
was not included in the algorithm in Fig-
ure 5. Apparently Scandura did not feel
it was necessary to make this subskill
explicit and assumed that it was part of the
subskill related to subtraction facts (Box
III in Figure 6). Although the subskills
identified by box VIII in Figure 4 and
box VI in Figure 6 correspond to the
same task, the procedures involved in
performing the task are very different as
can be seen by comparing steps 7a-d in
the algorithm found in Figure 2 and steps
4a-e in Figure 5.

**Subtraction Algorithm**

(1) Start at right
most column

(2) Subtract the
bottom number from top number

(3) Go to the
next column

(4a) Put a 1 in front of the top
number

(4b) Subtract the bottom number from new top
number using subtraction facts + 10

(4c) Go to the next
column and add 1 to the bottom No.

**Directed Graph**

START  \[\rightarrow\] \[\rightarrow\] \[\rightarrow\] \[\rightarrow\] \[\rightarrow\] STOP

Paths          Instances
1. \[\rightarrow\] 1. 7
2. \[\rightarrow\] 2. 368
3. \[\rightarrow\] 3. 1563
4. \[\rightarrow\] 4. 8456

Figure 5. Flowchart and directed graphs for “equal additions” subtraction algorithm.
(From Scandura, 1973a, p. 11).
Figure 6. Hierarchy for subtracting whole numbers based on equal additions procedure.

Which of the many possible algorithms for performing a given task is the best? Merrill (1976) has suggested that algorithms may be compared or evaluated in terms of the relationship between the difficulty level of the operations of the algorithm and the entry behavior of the target population which is expected to perform the algorithm. The length of time and number of operations required to perform the different algorithms given several initial inputs may also serve as a basis for comparison. The algorithms may also be compared in terms of Bruner's (1966) concepts of economy and power. Economy relates to the information storage requirements of the algorithm, while power relates to what effect the algorithm may have on the student’s ability to generate new hypotheses and combinations. Resnick and Ford (1976) have suggested that an algorithm which demonstrates how skilled individuals perform a task may not be the best algorithm to use to teach a novice to learn the task. They suggest that an algorithm to help novices learn a task should meet the following three criteria:

1. It must adequately display the underlying structure of the subject matter.
2. It must be easy to demonstrate or teach.
3. It must be capable of transformation into an efficient performance routine.

For example, one of the supposed purposes of the new math movement was to teach students algorithms which more adequately displayed the underlying structure of the subject matter. However, many parents seem to be complaining that their children have not been capable of transforming these algorithms into more efficient performance routines.

Conclusion

The purpose of this paper was to compare the hierarchical and information processing approaches to task analysis through taking a specific example and analyzing it using both approaches. It was argued that for many tasks both types of analysis should be used in order to ascertain the various types of relationships between the subskills or suboperations of the task. In order to accurately perform a hierarchical analysis, the instructional designer must have in mind a specific algorithm for performing the task. However, many mistakes can be made unless this algorithm is made explicit through an information processing or algorithmic analysis. Once the operations and decision points of the algorithm have been identified, they can be diagrammed in flow chart form. This flow chart will show the sequencing and output/input relationships between the operations of the task. The various paths through the algorithm can then be identified and thereby partition the domain of problems which can be solved by the algorithm into mutually exclusive equivalence classes. These equivalence classes can subsequently be ordered according to difficulty. The information obtained from these analyses can then be used as a basis for conducting a hierarchical analysis.

The instructional designer should be aware that there are many possible algorithms for performing any given task. The available algorithms should be evaluated and the most appropriate one selected according to the criteria specified in the previous section.

Instructional designers should also be aware that neither the hierarchical nor information processing task analysis procedures are appropriate for all types of tasks. Many tasks are neither algorithmic nor hierarchical in nature. Efforts to force such tasks into a hierarchical or algorithmic mold are futile. An analysis procedure which reveals other types of relationships such as complexity, chronology, or spatiality (Evans, Homme and Glaser, 1962) may be more appropriate.

References


Scandura, J.M. Structural learning and the design of educational materials. Educational Technology, 1973 13(8), 7-13. (a)