Educational Technology at the Crossroads: New Mindsets and New Directions

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Educational technology seems to be suffering from an identity crisis. Many exciting things are happening in the field, but increasingly we educational technologists find ourselves on the sidelines in our own ballgame. People from other disciplines are taking an interest in educational technology, but they show little interest in our knowledge base (often even little awareness that it exists!) and little interest in our professional organizations and publications. Why is this happening? What can we do about it? To what extent might our mindset be the problem? What new directions do we need to pursue to improve the health and value of our field? These are the central issues which this article discusses.

☐ This, the first issue of ETR&D, is a significant event for the field of educational technology, and it comes at a time when the field is undergoing an identity crisis like none in its history. Five years ago, the U.S. government funded its first Educational Technology Center. It was awarded to Harvard University, and no educational technologists were involved—no people who were knowledgeable about the considerable research and theory base on educational technology, no people who attended educational technology conferences such as AECT and ADCIS or the annual conference of Professors of Instructional Development and Technology at Shawnee Bluffs, no people who published in educational technology journals. That was a great disappointment, but we shrugged it off.

Now, five years later, the same project was open for competition again. Virtually all of the top educational technology graduate programs bid for the center, including a powerful consortium of leading programs: Indiana University, Syracuse University, University of Minnesota, University of Georgia, and Northern Illinois University. The same thing happened.

In November 1988, the North Atlantic Treaty Organization held an international conference on "New Directions for Educational Technology." Out of about 25 participants, three or four were educational technologists.

Please don't misunderstand me. I think it is

great for people with diverse backgrounds and training to embrace an interest in educational technology. We have always been a very diverse field, with people from learning theory, media, and systems theory backgrounds, among others. That diversity has advanced our field immensely. However, what concerns me is that these "new educational technologists" usually exhibit a total ignorance of and lack of interest in our considerable, well-validated knowledge base.

This isn't the only problem our field faces. Those of us in academe are all too used to our new students saying, "I never realized a field like this existed. It's just what I was looking for!" We seem to be the best kept secret in higher education!

Also of concern is how little impact we are having on the schools. With all of the recent concern over the quality of the schools, and with all that we have to offer for improving that quality, why are we having so little impact? How much of our knowledge base is impacting on teacher education? Close to half of my students are teachers embarking on a career change. Usually about halfway through my beginning course on instructional theory, several of them come to me saying, "If only I had known these things when I was teaching, I would have been able to do such a better job!" We should be having a greater impact on teacher education.

There is a message in these problems, and I think it is written on the proverbial wall. Nevertheless, these are exciting times for educational technology! The revolutionary advances in hard technologies bring us exciting new capabilities almost monthly, and they are spurring advances in soft technologies, especially instructional theory. Our knowledge base is reaching the point where we can achieve very significant improvements in learning in almost any learning environment. Yet we seem to be in risk of being left on the sidelines in our own ballgame.

Why is this? Is it that our knowledge base is weak or insufficient? Is it that we have become complacent? Is it an image problem—that others perceive us to be machine-oriented, anti-human, and advocates of programmed instruction? (How many of us *are* still teaching or practicing programmed instruction?) Is it that we have failed to embrace a paradigm shift that has swept the world around us? Has our mindset become outdated?

I am not sure of the answers to these questions, but they are questions that we need to start thinking about and discussing. In the remainder of this article I try to initiate some dialogue by discussing my perceptions of changes needed in our mindset in educational technology and some recommended future directions for educational technology.

MINDSET

This first issue of ETR&D represents the somewhat controversial joining of ECTJ and JID. On a more significant level, it symbolizes the joining of research and practice. It encourages practitioners to keep up on research, and it encourages researchers to keep touch with practice. However, its influence may go well beyond facilitating communication between researchers and practitioners. It may herald a change in mindset about how we go about our work, be it research or practice. Some of the kinds of changes in mindset are captured by the following distinctions:

- instruction versus construction
- description versus prescription
- analysis versus synthesis
- validity versus optimality
- R or D versus R&D.

Instruction versus Construction

At the NATO conference mentioned earlier, David Ferguson (1988) discussed the distinction between instruction and construction. To Ferguson, instruction implied the mindset of knowledge and skills flowing from one person to another, like little packages being delivered by the post office. On the other hand, *construction* meant the learners actively building meaning within their own heads,

rather than having it placed there by someone else. This distinction is somewhat parallel to common perceptions of the difference between behavioral theory and cognitive theory. Educational technology, like learning theory, grew up with the behavioral (instruction) mindset. But have we changed? Should we change?

After Ferguson's presentation, I argued that, for some instructional situations, the instruction mindset is far more appropriate, such as memorizing (automatizing) the addition facts, or teaching the names of your federal and state senators and representatives. It is also more appropriate for concept-classification and procedure-using tasks. Therefore, one should not be so quick to reject it. However, I also acknowledged that the construction mindset is far more appropriate for more complex kinds of learning, particularly understanding and thinking skills (cognitive strategies), both of which are discussed in greater detail later in this article. Also, I argued that many instructional theorists are, indeed, adopting a construction view for these types of learning.

In adopting such a view, however, we must be careful to maintain our interest in prescribing what a teacher or other instructional medium should do to facilitate such construction. Instruction is also required for construction. The new educational technologists need to understand that it is not sufficient to just describe what goes on, or should go on, inside a learner's head. It is important to prescribe what a teacher, or other medium of instruction, should do to help make it happen. It seems that many of the cognitive psychologists and artificial intelligence people who have taken an interest in educational technology are not at all interested in instruction, and in fact have a very narrow view of what educational technology is.

On the other hand, we educational technologists need to realize that, to make good prescriptions, we must understand what we need to make happen inside the learner's head. This is a different mindset. It does not abandon the instruction approach

we now espouse; rather, it expands it. Without such an expanded view, we not only run the risk of being left on the sidelines, but also of failing to meet the higher level needs of the learners we serve.

Description versus Prescription

Simon (1969) pointed out that the "sciences of the artificial"—such as medicine, engineering, and, yes, instruction—are concerned with prescription, whereas their related natural sciences—in this case biology, physics, and learning, respectively—are concerned with description. The distinction between prescription and description is an important one because a prescriptive theory needs to be eclectic, whereas descriptive theory doesn't—or can't (Snelbecker, 1983). Descriptive scientists, such as learning theorists, adopt a single theory and see how far it will go. On the other hand, prescriptive scientists, such as instructional theorists, need to be eclectic in their attempts to address practical problems.

I think it's fair to say that all descriptive theories contribute something useful, no matter how inadequate they may be overall, often for different aspects of a practical problem. Since instructional theory needs to address all aspects of a practical problem, it must draw from all learning theories. The same is true for counselling theory (Goldfried, 1980) and probably all other prescriptive domains. Hence we find a single instructional theory, such as Merrill's (1983) Component Display Theory, prescribing cognitively based tactics, such as mnemonics and analogies, as well as behaviorally based tactics, such as practice with reinforcement and various shaping and fading progressions.

A prescriptive mindset has long been held by educational technologists. As noted earlier, however, for the more complex types of learning it is important that we also be aware of the kinds of internal constructions which are occurring and should occur inside learners' heads. This will enable us to better prescribe the nature of the instruction. On the

other hand, many of the new educational technologists from cognitive science and artificial intelligence backgrounds seem to believe that prescriptions can never be generalized, and they maintain an exclusive focus on description (cognitive learning theory) for any generalizations they make. Since prescriptions take the form of rules governing an intelligent tutoring system, the implication is that none of the rules developed for a given domain are of any use whatsoever in creating a tutor for a different domain. Most of these new educational technologists make no attempts to report the rules underlying their tutors. The presentations and papers I've seen usually amount to little more than a "show and tell." Accordingly, their work has contributed little to the educational technology knowledge base (McCalla, 1988).

Fortunately, however, it seems that there is a growing trend for these new educational technologists to work on building prescriptive theory. For example, at the NATO conference, Alan Collins called for the development of a design science similar to aeronautics (Collins, 1988), and he has in fact developed a prescriptive theory for tutoring (Collins & Stevens, 1983). Elsom-Cook (1988) identified the goal of intelligent tutoring systems (ITS) research as "advancing educational theory." Reiser (1988) discussed a variety of general prescriptions for an intelligent programming tutor called GIL, including the timing of feedback and the use of examples. Although activities such as these show a growing trend for the new educational technologists to contribute to the prescriptive knowledge base, their efforts would be facilitated by greater familiarity with our current knowledge base (McCalla, 1988). The more they know about that knowledge base, the more useful their contributions are likely to be.

Analysis versus Synthesis

Most fields have probably followed a similar developmental pattern. Our field began by investigating general instructional variables, such as expository versus discovery, lecture versus discussion, and media-based versus traditional methods. It was soon realized that two discovery methods could differ more from each other than do a discovery and an expository method. The field then gradually entered an *analysis phase* in its development. The research objective was to break a method down into elementary components and discover which components made a difference. Experimental studies were ideally suited to the task. We then proceeded to build a considerable knowledge base of validated prescriptions, primarily for the simpler types of learning.

Recently we have found that the effects of each component are often influenced considerably by which other components happen to be present in the instruction. Furthermore, we have realized that practitioners need to think holistically—they need to identify the best combination of method components for a given situation. Hence, the field is entering into a *synthesis phase* in which the focus is on building components into optimal models of instruction for different situations (Reigeluth & Curtis, 1987). The research objective is to improve a given model or theory. Experimental studies are highly inappropriate for this task. An alternative will be discussed shortly. But first, since models and theories are the focus of the synthesis phase, it is helpful to consider the different kinds of instructional theories which can exist.

An instructional theory prescribes different methods of instruction for different conditions (Reigeluth, 1983a). In our work we have found three basic forms in which an instructional theory can do this. One form we refer to as the "intact models" paradigm. A different model of instruction (set of method components) is prescribed for each of a variety of conditions. For example, Merrill's (1983) Component Display Theory prescribes different "primary presentation forms" for different performance levels (see top of next page). Each of these instructional models is substantially different from the others, and each is prescribed for a different condition.

Another form of instructional theory is what we call the "variations on a model"

Performance Level	Primary Presentation Forms
Find-a-generality	Instance practice, Generality practice
Use-a-generality	Generality, Example, Instance practice
Remember-a-generality	Generality, Generality practice
Remember-an-instance	Example, Instance practice

paradigm. There is one general model of instruction, and variations are prescribed for different conditions. For example, Gagné's (1985) nine events of instruction are a general model (integrated set of method components), and differences are prescribed for each, depending on the kind of learning outcome desired (verbal information, intellectual skill, cognitive strategy, psychomotor skill, or attitude). Furthermore, different kinds of intellectual skills (e.g., concrete concepts, defined concepts, rules) call for some additional differences in some events of instruction.

The third form of instructional theory is what we call the "smorgasboard" paradigm. Here there is no model of instruction at all. Rather, there are different method components, each of which is prescribed based on a different condition variable, such that you "mix and match" according to the particular needs. For example, Keller's (1983, 1987) ARCS model is an array of motivational strategies and tactics which are selected individually depending on learners' motivational requirements and content.

As we strive to synthesize our piecemeal knowledge, it is helpful to keep these different forms of instructional theories in mind. Now, what about alternatives to experimental studies?

Validity versus Optimality

When the knowledge base we were trying to build was either descriptive or analytical, validity was the major research concern. However, when prescription and synthesis (prescriptive theories) are our focus, optimality becomes the major research concern. Is this particular prescriptive model or theory better than anything else currently available? Can we find any ways to improve on it? Experi-

mental studies are inadequate for answering these questions.

What I have been evolving toward with my students is what might be called a "formative evaluation" approach to research. As educational technologists we are all very familiar with formative evaluation as a tool for instructional developers (see e.g., Dick & Carey, 1985; Romiszowski, 1981). However, its purpose is to improve instructional products, whereas we want to improve instructional theories and models. Although much more work needs to be done to develop this research methodology, what we recommend at present is the following.

First, design and develop an instructional product solely on the basis of an instructional model or theory you wish to research. Try not to use any other prescriptions, not even your own intuition, in designing that product. This should make the product a true instance of the theory or model in the same way that your treatments in an experimental study are instances of your independent variables.

Second, conduct a series of one-on-one formative evaluations of that product. As in an experimental study, be sure that your students are broadly representative of the population to which you wish to generalize. Your initial one-on-one evaluations should probably be fairly obtrusive, with constant interaction between you and the student to identify any problems the student is having and to get suggestions from the student as to how the instruction might have been done better. You should correct any gross problems with the product right away, as long as you have good reason to believe the corrections will be beneficial for all students, or at least not detrimental to any. You should compare these results (problems, suggestions, and actual improvements) across a representative range of students to assess reliability.

Then you should conduct some unobtrusive one-on-one evaluations to corroborate those results—i.e., to assess their validity under more naturalistic conditions. These might be done by videotaping the instruction and the student's reactions to it; and then, immediately after the instruction, reviewing the videotape with the student and asking questions related to the earlier evaluation results. Several rounds of obtrusive followed by unobtrusive formative evaluations are advisable, especially if major revisions are made in the product each round. Naturally, as in an experimental study, replications with different content, different aged learners, and different settings and media would also promote external validity.

On one level, the results of these formative evaluations identify weaknesses in the product and suggestions for improving it, but since the product is an instance of the theory or model, the results also reflect similar weaknesses (lack of optimality) in the theory or model and provide suggestions for correcting those weaknesses. This kind of study yields much more data about a broad range of features of the theory or model, and these data are far more relevant for improving the theory or model than any experimental study.

This type of research is being done for dissertations by several of my students. Dave Will is translating a subset of the prescriptions in our simulation theory (Reigeluth & Schwartz, 1988) into a set of rules comprising an expert system. The subset is prescriptions for teaching the application of principles. The instruction developed by the expert system can then be formatively evaluated, and the rules for the expert system can be revised. Part of the plan is to make this expert system available electronically (similar to an electronic bulletin board) to any interested researchers, so that they can conduct this kind of research and then send back an annotated revised version of the expert system for any other interested researchers to investigate and build on. In this manner, researchers across the country can work on building a common knowledge base and have immediate access to advances made by others.

Another student, Catherine Roma, has developed some instruction based on our new theory for teaching "understanding" (meaningful learning) (Reigeluth, 1989a, Roma, 1989). She is now formatively evaluating it in the manner described above, so as to identify ways to improve the theory.

I have also recently become aware that this form of research has been conducted at Arizona State University by Vernon Gerlach. Furthermore, Alex Romiszowski has long advocated the use of development projects as a vehicle for doing research. His approach entails using the formative evaluation process to collect research data, similar to the methodology described above, but it also includes collecting data from summative evaluations (Romiszowski, 1988). No doubt, there are others who are experimenting with this methodology.

R or D versus R&D

This raises the issue of another mindset prevalent among both practitioners and researchers. We tend to think of research and development as two separate activities—you do research or you do development. As the earlier discussion of formative-evaluation research indicates, this is not the best approach for building prescriptive theory. Every developer can be a researcher with very little extra effort (Smith, 1985). It only requires that you (1) be familiar with an instructional theory (which you probably are anyway); (2) use that theory to design your product (which you probably do anyway), while noting any instructional features you use which aren't prescribed by the theory; (3) formatively evaluate the product (which you do anyway); (4) note ways you would change the theory (its prescriptions) based on the results of your formative evaluation; and (5) write it up for publication. There is virtually no extra expense and very little extra time involved.

On the other hand, researchers can obtain research funding more easily for formative-evaluation research. Development funds are much more plentiful than research funds, and researchers can fund their research either

by procuring a development project themselves or by volunteering to be of assistance on someone else's development project.

In sum, educational technology seems to be suffering from an identity crisis. We are ignored by many, including the new educational technologists. Why is this happening, and what can we do about it? Perhaps part of the problem is our mindset. Perhaps we need to think in terms of construction as well as instruction. In our quest for prescriptive models and theory, it may help if we place greater emphasis on optimality as opposed to validity. Given the need for our field to focus on synthesis efforts, maybe we should turn to a formative-evaluation type of research rather than using experimental studies. Perhaps we need to think in terms of R&D rather than R or D. Furthermore, maybe part of the problem is that the arts and sciences, which are descriptive, are considered more academically respectable than the professions, which are prescriptive. In this case, we may also need to be more politically active and more assertive in publicizing the value of our efforts.

Maybe. But one thing I am sure of is that we must not continue to ignore these problems and issues. We must discuss them, or we are destined to find ourselves on the sidelines in our own game.

NEW DIRECTIONS

Given that these changes are occurring in educational technology and that this issue of ETR&D symbolizes a significant change for us, this seems like an opportune time to ask, "Where are we in the field now, and where should we be going?" In the remainder of this article, I offer an organizing scheme which may provide some perspective on where we have come and where we need to go at this point in the development of our knowledge base. It may also facilitate the goal of synthesizing our current knowledge into a comprehensive set of prescriptions—a comprehensive theory of instruction.

Elsewhere I have discussed the conditions-methods-outcomes paradigm for instructional theory (Reigeluth, 1983a). Briefly, the *outcomes* are the effects of the methods of instruction: their effectiveness, efficiency, and appeal. The *conditions* influence the effects of the methods and therefore influence our selection of methods. They include the nature of the content, the learners, the learning environment, and the development constraints. The *methods* of instruction are the things we can do to improve the outcomes under different conditions.

To be comprehensive, a theory of instruction must prescribe the following kinds of methods:

- Organizational methods, including:
  Micro methods, which are tactics for teaching a single piece of the content.
  Midlevel methods, which are approaches that apply to a set of pieces of the content (see, e.g., Romiszowski, 1984), such as use of an expositive strategy or an experiential strategy.
  Macro methods, which are tactics and strategies for selecting, structuring, sequencing, synthesizing, and summarizing large chunks of content, such as a course or curriculum.
- Mediational methods,[1] which are concerned with the way in which the organizational methods are mediated.
- Management methods, which are concerned with the way in which the organizational and mediational methods are controlled, including such concerns as mastery learning and learner control.

Micro Organizational Methods

Many instructional theorists have proposed that the selection of micro organizational methods should depend primarily on the nature of the content (Reigeluth, 1983b). In our efforts to synthesize the current state of the

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[1] Mediational methods were formerly referred to as delivery methods. However, the term "delivery" connotes one-way communication and implies lack of concern for the notion of "construction" discussed earlier, so it has been replaced with a term which does not have such connotations and implications.

art in instructional theory into a coherent, unified, prescriptive knowledge base, we have noticed considerable similarity across various theories.

Perhaps the first type of learning to be analyzed and investigated because it is the simplest, most superficial type is Bloom's "knowledge" (Bloom, 1956), Merrill's "remember verbatim" (Merrill, Reigeluth & Faust, 1979), and Ausubel's "rote learning" (Ausubel, Novak & Hanesian, 1978). It is also one aspect of Gagné's "verbal information" (Gagné, 1985). A more complex type of learning is Bloom's "application," Merrill's "use-a-generality," and Gagné's "intellectual skills," which certainly require very different methods of instruction from the first type of learning. An even more complex type of learning has only recently begun to receive widespread investigation under the rubrics of "thinking skills" and "learning strategies." It includes Bloom's higher levels (analysis, synthesis, and evaluation), Merrill's "find-a-generality," and Gagné's "cognitive strategies."

Interestingly, several of these taxonomies of learning have identified another type of learning which has been largely ignored by instructional theorists until now, and in fact was largely ignored by learning theorists until recently. It is Bloom's "comprehension," Merrill's "remember paraphrased," and Ausubel's "meaningful verbal learning." It is also the other aspect of Gagné's "verbal information." When we want students to learn what an atom is, we hardly have concept classification (applying the concept) in mind. We don't really expect the students to be in a situation where they need to be able to say, "Oh! Look at that! That's an atom!" And we certainly don't want them to just rotely memorize what an atom is. No, there is clearly another type of learning which is perhaps best characterized by the word "understanding" (the "u" word to behavioral objectives proponents!), and understanding seems to arise through the construction of linkages or relationships between the new idea and what the learner already knows.

Of course, we then need to identify ways of assessing mastery, which is one of the major reasons for behavioral objectives, but there are many types of linkages and many ways of assessing the establishment of each linkage. It is too time consuming to specify them all with behavioral objectives. Furthermore, if the instruction is targeted directly to the few behavioral objectives which might be stated, the instruction becomes too narrow and the testing is likely to become remember-level rather than a true assessment of understanding.

In sum, we have come to believe that there are in the cognitive domain four major types of learning, each of which requires very different methods of instruction. In teaching these ideas to beginning graduate students, I have found that the most intuitive labels are: (1) memorizing information, (2) understanding relationships, (3) applying skills, and (4) applying generic skills. The various types of domain-specific content, such as concepts, procedures, and principles, can be acquired as any one of the first three types of learning. A concept can be memorized (either its definition or an example of it), or it can be understood (its relationships with other knowledge the learner has), or it can be applied (instances can be classified as examples or nonexamples of it). The fourth kind of learning is domain independent and generally requires more time to acquire. In our analyses of theories of instruction, we have found that these four types of learning require greater differences in the instruction than any other categorization or factor.

The field of educational technology has grown out of a behavioral orientation which has focused most efforts on prescriptions for memorizing information (association tasks) and applying skills (especially concept classification and procedure using). We have relatively little in the way of validated prescriptions for facilitating the acquisition of understanding. What work has been done has largely been on the development of descriptive learning theory, rather than prescriptive instructional theory. Considering recent advances in cognitive learning theory, it should be much easier now to develop useful in-

structional strategies for facilitating understanding. In fact, at Indiana University we have made progress recently on a project to develop prescriptions in this area (Reigeluth, 1989a). Adoption of a construction mindset has been very valuable in this effort.

Instructional theorists are already beginning to devote greater attention to generic skills: thinking skills, problem-solving skills, learning strategies, and metacognition. While much attention will continue to go to deciding *what* to teach in this area, it seems likely that instructional theorists will also place greater emphasis on figuring out *how* best to teach them. Of particular importance are prescriptions for designing a good simple-to-complex sequence for teaching any given generic skill, and prescriptions for integrating such single-skill sequences with each other and with a range of domain-specific content sequences.

We recently completed a project with Macmillan Publishing Company to provide scope and sequence recommendations for a new K–6 science program using the elaboration theory. Both we and Macmillan were very pleased with the results. However, several months after the completion of the project, Macmillan purchased a publisher who already had a K–6 science program, so the new series was shelved. Nonetheless, the project led to some important advances in the elaboration theory. Regarding generic skills, we found that the "simplifying assumptions" method for the procedural elaboration sequence needs to be applied separately to each generic skill that is to be taught, and we developed some prescriptions for how to integrate those sequences with the sequence of domain-specific content (Reigeluth, 1989b).

These two areas of the cognitive domain (understanding and generic skills) represent an important new direction for educational technology. They are not, however, the only types of learning which have been largely ignored by instructional theorists. Another type of learning is affective learning: attitudes and values, morals and ethics, social development, emotional development, personal development, and such. Martin and

Briggs (1986) have, in my opinion, provided an excellent beginning for instructional prescriptions in this area. While much attention is also likely to be placed on deciding which ones to teach, there is a great need for advances on *how* to teach them. This is certainly another important new direction.

However, the selection of micro organizational methods should not just depend on the nature of the content. The nature of the learner is important, as well as the capabilities of the media that are available. In our work, we have found that the nature of the learner has the greatest influence on decisions about *what* to teach rather than *how* to teach it. You don't want to teach things which the learner has already mastered, for that would be a waste of time and money and would demotivate the learner. On the opposite extreme, you don't want to teach things which are too far beyond the learner's current knowledge, for lack of important prior knowledge, including prerequisite skills (Gagné, 1985), would make learning very difficult, if not impossible.

Perhaps the second most important way that the nature of the learner influences the selection of micro organizational methods is in making decisions about the amount of instructional support provided to the learner—that is, how rich the instruction should be. It is important to assess the difficulty of the content based on the learner's ability and prior familiarity with it. The more difficult the content, the richer the instruction needs to be, including the use of more examples and practice, alternative representations (especially hands-on and visuals), attention-focusing devices, hints, and shaping (or successive approximations). A third way that the nature of the learner is important is in the selection of motivational strategies. A motivational profile of the learner is very important for selecting appropriate motivational strategies (Keller, 1983, 1987).

With respect to media capabilities, significant strides in information technologies are providing educational technologists with tools of a magnitude of power previously undreamed of. Most current micro organiza-

tional methods were developed within a "page" mentality. To take full advantage of the capabilities of new mediational systems, our thinking must advance beyond such a static, confining level. We need prescriptions which take advantage of the dynamic, interactive, and artificial intelligence capabilities of computers and interactive video.

Computer-based simulation possesses great potential for taking advantage of advanced technologies, but most simulations fall miserably short of their potential. Prescriptions for improving their quality are sorely needed. Alessi and Trollip (1985) have developed some prescriptions, and we recently completed a two-year project to further develop such prescriptions (Reigeluth & Schwartz, 1988). However, much more work remains to be done to test, refine, and further develop such prescriptions. I expect we will see considerable advances in this area over the next decade.

Advances in information technologies have also made possible the design of intelligent tutorial systems which can be used alone or in combination with simulations or other instructional approaches. The major deficiency of such systems is an inadequate set of instructional rules for an expert tutor so that it will optimally facilitate learning. Unfortunately, much of the deficiency is due to the fact that the developers of most expert tutors have ignored the existing instructional theory knowledge base. However, we also need to do a better job of operationalizing our prescriptions to the level of specificity necessary for expert tutors. Dave Merrill (1989) has made some important advances in this area, but much more work is needed.

Making maximum use of the capabilities of advanced technologies is certainly another important new direction for educational technology.

Midlevel Organizational Methods

Some instructional planning is done on a level which is broader than micro methods (for a single idea) but considerably narrower than macro methods (for an entire course). Bruner's notion of a learning episode is a good example. A learning episode has a problem-solving character, it has a clear beginning and a clear end, it builds up to a climax of understanding, and its length should be proportional to the payoff—the magnitude of the climax of understanding (Bruner, 1960). Romiszowski's (1984) overall instructional strategies are another example, and include such alternatives as an expositive strategy and an experiential strategy. However, there is very little in the way of reliable prescriptions in this area.

Two of my doctoral students, Jeannette Olson and Laura Dorsey, have undertaken a project to catalogue the viable mid-level strategies which have been proposed to date and to develop prescriptions as to when each is most appropriate to use (Dorsey & Olson, 1989). The strategies include apprenticeship, debate, field trip, game, ancient symposium, laboratory, lecture, project, simulation, role play, brainstorm, tutorial, and others. This is certainly an area in which much more work is needed to provide useful prescriptions for instructional designers.

Macro Organizational Methods

Macro organizational methods include prescriptions for how to select, structure, sequence, synthesize, and summarize the course content. Our knowledge base is deficient in virtually all of these areas. Let us first address how to structure and sequence a course or curriculum. Based on our efforts to synthesize the state of the art in this area, we have found considerable evidence that every pattern of sequencing is based on a single type of relationship within the content (Reigeluth, 1989c). For example, the chronological sequence is based on the time relationship among events, Gagné's hierarchical sequence is based on the learning prerequisite relationship among skills, the forward-chaining procedural sequence is based on the order relationship among activities, our elaboration theory's conceptual elabora-

tion sequence is based on the "parts" or "kinds" taxonomic relationships among concepts, Scandura's shortest-path sequence (further developed and popularized by Paul Merrill, 1976, 1987) is based on the simple-to-complex relationship among paths of a procedure, and so forth.

We know relatively little about the kinds of relationships that are most important for a sequence to maximize such goals as building stable cognitive structures, facilitating creative thought, and allowing for maximum appropriate learner control. New approaches to sequencing will probably be particularly important for generic skills, understanding, and affective learning. It seems likely that optimal sequencing strands will be developed for each of these types of learning, then interwoven with each other to form a complete course or curriculum sequence. We developed some prescriptions for doing this in our K–6 science project with Macmillan mentioned earlier. A student of mine, Katherine Beissner, and I have continued this work on a project to redesign a course which she teaches at Ithaca College (Beissner & Reigeluth, 1989). Additional work is sorely needed in this area, and it represents a promising new direction for educational technology.

Synthesis is the process of explicitly teaching the relationships among ideas. Very little attention has been paid to developing useful prescriptions in this area. In our work on integrating prescriptions for macro methods, we have identified a variety of types of "pervasive" relationships, relationships which exist on a continuing basis, such as "A is a kind of B, which is a kind of C, which is a kind of D . . . ," and "M causes N, which causes O, which causes P . . ." (see e.g., Reigeluth,

1983c). However, these are probably only the tip of the iceberg in relation to all the important kinds of relationships to teach. Again, this should be a fruitful area for future work.

Mediational Methods

Given that our field has strong roots in media, we have a tendency to constrain our instructional designs to certain mediational systems, particularly to such resources as print, computers, and video. However, it is helpful to keep in mind that many other types of mediational systems can be used. We should keep in mind that the source of instruction can be human or nonhuman, that a human source can be a professional or an amateur, that a nonhuman source can be instructionally designed or not created specifically for purposes of instruction, and that the intended receiver can be an individual or a group. These characteristics yield the kinds of mediational systems shown in Table 1. Please note that the labels in the eight cells of the matrix are familiar concepts that don't overlap completely with the concept as defined by the characteristics of the source and receiver. They are included merely to be illustrative of the sort of approach one might think of first for each category. There is also considerable overlap between these categories and the midlevel strategies mentioned earlier. Furthermore, it is important to keep in mind that almost any medium or combination of media can be used within each of these categories.

Instructional designers have had a tendency to use individualized resources without considering that another mediational system might be better. Cost-benefit analysis is

TABLE 1 □ Mediational Systems

	SOURCE			
RECEIVER	HUMAN		NONHUMAN	
	Professional	Amateur	Designed	Natural
Individual	Tutoring	Peer Tutoring	Individualized Resources	Individual Projects
Group	Lecture	Discussion	Group Activities	Group Projects

likely to be very important in making informed decisions. This is another important new direction for educational technology.

Management Methods

As instructional tools become more powerful and more varied, the task of managing instruction becomes more formidable—and more important. It is not just a matter of coordinating diagnosis and revision activities, although that is certainly very important. It is also a matter of deciding which kind of resource is important for whom and when, and which strategies are important for whom and when for each resource. A wide variety of considerations comes into play, including individual differences, mastery learning, record keeping, learner control, scheduling, incentives, and much more. With the development of expert systems, it is possible to think of designing an "advisor" into computer-based instruction, an advisor who will monitor the learner's activities, intervene with advice when appropriate, answer questions about instructional management; and serve other instructional management functions. But what are the rules which should govern such an advisor? And what instructional management activities are best left to a human? Addressing such management issues is indeed an important new direction for educational technology, or, more accurately, it takes an old direction into new territory.

Other Concerns

Another issue that has been too little explored in our research and theory is that of motivating learners. All of the above-mentioned kinds of methods can be used to enhance motivation to learn: organizational, mediational, and management. Motivational strategies were largely ignored by instructional theorists until very recently. John Keller (1983, 1987) has done much to integrate the current knowledge about motivation into a set of prescriptions for instructional design-

ers, but more work is needed in this area, particularly regarding motivational strategies which are uniquely possible with advanced technologies.

Another neglected issue in educational technology is the design of whole educational systems. We are finding that our powerful new learning tools are not being adopted by school systems the way they can and should be; the structure of the school system works against them. At the same time, there is increasing recognition that the problems with our schools are ones which cannot be fixed by providing more of everything: more teacher training, more teacher pay, more school hours in a day, more school days in a year, and so forth. For a quantum improvement in education, we need to develop a better *system*—we need to restructure the schools. With our field's emphasis on systems thinking, we are uniquely qualified within colleges of education to help public schools to restructure. Along with this unique qualification comes a certain responsibility, and there is evidence that our field is beginning to awaken to this responsibility. A recent special issue of the *Journal of Instructional Development* (Vol. 10, No. 4) was devoted to ID in the schools. At Indiana University we have recently become involved in helping the Indiana Department of Education to plan better ways to structure the Indiana public schools to meet the needs of an information society. Bela Banathy (1988) has long been working on ways to bring about systems changes in the schools. However, our knowledge base is woefully inadequate in this area. What kind of structure should our schools have? This may be among the most important of the new directions for educational technology.

CONCLUSION

Many exciting things are happening in the field of educational technology, but increasingly we find ourselves on the sidelines. People from other disciplines are taking an interest in educational technology, but they have shown little awareness of or interest in our

knowledge base. This article has attempted to initiate a discussion of some changes in mindset which may deserve consideration: thinking in terms of construction as well as instruction, viewing the focus of research as the quest for optimality as opposed to validity, viewing the formative-evaluation type of research as more appropriate for continued development of our knowledge base than are experimental studies, and thinking in terms of R&D rather than R or D.

Given the challenges that face us and the rapid changes that are occurring in educational technology, we need to look for new directions which will be most beneficial for improving the health and usefulness of the field. From an instructional theory perspective, I believe that some of the most important new directions include the development of the following kinds of strategy prescriptions:

1. prescriptions for types of learning which have been largely ignored by the field, such as understanding and generic skills.

2. prescriptions which take advantage of the unique capabilities of new technologies, such as simulations and intelligent tutors.

3. prescriptions for midlevel strategies.

4. prescriptions for most macro organizational methods, especially structuring and sequencing a course or curriculum and synthesizing ideas.

5. prescriptions for selecting mediational systems.

6. prescriptions for designing instructional-management systems.

7. prescriptions for motivating learners.

8. prescriptions for complete, restructured, educational systems.

The kinds of advances in our knowledge base discussed herein will not be easy to achieve. They will require vision and resources, communication and cooperation. Whatever the obstacles, these advances are strategically crucial for helping us to strengthen the most important economic resource in an information society: the knowledge and capabilities of our people. ☐

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