The Carroll Model

A 25-Year Retrospective and Prospective View

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The Model of School Learning, first published 25 years ago, has taken its place as a useful guide in research on teaching and learning in schools. The model accounts for variations in school learning with five classes of variables, three of which can be expressed in terms of time, the other two in terms of achievement. Most aspects of the model have been confirmed, although details remain to be filled out by further research. Ways that the model might be used to address current problems in education are considered. The model's emphasis on aptitude as a determinant of time needed for learning suggests that increased efforts be placed on predicting student potentialities and designing instruction appropriate to those potentialities, if ideals of equal opportunity to learn are to be achieved within a diversity of educational objectives.

The year of 1988 marked the 25th anniversary of the publication of "A Model of School Learning" (Carroll, 1963), an article that has elicited much more attention than I anticipated when I wrote it. The article has been much cited, quoted, and used in guiding research into various aspects of education and teaching. It has also been a basis for major programs of educational innovation (e.g., the Beginning Teacher Evaluation Study of Denham & Lieberman, 1980). Here I consider whether the model has been adequately confirmed as an interpretation of school learning effects, and I then ask in what ways the model can be used to solve current problems in education.

The Model's Origins

The model had its roots in work on foreign language learning that showed that persons with low aptitude, as measured by certain tests, generally took much longer to achieve a given criterion of learning than persons with high aptitude. Other factors seemed to be operative as well, such as the quality of instruction and the student's ability to understand instructional materials. These and other factors were embodied in a formal, quasi-mathematical model in a technical publication on foreign language aptitude (Carroll, 1962). It seemed reasonable, however, to generalize the model to apply to the learning of any cognitive skill or subject matter.

Five classes of variables. The model, as presented in 1963, postulates five basic classes of variables that would account for variations in school achievement. Three are assumed to be amenable to expression in terms of time: *Aptitude* is the name given to the variable or variables that determine the amount of time a student needs to learn a given task, unit of instruction, or curriculum to an acceptable criterion of mastery under optimal conditions of instruction and student motivation. High aptitude is indicated when a student needs a relatively small amount of time to learn; low aptitude is indicated when a student needs much more than average time to learn. *Opportunity to learn* is defined as the amount of time allowed for learning, for example by a school schedule or program. Frequently, opportunity to learn is less than that required in view of the student's aptitude. *Perseverance* is defined as the amount of time a student is willing to spend on learning the task or unit of instruction; in this sense, it becomes an operational definition of motivation for learning. The time actually spent on learning, in any given situation, is the shortest of the three time variables. That is, the amount of time spent is the time actually needed by a student, reduced by any amount of time that the student does not spend in learning because of lack of opportunity (from external circumstances not under the student's control) or the student's own unwillingness to spend as much time as is needed.

The other two variables are assumed to be related to achievement: To the extent that *quality of instruction* is less than optimal, time needed for learning is increased. Furthermore, to the extent that the student is lacking in *ability to understand instruction*, the amount of time needed is increased. The model is not very specific about the characteristics of high quality instruction, but it mentions that learners must be clearly told what they are to learn, that they must be put into adequate contact with learning materials, and that steps in learning must be carefully planned and ordered. Ability to understand instruction is described as including, besides language comprehension, learners' ability to figure out for themselves what the learning task is and how to go about learning it.

Educators and educational researchers have given most attention to the model's emphasis on time as an important variable in learning, as expressed in the contention that the degree of learning or achievement is a function of the ratio of the time actually spent on learning to the time needed to learn.

One of those whose thinking was influenced significantly by the model was Benjamin Bloom (1968), who used it as one basis for his concept of mastery learning. Bloom came to believe that nearly all students could achieve mastery of standard school subjects if attention were paid to increas-

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ing the ratio of time spent to time needed, either by increasing the time spent (the numerator of the ratio) or by reducing the time needed to learn (the denominator), or both. This might be done by improving quality of instruction and enhancing students' motivation and aptitudes or "entry characteristics." Mastery learning became a popular and widely used term, and it has been the subject of much research and experimentation. It is not my term, however; although mastery learning uses many of the concepts of the model of school learning, I think of the model as offering a broader, more theoretical basis for explaining and interpreting school learning effects.

Previous Treatments

In 1985 I reviewed Bloom's and a host of early treatments and discussions of the model (Carroll, 1985) that had appeared up to 1980, based mainly on a survey of the 168 citations of the 1963 article that were referenced in the *Social Sciences Citation Index* over the years 1969 to 1980. The article continues to be cited even now; there are 133 citations in *Social Sciences Citation Index* over the years 1981 to 1986. I have looked at a good many of these articles, and I comment here on a few of them.[1]

It has always been a matter of some astonishment to me that I am credited with directing attention to time in learning, an exceedingly obvious variable that must have been in the minds of educators over the centuries and that has figured heavily in the work of theorists and experimenters on learning. Learning curves abound in journals and textbooks, plotting increasing performance against time or number of trials. I have always cautioned that time as such is not what counts, but what happens during that time. I can agree with Gage's (1978) observation regarding studies of engaged time, cited by Shulman (1986), that "time is, in a sense, a psychologically empty concept" (p. 75).

The problem is, of course, that although we can measure time—certainly elapsed time, and possibly 'academic learning time' or 'time on task' (Karweit, 1983)—we cannot meaningfully measure what goes on in the head of the student during that time, or insure in any way that what goes on in the student's head is addressed to learning. All that we can say with some certainty is that any learning that happens to occur does require time. That was the main message of the model of school learning, insofar as it pertained to time. But if the model has drawn attention to this problem, the effect has apparently been highly salutary, for it stimulated a long series of researches devoted to time-on-task and academic learning time. Nevertheless, we have still not adequately considered time as a variable. Educational psychology as a science still has no adequate procedures for estimating how long a given unit of instruction will take to be learned by students with different aptitudes. (I came to realize this, recently, when I was asked to specify how long students ought to take to master units of a correspondence course.)

Expansions and Adaptations

There have been various expansions and adaptations of the model. One interesting expansion is a new mathematical model proposed by Aldridge (1983) and tested in a classroom setting, at least in a preliminary way, by Johnston and Aldridge (1985). Aldridge used the basic variables of the Carroll model but put them into a more elaborate mathematical formulation. Johnston and Aldridge found "positive but not compelling evidence" (p. 553) that this new model of mastery learning is correct. I find this work engaging because it seems to carry out my original intention (Carroll, 1962) to mathematize school learning effects.

Shulman and Carey (1984) accepted the basic process-product emphasis of the Carroll model but added considerations of affect. As they put it, "Psychologists must learn to understand the 'hot cognitions' or thoughtful passions characteristic of teachers and pupils before we begin to have an adequately rich understanding of either reasoning or civility" (p. 522). In a later, highly thoughtful and philosophical review, Shulman (1986) has suggested that models like mine are only highly oversimplified constructions of reality, based on a 'bounded rationality,' that can hardly do justice to the complexities that are inherent in teaching and learning. Even a moderately oversimplified model is often useful, nonetheless, in dealing with complex phenomena.

Research by Haertel, Walberg, and Weinstein (1983) has centered on Walberg's model of educational productivity, which is essentially an expansion of the Carroll model to make explicit reference to the social environment of the classroom, the student's home environment, peer influences, and the effects of mass media. It's possible, of course, to interpolate these variables into the Carroll model as originally conceived (with a little forcing of terms, perhaps), but it may also help to consider these variables separately. Walberg (1984, 1986) stated that syntheses of educational research based on an expanded model "have brought a new level of scientific maturity to research on teaching" (p. 214). An elaborate study by Parkerson, Lomax, Schiller, and Walberg (1984), using LISREL-type path analysis, identified the best combination of these constructs for predicting achievement in science learning. It is striking that correlations and effect sizes for the basic variables of the Carroll model, as somewhat expanded, tend to be largely significant in the directions expected. Of those variables, only quality of instruction failed to show a consistently significant effect; possibly that is due to problems in measuring this variable. In any case, these results are a positive vindication of models like mine and Walberg's, and an invitation to their further use in predicting schooling effects and in thinking about how to organize learning in classrooms.[2]

Despite progress in educational research, however, according to Sirotnik (1983), the benefits to actual teaching practices are uneven. In his study of over a thousand elementary and secondary classrooms, Sirotnik found that the larger part of class time was spent in teachers lecturing to classes or in students working on written assignments. In Sirotnik's view,

> *the good news is that this monotonous scenario of teacher talk to total class and student work on written assignments is consistent with the recommendations emerging from current research on effective teaching practices: increasing quantity of schooling, specifically time-on-task or academically engaged time, raises scores on achievement tests. The roots of this line of research can be traced through the work of Carroll, Wiley, Bloom, and a host of others. . . . This research is useful in at least two respects. First, it reaffirms*

some fundamental premises implicit in our common form of pedagogy—didactics and practice. In particular, it reinforces the connection between concerted teacher-learner effort on specific skills and test scores which measure the attainment of those skills. Second, and more importantly, this research focuses attention on the complexity of mastery learning in the ordinary classroom setting and may eventually lead to more definitive studies of viable teaching strategies. Unfortunately, the bad news is that time-on-task research may have also diverted attention from critical instructional variables such as discussion, demonstration, questioning at higher cognitive levels, praise, reinforcement, student decision making, and positive affective climate. These are practices which we rarely observed in our study, but which are valued teaching strategies by many educators and researchers and are correlated positively with achievement outcomes in many empirical studies. [sic]... Clearly, it is the quality *more than the quantity of schooling which best serves as an educational and research focus. Quality of schooling includes not only time-on-task, but time* well spent. *(pp. 25–26)*

So, it seems, there is both good news and bad news about the way in which models of school learning have been applied and interpreted in classrooms. What may have gone wrong—at least some of the time?

Perhaps there is a clue from an informal discussion I recently had with an experienced, highly intelligent classroom teacher. We were talking about concepts of mastery learning. As an example, he wanted to consider how one might teach children the meaning of the word *musket*. Using mastery learning, he thought, he would have to concentrate on teaching the definition of the word, as found in dictionaries, and having children practice writing sentences or stories using the word correctly. In contrast, if he could ignore mastery learning ideas, he would prefer to take the children on a field trip to a museum where they could learn the full meaning of the word by seeing muskets on display and hearing something about their role in the American Revolution. To be sure, this might be a more inefficient way of teaching, but he thought it would be more meaningful and memorable, and in addition, it would lead to a different kind of mastery from that produced by a conventional mastery learning procedure.

It is obvious that this teacher, to the extent that he had been exposed to notions about mastery learning, had gotten the impression that it required analyzing learning tasks into small steps and then using drill and practice procedures to pound in the learning. I argued with him, however, that mastery learning, or at least the model of school learning, carries no such implication. The model of school learning requires clear specification of the task to be learned. But this specification need not break the task into small steps, and it makes no requirement that drill and practice procedures be followed. If a teacher wants to analyze learning the meaning of *musket* as a task involving recognizing the special characteristics of muskets and their importance in the wars of the 18th century, attaining a high quality of instruction might indeed involve arranging trips to museums, seeing historical films, and other things. Achieving criterion success might take longer than a more lockstep approach, but that would only be the consequence of a different, but perhaps better justified, analysis of the task.

There is perhaps a lesson here for those who want to promote the concept of mastery learning, or, for that matter, the model of school learning. Mastery learning does not necessarily require breaking down the learning task into highly specific stages and skills, nor does it demand attending to those skills one by one in isolation from the total learning task. Sometimes it may be useful to look at specific skills, but they must be taught in the context of the broader final task and in relation to each other. Some reading programs, for instance, have attempted to break reading into numerous distinct skills, each taught with focused work sheets. Such a plan can become top-heavy and cumbersome. It draws too much attention to particular skills, without putting them into a total context of reading instruction. Sometimes, it is reported, the students undergoing such programs have to spend so much time on the skill sheets and work books that they have little time to apply their skills in actual reading. Most reviews and 'think pieces' on the model of school learning or mastery learning provide no explicit discussion of this issue, but it deserves scrutiny in both its theoretical and empirical aspects.

Time-on-Task and Other Variables

The literature contains, of course, much discussion of the time-on-task and academic learning time concepts. These ideas even found their way into the U.S. Department of Education's (1986) little monograph *What Works*. One of the 'findings,' "Managing Classroom Time," was clearly derived from work on the model of school learning and mastery learning:

> *How much time students are actively engaged in learning contributes strongly to their achievement. The amount of time available for learning is determined by the instructional and management skills of the teacher and the priorities set by the school administration. (p. 34)*

The importance of quantity of instruction was also acknowledged in the finding that student achievement rises significantly "when teachers regularly assign homework and students conscientiously do it" (p. 41). This monograph, however, dodged saying much about other aspects of the model of school learning. It implicitly granted that students differ in ability to learn, but limited itself to citing the finding that "children's understanding of the relationship between being smart and hard work changes as they grow" (p. 33). At another point, it emphasized that "accomplishment in a particular activity is often more dependent upon hard work and self-discipline than on innate ability" (p. 16). But it said little or nothing about adjusting classroom time to the needs of slower learners, as it might well have done.

The professional research literature is full of evidences of concern with how time-on-task should be defined (Anderson, 1984; Karweit, 1983; Strother, 1984). I was impressed with the Karweit and Slavin (1982) review that showed that different definitions of time-on-task could lead to important differences in substantive conclusions and with Hawley and Rosenholtz's (1984) elaborate review of some three thousand studies that concluded that optimizing academic learning time is one of the most important factors in improving student achievement. We need better measures of time-on-task. Techniques that memory re-

searchers (e.g., Naus, Ornstein, & Aivano, 1977) have employed to observe and measure amount of rehearsal would possibly be useful. Students could be asked to give overt rehearsals of material to be learned. Time during which such overt behavior could be observed could be counted as time-on-task.

On the topic of opportunity to learn, the Carroll model has been often cited in discussions of the optimum length of the school year, the length of the school day, and related matters (e.g., Pittman, Cox, & Burchfiel, 1986). Levin's (1986) caution about recommending longer school days as an efficient way to improve student achievement is worth noting, however. Although time may be important for learning, excessive time in the school day could have adverse effects on such factors as motivation or perseverance. This caution might not apply, however, to the length of the school year; the time factor may truly be part of the explanation for the appreciable disparities in international comparisons of achievement in countries with different lengths of school years. More scrutiny of the IEA studies from this point of view may be in order, along with studies of plans for increasing the amount of time during the school year that students are given opportunity to learn.

My previous review (Carroll, 1985) of responses to the model of school learning suggested that the variable of aptitude, as indicated by time needed to learn (TTL), had not received adequate attention. Some progress has been made since, particularly by Gettinger (1984b), whose review of the TTL literature points out that this variable had not yet "been adequately researched, measured, or effectively used in educational diagnosis" (p. 15). Earlier, Gettinger and White (1979) had developed procedures showing that sample learning tasks might be better predictors of success than standardized intelligence tests. Gettinger has provided additional evidence that TTL relative to time spent (TSL) is an important predictor of achievement (Gettinger, 1984a), and that reducing opportunity to learn relative to TTL has a negative effect on achievement (Gettinger, 1985). There are manifold possibilities, with many practical implications, in further research of this sort.

The model of school learning assumes that students differ in the amount of learning time they need. If these differences are to be adequately taken account of, considerable skill in classroom management is required of teachers. Arlin (1982) confirmed that teachers tend to adjust instructional time to the needs of the slower learners; probably this does not properly serve the needs of faster learners. Borg and Ascione (1982) demonstrated the value of training teachers in classroom management techniques pertaining to the use of time. The complexity of the problem of classroom management is clearly seen in a volume edited by Levine (1985) reviewing procedures of organizing mastery learning in different situations.

Much recent educational research has been devoted to the variable of quality of instruction. Perhaps because the Carroll model of school learning does not deal extensively with elements involved in quality of instruction, it has not been particularly influential in these studies. Bloom's elaboration (1968) of some of these elements, in his concept of mastery learning, undoubtedly drew greater attention to quality of instruction and, as a number of reviewers have proclaimed, led to greater educational gains when those elements were adequately dealt with. Nevertheless, the elements stressed by Bloom have been largely mechanical or procedural in nature, such as the use of periodic formative testing, corrective feedback, student tutoring, and homework assignments. These are all to the good, but they neglect the basic issue of how the content of instruction is to be organized and presented. Only in recent years has instructional technology resumed looking at the cognitive processes that students need to develop and master in acquiring particular subject matters such as reading, social studies, science, and mathematics and considering what instruction is needed to promote the use of these cognitive processes. Some of the studies reviewed in the latest edition of the *Handbook of Research on Teaching* (Wittrock, 1986) and many of the studies reported in the new journal *Cognition and Instruction* exemplify these recent trends. Insofar as the model of school learning incorporates quality of instruction as one of its major variables, these studies are not out of line with predictions of the model. Perhaps, with these and other studies, we are on the verge of being able to define and measure that elusive variable, quality of instruction, but such measurement will still be difficult. There is much more to be learned from analyses of good and poor instruction in classroom discourse and in printed materials.

A number of recent studies have considered the variable of motivation, or perseverance. Grabe (1982) and Grabe and Latta (1981) were concerned with measuring student effort and perseverance and determining the interrelationships of academic motivation, effort, and achievement in a flexible mastery learning situation. They confirmed that effort variables accounted for differences in student achievement even when aptitude was controlled, and also that achievement motivation had some sort of effect, though perhaps only indirectly. Similarly, Laffey (1982) used several measures of student involvement in social studies instructional activities in an urban high school, finding that these measures were significantly related to achievement. This sort of research supplements time-on-task research by looking at what motivates students to spend their time on task. A seemingly contrary finding, a negative correlation between effort and performance when ability was partialled out, was reported by O'Connor, Chassie, and Walther (1980). It may possibly be explained, however, as a result of low ability students wasting too much time due to inadequate study skills. (One of the nice, but troublesome things about the Carroll model, like Freud's psychoanalytic theories, is that one often can twist things to explain almost any finding!)

One of the specific predictions made in the Carroll Model of School Learning is that increasing the learner's perseverance (motivation) will not alter the degree of learning or learning rate, if time is held constant. This prediction was rather convincingly confirmed in a study by Millman, Bieger, Klag, and Pine (1983). The time needed to learn a paired-associate task under an encouragement condition designed to increase perseverance did not differ from the time needed to learn under a discouragement or control condition.

Overview and Prospects

Retrospectively, for the past 25 years, and increasingly in recent years, the Carroll model has been in the air. All or most of its components have been amply confirmed as influential in school learning, although it has not always been

possible to say exactly *how* they are effective or how they can be controlled or manipulated. Furthermore, the precise relations postulated among the variables of the model have not been adequately investigated, although some progress has been made. For example, few studies have tested the model's hypothesis that variations in quality of instruction make differences in time needed to learn. A possible exception is Sweller and Cooper's (1985) finding that time to learn from worked examples in algebra is significantly less than time to learn from conventional problem solving search techniques.

Prospectively, if past trends continue, the model will guide further investigations and refinements of its features. In the long run, the model will take its place as having been, at a particular period, a useful blueprint for educational research. With time, its details may become obscured or eclipsed by subsequent developments and expansions. But old models never die, they just get laid away.

How can appeal to the model of school learning be made to improve education? Part of my answer relies on a fundamental tenet of my philosophy of education, that we should seek mainly to achieve equality of *opportunity* for all students, not necessarily equality of *attainment*. In this respect, the model of school learning differs from Bloom's mastery learning concept, which seems to be focused on achieving equality of attainment. In view of the model's emphasis on the role of individual differences in aptitudes and in students' ability to understand instruction, I doubt that true equality of attainment can ever be realized, even if this were desirable (a point that is at least debatable). Emphasizing equality of opportunity means not only providing appropriate opportunities to learn (*appropriate*, not necessarily *equal* for all students), but also pushing all students' potentialities as far as possible toward their upper limits. Assessing students' potentialities (which differ markedly) implies that every available means, including carefully devised psychological and educational tests, work-sample learning tests, and many other ways of acquiring information about students, should be used to estimate, at least provisionally, what each student's potentialities may be, and their nature. Given those potentialities and with a view to the realities of time available, educational programs should be devised and selected to permit students to travel as far as possible toward realizing their capabilities for learning. There should also be continual reassessment of potentialities, with corresponding adjustments in educational programs.

All this will require still more attention than is now given, oftentimes, to educational management—to assessment and guidance of students, grouping and assignment of students to different educational programs, and planning the use of classroom time, among other things. It also will call for research to develop tools for educational management. But only in this way can the full implications of the model of school learning be realized. That is, only in this way can the variable of opportunity to learn be fairly and equitably specified for all students. Inevitably, I think, some degree of "streaming" and tracking of students is necessary; objections to such practices stem largely from misplaced egalitarian attitudes. Equality of opportunity to attain potentials implies that students with different amounts and kinds of aptitude need to have educational programs that differ in pace and content, and perhaps in many other ways. As someone has put it, we need not only equality of opportunity but also diversity of opportunity.

For all students, quality of instruction must be maintained at the highest levels appropriate in a given case. Teachers must be not only intelligent and competent as classroom managers but also adequately knowledgeable about the subject matter they teach. Instructional materials should be prepared and sequenced on the basis of the best research on the cognitive skills involved, and matched in a challenging way to students' levels of aptitude, skill, and knowledge. Instruction should clearly specify what is to be learned. Such procedures of mastery learning as formative testing, corrective feedback, and so forth should be used whenever they are appropriate and feasible.

The available evidence suggests that when the variables of quality of instruction and opportunity to learn are properly managed, the variable of student perseverance—willingness to learn—will take care of itself. □

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[1]There are a number of treatments of the model in textbooks and general reference works. In the recent *International Encyclopedia of Teaching and Teacher Education,* for example, there is a chapter about the model by Clark (1987). In what seems to me to be a somewhat odd and far-fetched way, Clark attempts to illustrate use of the model by applying it to explain SAT score declines. Other accounts of the model are to be found in various chapters in Wittrock's (1986) *Handbook of Research on Teaching* and in the fifth edition of the *Encyclopedia of Educational Research* (Mitzel, 1982). The original articles (Carroll, 1962, 1963) and other writings of mine connected with the model are now available in a book edited by Lorin Anderson (1985).

[2]I would caution, that LISREL-type path analysis, if it is limited to the study of linear relations, may not adequately capture the nonlinear relations postulated by the Carroll model, as represented by ratios among variables, for example.

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