Commentary

Elaborating the Elaboration Theory

☐ Charles M. Reigeluth

In this article, the author comments on the preceding article, "A Critical Review of Elaboration Theory," by Brent Wilson and Peggy Cole

☐ I commend Brent Wilson and Peggy Cole for a generally excellent article. I applaud the spirit of continually improving our knowledge base about instruction. They have done a fine analysis of advances in cognitive theory that have important implications for our young but growing knowledge about sequencing instruction. They have also developed some useful recommendations that should be (will be) incorporated into the next elaboration of elaboration theory (ET). ET is a cognitively based theory of instruction (Reigeluth & Stein, 1983) and must continually take advantage of advances in cognitive psychology.

ET has, in fact, been changing continually since its inception in 1977, and some of the Wilson and Cole recommendations have already been implemented. For the procedural orientation, in 1979 we developed the simplifying conditions method (Reigeluth & Rodgers, 1980) to replace the content-structure-based method previously used to sequence complex procedures. The content-structure-based method we had adopted was the path analysis method developed by Joseph Scandura (1973) and Paul Merrill (1978). In 1985 we extended the simplifying conditions method (SCM) to the theoretical orientation (Reigeluth, 1987), where it also replaced a content-structure-based method, one that identified and used the same kind of taxonomic relationship among principles that the conceptual orientation did for concepts: broader, more general, and more inclusive principles being taught before the narrower, more detailed principles that elaborate on them.

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THE SIMPLIFYING CONDITIONS METHOD

Briefly, the simplifying conditions method (SCM) entails working with task experts to identify a very simple kind of case they have experienced that is as representative as possible of the task as a whole. This kind of case constitutes the "epitome" of the task. Next, the ways in which the simple version of the task differs from the most complex versions are identified with the help of task experts and are listed as the "simplifying conditions"—real-world conditions that distinguish the epitome version from more complex versions of the task. The simplifying conditions are then relaxed, usually one at a time, in the order that introduces the most important and most representative remaining versions of the task first (Reigeluth & Kim, 1991).

Often, relaxing a simplifying condition results in too much new knowledge being needed for the learner to perform as an expert. When such a primary simplifying condition is relaxed, then—and only then—are some secondary simplifying conditions identified and inserted. Those secondary simplifying conditions could all be relaxed in order of importance and representativeness before any additional primary conditions are relaxed, but generally it is preferable to relax all the primary conditions before any secondary ones, because this gives the learner a broader, more representative view of the task earlier on in the instruction.

Although the conceptual elaboration sequence has remained unchanged since Reigeluth and Darwazeh (1982), we don't believe it is very important or relevant for sequencing most courses or curricula. The SCM has become the major sequencing strategy offered by ET, and it is not constrained to a single organizing structure; indeed, it is not based at all on any content structures. It offers the kind of flexibility that Wilson and Cole advocate. Furthermore, in contrast to Wilson and Cole's comments about the content-structure-based ET, it is highly consistent with the sequencing approaches of Burton, Brown, and Fischer (1984), as well as with those of Bunderson, Gibbons, Olsen, and Kearsley (1981) and White and Frederiksen (1986), which Wilson and Cole acknowledged as consistent with ET.

Following are some specific issues raised by Wilson and Cole that I would like to address.

INTERNAL VS. EXTERNAL KNOWLEDGE STRUCTURES

This issue is discussed by Wilson and Cole on p. 65. The controversy, which usually entails pitting an "external body of knowledge" against the knowledge inside an individual's head, seems to me to overlook one important point: The whole purpose of external knowledge structures is to represent internal knowledge structures. Our goal is for the two to become the same. When experts create external knowledge structures, they are trying to communicate their own internal structures. They want to make the external as similar as possible to the internal (within the constraint of having to simplify).

External structures are useful for experts to share their views, learn from each other, and develop some common understandings, concepts, and terminology. They are also useful in instruction, where the purpose of presenting an external structure is to make the internal as similar as possible to the external. We want to help the learner to develop an internal structure that is as similar as possible to the internal structures of experts. This is true regardless of whether or not the experts have reached consensus, although in cases where they have not, it behooves us to help the learner to understand the major alternative knowledge structures.

People individually construct their own meanings, but the purpose of instruction—and indeed of language and communication itself—is to help people to arrive at shared meanings. To the extent that external knowledge structures reflect the internal structures of experts, they can be valuable tools to facilitate learning. It is not very useful to talk in such dialectic terms as one versus the other. I applaud Wilson and Cole for their insights on this matter.

CONNECTIONISM AND AUTHENTIC TASKS

I think there is much merit to the connectionists' pattern-matching and pattern-using view of thinking. I believe it is one important mode of thinking, though certainly not the only one. There seems to me to be much evidence of rule-based thinking as well, although one could argue that a rule is nothing more than a pattern for action. Either way, it seems that patterns have parts and could be taught by partitioning them into their discrete parts. So the issue of taking a holistic versus analytic approach seems to me to be a separate issue from viewing thinking as pattern based versus rule based.

One of the major purposes behind the development of ET was to develop a sequencing strategy that was much more holistic than the predominant parts-to-whole hierarchical approach. The SCM moves a step further in that direction. With SCM, it is no longer necessary to partition knowledge into discrete structures. You find out from your experts what the simplest representative version of the task is like, and you can teach it in a holistic manner regardless of whether it is best viewed as rule based or pattern based. Alternatively, you could take an analytic approach and partition that version into discrete components and teach those components one at a time, if you felt your learners would benefit most from that approach. ET is neutral on this issue, although I suspect that some intermediate position, some combination of the two, will prove most beneficial to learners.

In contrast, ET is not neutral on the issue of authentic tasks. It is true, as Wilson and Cole point out, that "ET currently does not provide detailed prescriptions for making instructional sequences 'authentic' or 'situated' in a context similar to real-life problems" (p. 66). However, ET does advocate that such be done. It advocates that the epitome be as representative as possible of the real-world task as a whole. If such an epitome version of the task is still too complex to teach in about ten hours of learning time, then—and only then—should the task be further simplified in a way that sacrifices authenticity. Similarly, situatedness (in a real-world setting) is viewed by ET as often desirable (at least by the end of the instruction), but its use is a cost-effectiveness decision that may result in selection of such alternatives as simulations, role-playing, or even written case studies.

CONTENT STRUCTURE AS ORGANIZING STRUCTURE

Given the replacement of a content-structure method for sequencing by the SCM, the comments by Wilson and Cole on this issue are largely irrelevant now. However, there are a few issues that I would like to address.

There is an important reason why we selected only three kinds of organizing structures for ET. First of all, ET was developed for sequencing skill-oriented tasks, what Merrill (1983) calls "use-a-generality" tasks. For purposes of prescribing instructional strategies, it appeared (and still appears) most useful to think in terms of three major kinds of skills: concept classification, procedure using, and principle using. ET has not yet been expanded to non-skill areas, such as sequences for developing understanding, attitudes, or morals and ethics.

Secondly, we have found that every pattern of sequencing is based on a single kind of relationship within the content, that is, among the elements of knowledge. Gagné's hierarchical sequence is based on the learning prerequisite relationship among skills; the procedural sequence (sometimes called a forward-chaining sequence) is based on the performance prerequisite relationship among steps of a procedure; the chronological sequence is based on the historical order in which events occurred; the Scandura/Merrill shortest-path sequence is based on the relative complexity of different paths through a procedure; and so forth. Therefore, our intent was to identify all those kinds of relationships that represented levels of complexity wherein the simplest elements were also the most holistic elements. We found that some relationships were "pervasive," that is, they applied to a set of elements, such as A is to B as B is to C as C is to D. Among concepts, they were the kinds and parts relationships (which are qualitatively the same: superordinate, coordinate, and subordinate); for procedures, they were complexity of "paths" (or versions) of the task; and for principles, they were level of generality, breadth, and inclusiveness. We could not find any other kinds of relationships for skills that met all of these criteria.

Another issue is that of a single organizing structure. Since about 1980 we have talked about multi-structures, which are a hybrid of two or more structures, and we indicated that such a structure could be used as the basis for forming a hybrid sequence. However, we also indicated that whenever such a multi-structure was not used, then only one content structure should be used to create the elaboration sequence. Our thinking has changed on this. A study by Beissner and Reigeluth in 1987 showed that procedural and theoretical content could be elaborated simultaneously as what we called "parallel structures," and we have come to understand that many separate sequences (strands) can be woven together to form a complete course or curriculum sequence. For instance, a sequence for developing attitudes could be interwoven with a sequence for developing skills and one for developing understandings. However, we still believe that each individual strand is likely to be based on a single type of relationship.

On p. 67 Wilson and Cole discuss a variety of "orientations" suggested by Posner and Rudnitsky (1986): "inquiry, application, problem, decision, skill, or personal growth." I would characterize our "orientations" as skill and application (synonymous in my view). I would consider inquiry and problem orientations as a separate dimension that can be used with any of our orientations—you can use an inquiry approach with a conceptual, procedural, or theoretical orientation. So it is not accurate to say that even the "old" ET restricted such alternative "orientations" from being used by a designer.

ILL-STRUCTURED DOMAINS

The issue of ill-structured domains is not new to ET. Reigeluth and Merrill (1984) identify complex cognitive tasks ("transfer tasks") as distinct from well-structured ("procedural") tasks. ET's theoretical orientation analyzes such tasks as to their underlying principles (causal models),* which an expert uses to invent new solutions to new problems. However, what ET does not yet include is explicit prescriptions for dealing with those ill-structured domains in which either multiple perspectives or alternative procedures (approaches) are important. It does not exclude them, but it does not explicitly include them, and I agree it should. But Wilson and Cole are a bit misleading when they equate on p. 68 the three kinds of skills (the three orientations) with the "widely diverging views about the nature of knowledge and expertise" held by educators, philosophers, and humanistic theorists. As mentioned earlier, the three types of skills were not intended to be an exhaustive taxonomy of types of knowledge and expertise; they were merely the recognition of three types of pervasive relationships that provide a basis for skills to be sequenced in a holistic manner.

SEQUENCING ISSUES

I would like to make two small points about cascaded problem sets (Schank & Jona, 1991). First, when ET begins with the simplest case, it is referring to application-level learning, whereas when Schank begins at the end and then works backwards, he is not teaching learners how to do the final skill first. In fact, his approach is basically a kind of placement test to determine where to start the instruction. I wholly support this practice and agree that ET would be enhanced by explicitly including it. Second, I am less sympathetic with Schank's prescription to break a problem down into its constituent parts, then break each of those parts down into its parts, and so forth. As Wilson and Cole indicate, this is more consistent with the parts-to-whole sequencing advocated by Gagné and is in sharp contrast to the holistic approach advocated by ET.

I greatly appreciate the suggestion by Wilson and Cole to modify ET's conceptual elaboration sequence to work out from the middle

*Please note that we believe that causal models are usually probabilistic (or stochastic) rather than deterministic—that is, a certain cause does not always have the indicated effect. There are also usually multiple probabilistic causes and multiple probabilistic effects. We find systems thinking to be highly relevant here.

(both up and down), rather than strictly use a top-down conceptual sequence. I have long been concerned that one cannot really consider a concept at the top of a conceptual structure to be clearly simpler than a concept at the bottom.

I find myself somewhat concerned about the discussion of "Sequencing for Conceptual Change," which starts on p. 71. Case's model is irrelevant to ET (a theory for sequencing instruction) as far as I can tell, but I agree with the four points of his that Wilson and Case describe. Second, I am not so sure that "we cannot anticipate students' emergent mental models." With carefully designed instruction, we can lead learners to develop common bugs in their mental models and help them to correct those bugs (see, e.g., Collins & Stevens, 1983). Third, the traditional ID approach described by Newman, Griffin, and Cole (1989) has little relevance to ET. On the other hand, their "teacher-based approach" seems to have many weaknesses which Wilson and Cole have overlooked: (1) the learner is made to be very dependent on the teacher; (2) the learner will be a passive observer much of the time early in the instruction; (3) the task is in effect being broken into component parts, with the teacher performing some parts and the learner performing others; and (4) no guidance appears to be offered as to how to decide what and how much the learner should do at each stage of the instructional sequence—some teachers will be able to make good decisions intuitively, others will not.

Regarding the internal reflection-in-action processes, I am left wondering where the notion of academic theories entered the picture. ET, and every other approach to task analysis with which I am familiar, entails analyzing an expert's activities and/or mental models ("personal theories of practice"), not relying on academic theories. I suppose Schön (1987) is coming from a public school teaching perspective where teacher educators espouse a very different approach from instructional designers, but I would have felt more comfortable if Wilson and Cole had pointed this out. Also, this casts a long shadow of doubt on the assertion that "by extension, we could argue that instructional designers simply cannot capture, represent, and teach the 'content structure' really needed for expertise" (p. 73). In fact, with our task analysis and knowledge engineering techniques, we can indeed capture much, though not all, of it, depending on how ill-defined the domain is.

I found Putnam's (1991) stages of competence in the use of recipes intriguing. It is certainly very different from ET's simplifying conditions method. The simplest version of the task (the epitome) could be learned at all three of Putnam's stages before progressing to a more complex version. This would likely avoid some of the problems inherent in the use of recipes yet still permit the three positive functions Putnam identified. In particular, novices would learn the limitations of recipes from the first week or so of their instruction.

Finally, Wilson and Cole indicate that "currently, ET does not directly address the issue of building instruction around design activities" (p. 75), that is, designing computer lessons to teach what they are themselves trying to learn. I have long believed that one of the best ways to learn something is to teach it, so I heartily approve of this activity. It is not currently a part of ET because I do not consider it to be a sequencing strategy.

RECOMMENDATIONS

Although the first recommendation by Wilson and Cole, "deproceduralize the theory," is inconsistent with Schön's advocacy of the use of recipes, I support the spirit behind it. I don't think the procedure for using the theory should dominate the exposure of people to the theory. In fact, I'm a bit surprised that they feel that it does. I have tried in my writings to distinguish clearly between the theory itself—its principles, models, and strategies—and a development procedure that can be used to implement it. One of the most frequent criticisms of the sequencing prescriptions of both Ausubel and Bruner was that it was very difficult to figure out how to operationalize them. That is why I have often included development procedures, but always at the end of my writings, and with less space devoted to them than to the theory. In essence, I don't feel it would be beneficial to *deproceduralize* ET, but I do feel it is important to *de-emphasize* the procedure. I sense that may be the spirit of the recommendation.

I have some concerns about the first "key principle." Unlike the two that follow it, it is not a prescriptive principle. In addition, I believe all subject matter has many underlying (and interconnected) content structures, not just one. Furthermore, I don't think all content structures are personally idiosyncratic—I think there is considerable consensus among experts in many domains, even though there may be alternative ways of doing the same things in such domains.

Recommendation 2, "remove unnecessary design constraints," has already been implemented, in my view, by the SCM.

Recommendation 3, "base organization and sequencing decisions on learners' understandings," is well taken, particularly regarding the prescription to start in the middle and work both up and down for a conceptual sequence. The remaining items under recommendation 3 are really outside the scope of ET, although I agree with all of them.

As to recommendation 4, "assume a more constructivist stance," I agree that much of an expert's knowledge *in ill-structured domains* is "tacit and ineffable, resistant to reduction and analysis." But I also think that there is considerable consensus among experts in many well-structured domains, as I discussed earlier. I agree that more constructivist notions need to be integrated into ET to better deal with ill-structured domains. I also think that development of more creativity and intuition would be beneficial in many such domains.

CONCLUSION

A radical restructuring of ET, as called for by Wilson and Cole, is indeed justified. It has in fact already occurred to a large extent, and will surely continue. Some of the suggestions by Wilson and Cole which have not been implemented already through the SCM will definitely be implemented in my future writings, and I am deeply grateful for their thoughtful and thorough analysis and recommendations. □

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Some Uneasy Inquiries Into ID Expert Systems

☐ Craig Locatis
Ok-choon Park

Alternative approaches to developing software automating instructional development are described in this article. Information management and expert system approaches are compared. General assumptions underlying the development of all authoring tools, including conventional authoring systems, and additional assumptions underlying the development of expert ID tools are identified. Questions are raised concerning the viability of ID automation tools. It is argued that conventional authoring systems may not be as inadequate or inferior as ID expert system developers have claimed, and that of two approaches to ID automation, tools emphasizing information management are probably most useful. Information management tools, however, still may be inappropriate in some contexts.

☐ Authoring systems, which allow course developers to build displays, specify inputs, and branch students, focus on how such course ingredients are realized in specific lessons (cf. Kearsley & Locatis, in press; Locatis & Carr, 1985; Park & Seidel, 1989a). While these "programmerless" tools for developing computer-based instruction have been around for some time, instructional design (ID) expert systems are relatively new. ID expert systems are part of a family of software tools for automating course development. In theory, both authoring systems and automation tools could be used to develop conventional computer-based instruction, with prespecified branch points, and intelligent tutors, with branching based on complex performance models (cf. Park & Seidel, 1989b; Wenger, 1987). In practice, the tools concentrate on conventional instruction. Their major difference is that authoring systems are meant for building the final product, while automated ID tools are intended for planning it.

Automated ID tools differ in design and approach, and their developers make varied assertions about tool intelligence, the role of theory, and the prescriptive assistance that should be provided (cf. Gustafson & Reeves, 1990; Kearsley, 1986; Li & Merrill, 1991; Pirolli & Russell, 1990; Wilson & Jonassen, 1990/1991). This article focuses on programs that purport to be theory-based expert systems that

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