33. LEARNER-CONTROL AND INSTRUCTIONAL TECHNOLOGIES

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This chapter has several purposes: (a) to update the literature base of learner-control studies provided in previous reviews; (b) to review the paradigms employed in CBI research on learner control in instructional technologies; (c) to focus and expand on the suggestions made or implied in these reviews that a number of individual learner differences (and by implication the mental processes they reflect) can greatly contribute to both the choices students make and to the effectiveness of those choices; (d) to explore the impact on learner-control effectiveness of both rational-cognitive processes and emotional-motivational states of the learner; (e) to propose some instructional prescriptions for the use of learner-controlled activities; and (f) to suggest avenues for future research.*

33.1 LEARNER CONTROL AND COMPUTERS

The thrust of discussion here involves learner control over instructional activities that are based on or delivered by a computer (including interactive videodisc, CD-ROM, and related technologies). The exploration of learner control within more traditional delivery systems—for example, the *Audio-Tutorial Approach* (see 22.2.2) of Postlethwait, Novak, and Murray (1972) and the *Personalized System of Instruction* (*PSI* or *Keller Plan*) of F. S. Keller (1974)—is comprehensively addressed in Reiser's (1987) chapter on the history of educational technology. (See also 22.2.)

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33.2 LEARNER CONTROL IN INSTRUCTION

In general, "learner-controlled instruction," regardless of the instructional delivery system employed, refers to those instructional designs where learners make their own decisions regarding some aspect of the "path," "flow," or "events" of instruction. Such an instructional process is not in any way new or novel; in fact, when examined closely, most instructional designs are seen to consist of a mixture of learner-controlled and instructor-prescribed events.

Designers may wish to base their decisions about the provision of learner control around any of several instructional models or theories commonly used to guide the selection of instructional methods. These models or theories (e.g., Gagné, Briggs & Wager, 1988; Merrill, 1983) usually consist of very small elements or component activities (see 18.4) (e.g., motivating activities, informing students of the objective, presenting information, providing feedback to learners on their performance) to be drawn upon or assembled into an instructional design. These models, too, coincidentally function very handily as practical menus of instructional components about which the designer may decide whether, when, and how to place under the learner's control.

Possibilities for learner control of these types of learner-controlled activities would apply to any format of instructional delivery system. However, because the literature base focusing specifically on learner control in computer-based instructional environments is a fairly well-defined subset of studies within the larger domain of general learner control (including, e.g., correspondence courses and independent study), the remainder of this paper will focus specifically on those issues of learner control that are related to technology-based instructional delivery systems.

(For additional discussions of issues related to learner control, see also 7.4.5, 12.2.3, 13.3.1, 14.6.2, 22.3.9, 22.5.5., 23.7.2, and 25.9.4.)

33.3 LEARNER CONTROL IN COMPUTER-BASED INSTRUCTIONAL DELIVERY SYSTEMS

A supposed advantage of computer-based instruction (CBI) over more traditional forms of instruction is its capability to deliver to students "individualized" lessons. That is, the computer can assemble and present to different students tailored lessons with wide variations in sequence of information, amounts of examples and practice questions, or kinds of feedback and review, to name just a few possibilities. In such situations, the computer program assumes the role of manager or guide of instructional activities. In such situations, students "receive" the instruction and have little or no explicit choice over what is given.

Alternatively, the instructional computer program may abrogate such decisions and allow learners to select the instruction they are to receive. Here, the learner operates to control the "flow" or "path" of instructional materials. Although it is certainly possible that learner choices might be afforded at a "macro" level of instruction, i.e., at the level of curricula, units, or lessons (see Romiszowski, 1986, for a discussion of instructional levels), typically the types of instructional choices provided in computer-delivered instruction operate at the "micro" scale, that is, at the level of small instructional elements, activities, or components.

There are many common instances of instructionally related activities that fall within the general framework of technology-based "learner control." For example:

- Standard computer-based and multimedia (e.g., videodisc, CD-ROM) instruction for direct instruction (e.g., drill and practice, and tutorial). This type of software follows an overall instructional design strategy but permits students to make their own decisions about, for example, what topics to see and when, how many exercises to take, or when to quit the lesson.
- Computer-based simulations (see 17.4, 17.5). These programs operate almost entirely under the learner's control (Reigeluth & Schwartz, 1989) in that the continual and often complex manipulations of the simulation's parameters are nearly totally left to the discretion of the learner.
- Tools for indirect learning such as word processing, programming, telecommunications, and databases. Billings (1982) argues that these tools are of a different class from typical computer-assisted instructional lessons. She argues that in these applications, learner control is inherent in the software and offers the potential for more complex learning by the students than more traditional instruction. These are called *tools for indirect learning* in that students should not learn the tools for their own sake, but rather that these softwares be utilized in the pursuit of other learning outcomes (e.g., writing skills, mathematical reasoning, critical thinking).
- Instructional and informational applications developed around hypertext or hypermedia technologies (e.g., Bowers & Tsai, 1990). Such innovations offer to learners previously unconceived freedom of movement and choice of media displays. So-called "electronic encyclopedias," especially those designed for K-12 school use, are examples of this type of technology. The structures of these databases have important implications for information accessibility and the ease of navigation around the database, i.e., what learner control features are offered (Duchastel, 1986a; Wilson & Jonassen, 1989).
- On-line computer documentation, which allows the user the options of either following a detailed walk-through of major procedures and functions, or jumping around according to the needs of the moment (so-called "just-in-time" helps). These features most commonly serve as simply performance job aids, but they are frequently used as aids for learning, as well (Rossett & Gautier-Downes, 1991).

33.4 RATIONALE FOR LEARNER CONTROL IN CBI

There seems to be several philosophical, practical, and theoretical reasons for allowing learners some control over events occurring during CBI lessons. In fact, the use of traditional, rather rigidly controlled computer-assisted instruction may actually run counter to the educational philosophies promoted by many teachers in the arts and humanities, and which encourage student exploration and expression. D. W. Hansen (1982/1983) argues that allowing students more user control will increase the chance these teachers would want to include computer-based activities in their classes.

Additionally, to many educators and instructional designers, the expression "learner-controlled instruction" suggests a class of instructional events or tactics intended to increase learner involvement, mental investment ("mindfulness," as Salomon, 1983, phrased it), and achievement. The approach is to emphasize the learner's freedom to choose those learning activities that suit his or her own individual preferences and needs.

On a more pragmatic level, Steinberg (1984) says that, if learning is found to be equivalent in both learner- and computer-controlled settings, design costs should shrink, time spent learning should be reduced, and attitudes and motivation should become more positive if a learner-controlled framework for instruction is adopted.

Instructional design theorists, too, have found ample reasons for including provisions for learner control in computer-based designs. In his design theory, Merrill (1983) prescribes learner control of content (encompassing curriculum, lesson, and module selection) and of strategy (spanning various forms of presentation). Bunderson (1974), Faust (1974), and Fine (1972) each present an assortment of learner-controlled activities derived from Merrill's early design theory (Merrill, 1973; Reigeluth, 1979). The *TICCIT* (*T*ime-Shared *I*nteractive, *C*omputer *C*ontrolled *I*nformation *T*elevision) system, derived from Merrill's early theory, provides the learner with many types of options, some of which are dependent on the current course (such as reviews, menus, quizzes, faster/slower type of feedback, level of question difficulty, and topic surveys), while others are constant across any course delivered by the system (such as backward or forward movement, access to a calculator, access to a glossary, and opportunity to leave an on-line comment; there is even a feature that gives the student the option to "CUSS" at the computer when things go wrong!).

Reigeluth and Stein (1983) in their instructional design theory also hypothesize that ". . . instruction generally increases in effectiveness, efficiency, and appeal to the extent that it permits informed learner control by motivated learners" (p. 362). Federico (1980), too, suggests that learner control might be a useful alternative to the classic aptitude-by-treatment interaction approach (see 22.3.3), in that "learners can become system independent by enabling them to manipulate and accommodate treatments to their own momentary cognitive requirements" (p. 17).

A rationale from a different perspective comes from a survey of adult learning preferences. Penland (1979) found that the top four reasons why adults prefer learning on their own were expressed as desires to "set my own learning pace," "use my own style of learning," "keep the learning strategy flexible," and "put my own structure on the learning project." Discussing the differences between adults and children, Hannafin (1984) argues that under CBI conditions, older students should realize the benefits from learner control more than younger students because they have acquired more (and presumably better) learning strategies.

Some of the research from the psychology of basic learning procésses also implies possible advantages of learner control. For example, one might expect a learner-controlled instructional treatment to induce more elaborate mental processing by students as a result of their having to ponder the choices they face. Salomon (1983, 1985) refers to the degree of such mental activity as "invested mental effort." The more such effort expended, he implies, the more mental elaborations the student performs, resulting in deeper, more meaningful learning. In contrast, one might not expect as much cognitive elaboration from students proceeding through a more "passive" instructional treatment. In plain language, learners given control over their instruction might be more likely to think about what they are doing as a result of having to make choices along the way.

Hartley (1985), too, argues for the need for more attention to basic psychological processes when studying the impact of computers on learning, and he supports the use of learner control of instruction as a means for students to develop their own cognitive structures. That is, consistent with a constructivist view of knowledge development (see 7.3), he proposes that the learning of complex knowledge structures is facilitated when the learner himself or herself can participate in the construction of those mental structures. This constructivist approach is also promoted by Salomon and Gardner (1986) who suggest that ". . . individuals mold their own experiences by the traits and goals they bring to the encounter, the way they apprehend the technology and the situation, and the *particular volitional choices they make.* In so doing, learners, particularly when given interactive opportunities with computers, are likely to affect the way these opportunities are going to affect them" (p. 16, emphasis added).

Indeed, the emerging constructivist paradigm of learning as an inventive learning process rather than an acquisitive one almost requires some type of attention to the degree and types of control the learners will exert during the learning process. Lebow (1993), for example, suggests that, to constructivists, the strategic availability of learner control options can provide structural support for the values of personal autonomy, personal relevance, active engagement, and reflectivity, all important characteristics undergirding the constructivist philosophy of education. (See 7.4.5 for further discussion of constructivisim and learner control.)

33.5 THE EFFECTIVENESS OF LEARNER CONTROL IN CBI

Unfortunately, the empirical research on learner control in instructional contexts does not support its unconditional use (Carrier, 1984; Hannafin, 1984; Milheim & Martin, 1991; Steinberg, 1977, 1989). Many authors of texts on CBI design caution against cavalierly offering a variety of options to learners (e.g., Alessi & Trollip, 1985; Jonassen & Hannum, 1987; Steinberg, 1984) because such a strategy does not seem to improve overall learning. O'Shea and Self (1983, Chapter 3) summarize much of the unpublished research on the effectiveness of the early TICCIT system and conclude that it is difficult to support its widespread use. Merrill (1983), too, concludes that college-level students generally do not make good use of learner control options, a position also taken by Carrier (1984). Snow (1980), commenting on the use of learner control in adaptive instruction, argues that far from eliminating the effects of individual differences on learning, providing learner control may actually exacerbate these differences.

Research on learner control in CBI has typically compared learner-controlled and program-controlled treatments in a fashion reminiscent of, and analogous to, media comparison studies conducted in the 1960s and 70s (and with analogous methodological problems; see Reeves, 1993, for a thorough critique). The following is an updated summary of research findings comparing learner-controlled computer-based instruction with either partial learner-controlled versions or complete computer-controlled versions for the three most common types of dependent variables measured in such studies, namely, learning, time-on-task, and attitudes and affect.

Generally speaking, these studies compare treatments that present a mixture of the specific instructional events actually subject to learner control. Also, contrary to Hannafin's (1984) claim, both adults and children seem to have been well represented in these studies. Many of these studies were also reviewed by Carrier, (1984), Hannafin, (1984), Milheim and Martin (1991), and Steinberg (1977, 1989), but are discussed in this chapter with more stress given to attempting to understand the underlying processes governing students' choices. Additionally, many studies are examined here which have not been included in previous review papers.

33.5.1 Learning

On the whole, results have been mixed, but instructional treatments under the learner's control have been shown most often to be as effective or less effective than treatments under more computer control. Also contrary to a suggestion by Hannafin (1984), findings from the literature reviewed here indicate that children do not seem to be less able to handle learner-controlled situations than adults.

A few studies have supported the use of learner control of at least some instructional events (Avner, Moore & Smith, 1980; Campanizzi, 1978; Ellermann & Free, 1990; Kinzie, Sullivan & Berdel, 1988; Mayer, 1976; Newkirk, 1973; Shyu & Brown, 1992). Most of these support Hannafin's (1984) suggestion that learner control promotes a deeper or more long-lasting effect on memory. Newkirk (1973), for example, found a long-term learning benefit for learner control, but not for program control. Mayer (1976) found that more complex outcomes were learned better when learners were able to control the order of presentation, while simple outcomes were learned better under experimenter-controlled conditions. In one of the few long-term studies of the effects of learner control in CBI, Avner et al. (1980) found that students using highly "interactive" learner control showed a greater degree of high-level skills than did the students within a more "passive" type of CBI. There were no differences between these groups on low-level skills, however. In a paired-associate task investigated by Ellermann and Free (1990), students who could select the order of presentation seemed to have a stronger memory trace, implying more engagement of cognitive structures.

In contrast, studies by R. C. Atkinson (1972), Belland, Taylor, Canelos, Dwyer, and Baker (1985), Johansen and Tennyson (1983), Lee and Wong (1989), MacGregor (1988), Morrison, Ross, and Baldwin (1992), Olivier (1971), Pollock and Sullivan (1990), Reinking and Schreiner (1985), Rivers (1972), C. L. Tennyson, Tennyson, and Rothen (1980), Tennyson and Buttrey (1980), Tennyson, Park, and Christensen (1985), Tennyson, Welsh, Christensen, and Hajovy (1985), all found various types or degrees of program control superior to learner control of the same instructional elements for posttest achievement. Many of these authors speak of learners not having or not knowing how to utilize appropriate strategies when they are left to themselves to manage their learning environment.

Interestingly, most studies in which the computer controlled the rate of pacing, that is, the length of time in which screenfuls of information were presented to the student (Belland et al., 1985; Dalton, 1990; Tennyson, Park & Christensen, 1985; Tennyson, Welsh, Christensen & Hajovy, 1985), found learning under those conditions better than self-paced conditions (in which the learner controls the speed at which material is presented), the usual fixture in most CBI programs. One study by Milheim (1990), however, did find learning better under a learner-controlled pacing condition.

Additionally, in a meta-analysis of 10 years of interactive video instruction, McNeil and Nelson (1991) conclude generally that program-controlled conditions are superior to learner-controlled condition. They suggest however, that partial (i.e., "guided") learner control over review and practice activities might be better for learning than program control over these activities, although they caution that too few studies included such conditions to make the conclusion unequivocal.

Most studies, however, found no differences overall between learner-controlled and program-controlled treatments (Arnone & Grabowski, 1992; Balson, Manning, Ebner & Brooks, 1984/1985; Beard, Lorton, Searle & Atkinson, 1973; Carrier, Davidson, Higson & Williams, 1984; Carrier, Davidson & Williams, 1985; Carrier, Davidson, Williams & Kalweit, 1986; Fredericks, 1976; Goetzfried & Hannafin, 1985; Gray, 1987; Hannafin & Colamaio, 1987; Holmes, Robson & Steward, 1985; Hurlock, Lahey & McCann, 1974; Judd, Bunderson & Bessent, 1970; Judd, O'Neil & Spelt, 1974a; Kinzie & Sullivan, 1989; Klein & Keller, 1990; Lahey, 1978; Lahey & Coady, 1978; Lahey, Crawford & Hurlock, 1976; Lahey, Hurlock & McCann, 1973; Lee & Lee, 1991; López & Harper, 1989; McCann, Lahey & Hurlock, 1973; Murphy & Davidson, 1991; Pridemore & Klein, 1991; Relan, 1991; Ross, Morrison & O'Dell, 1988, 1989; Schloss, Sindelar, Cartwright & Smith, 1988; Schloss, Wisniewski & Cartwright, 1988; Strickland & Wilcox, 1978; Wilcox, Richards, Merrill, Christensen & Rosenvall, 1978). The various conclusions drawn from this "no-difference" finding are interesting and tend to reflect a good deal of rationalization. Some of the researchers use this finding to support the use of learner control, saying that programming the computer to handle the myriad complex types of branching that could potentially occur in a lesson is far too difficult. So therefore, since their research indicates it would at least do no harm, it is better to let students handle their own lesson branching. Other researchers use the "no-difference" result to justify program control of instruction, saying that other benefits, such as time savings (discussed next), are realized by not letting learners control their own instructional paths. Still other researchers look more closely at their data to discern any interaction effects that may be operating; that is, learner control or program control might be better for some people or under some conditions, but not on the whole. These types of studies are discussed in more detail later in this chapter.

33.5.2 Time-on-Task

Several studies also included as a dependent variable the length of time students took to complete a lesson. A few studies found students in learner-controlled CBI groups taking more time to finish the lesson than program-controlled groups. In a study by MacGregor (1988), elementary students worked in pairs, and those in the learner-controlled group were given the opportunity to participate in an on-line instructional game; students in the program-controlled group were not. The author attributed the time-on-task differences to the fact that the game aroused quite a bit of interest, thus generating a lot of talking and other social activity within the pairs, thus naturally consuming more time in the process. Dalton (1990) also found that students in a condition in which the computer controlled the pacing of materials spent more time than those in learner-controlled pacing. He, too, suggests that the amount of socializing observed among the paired members of the learner-controlled condition accounted for the longer time spent. Shyu and Brown (1992) explain that longer times in their study for students under learner control can be explained by those students needing more time to figure out how to operate the learner control features of the computer program. Another study (Avner et al., 1980) found that while students in learner control conditions spent more time during on-line tasks, they spent less time during related off-line tasks, in this case laboratory activities. Interestingly, none of these authors of studies attributed the additional time spent by students in learner-controlled conditions to a greater or deeper degree of cognitive engagement, even though there is theoretical justification for such a conclusion.

A few studies found no differences in time spent (Hurlock et al., 1974; Kinzie & Sullivan, 1989; Lahey et al., 1973). The bulk of studies, however, found that learner-controlled groups spent considerably less time than program-controlled groups (Fredericks, 1976; Johansen & Tennyson, 1983; Lahey et al., 1976; Murphy & Davidson, 1991; Rivers, 1972; Ross et al., 1988; Schloss, Sindelar, Cartwright & Smith, 1988; C. L. Tennyson et al., 1980; Tennyson, 1980; Tennyson & Buttrey, 1980).

Researchers investigating "efficiency" of time spent during a lesson have found mixed results. Dalton (1990) found no differences on achievement-per-time-spent between self-paced and lesson-paced interactive video formats, although Relan (1991) did find such differences in a CBI study favoring the least amount of learner control. Another study (Goetzfried & Hannafin, 1985) did find differences between groups on an efficiency variable they define as the number of concepts a student sees per minute. In their study, however, learner control was the least efficient; that is, it promoted a slower progression through the lesson.

In some of these studies (Goetzfried & Hannafin, 1985; Johansen & Tennyson, 1983; C. L. Tennyson et al., 1980; Tennyson, 1980; Tennyson & Buttrey, 1980), shorter time was also linked to poorer performance. One possible explanation for these findings lies in the confounding of instructional control, time-on-task, and amount of instructional material seen. That is, learners navigating their way through a lesson might spend less time because they opted to skip over large amounts of instructional material. If this omitted material were crucial for overall lesson performance, these students might naturally be expected to perform more poorly than would students progressing through a program-controlled, but more "complete," lesson package. This notion is also offered by Lepper (1985), who suggests that students under learner control might see differing amounts or kinds of instructional material than students under program-controlled treatments. (In fact, for some situations it is entirely likely that each student under learner control selected his or her way through a completely different instructional treatment!) Therefore, in these studies we do not know whether the culprit for the supposed failure of learner control is the fact that students were granted control, per se, or simply saw suboptimal amounts of instruction as a result of "poor" choices. Indeed, several of these studies do report that students in learner control spent less time because they saw fewer instructional screens (e.g., fewer examples).

Commenting on the problem of learners choosing low amounts of instruction, Higginbotham-Wheat (1988) and Ross and Morrison (1989) draw the conclusion that learner-controlled instruction should allow naive or otherwise unprepared students to select context, sequence, and presentation style variables only, and should not allow students to choose instructional events that could alter the amount of content support, unless they have the prerequisite skills or training. It seems safe to say that the confounding of learner control, time-on-task, and amount of instructional material is a matter that can prevent clear conclusions about the relative merits of offering control to learners. This issue surfaces again later in this chapter.

As with the findings of no difference in learning between learner- and program-controlled groups mentioned earlier, the authors of the studies who found shorter times for learner control also are quite creative in the implications they draw from that finding. Some authors claim that if learning is equivalent, but time spent is shorter, learner control is desired because of the time "savings" or "economies." Others say that the shorter times from the learner control groups mean less time-on-task and time for cognitive processing, inherently undesirable outcomes, and thus should be avoided.

33.5.3 Attitudes and Affect

Most of the studies that measured the students' attitudes toward computer-assisted instruction or toward learner control over instruction found either no differences or a favorable attitude from students who experienced a learner-controlled treatment compared with program-controlled groups. The author of the one study that did find relatively negative attitudes in the learner control group (Gray, 1987) explained the findings as due to resentment and frustration at the complexity of the instructional decisions the students under the learner-controlled condition were required to make.

A few studies (Arnone & Grabowski, 1992; Beard et al., 1973; Judd et al., 1970; Kinzie et al., 1988; Lahey, 1978; Pridemore & Klein, 1991; Shyu & Brown, 1992) found no differences between learner-control and program-control groups in student attitude toward CBI. Additionally, one review (Judd, 1972) also concluded that, generally, learner control does not contribute to improved attitudes. However, it is quite possible that the early computer studies included in Judd's paper do not represent the highly interactive approaches used for instruction on modern microcomputers.

Six studies did find positive attitude effects for students in learner-control groups (Hintze, Mohr & Wenzel, 1988; Hurlock et al., 1974; Judd et al., 1974a; Milheim, 1989; Morrison et al., 1992; Newkirk, 1973). For example, the study by Milheim (1989) exploring interactive videodisc instruction found better attitudes toward the instructional activity for students under learner-control pacing compared with students who experienced program control of lesson pacing. In most of the studies examining attitudes, students were exposed only to one type of program (i.e., they only saw a learner-controlled version or a program-controlled version). One of the most interesting of all the studies examining attitudes is presented by Hintze et al. (1988), who compared attitudes in dental students in Denmark, each of whom actually had a chance to experience several versions: completely learner-controlled, partially learner-controlled, and computer-controlled instructional situations. They found the overwhelming majority of students preferred at least some learner control. Interestingly, males by far preferred complete learner control, while female preferences were split between partial and total learner control. They suggest possible explanations for this finding, including that it might be due to the fact that males typically have spent more time with computers, and thus are more likely to want to explore with them when given the chance. Dalton (1990) also found some interesting interactions between gender and learner- or program-controlled treatments on attitudes. Specifically, he found that females under lesson-controlled pacing ended up with better attitudes toward instruction and toward the content of the lesson than females under learner-controlled pacing. Males, however, under program-controlled pacing had significantly worse attitudes toward content than males under learner-paced lessons. However, convincing explanations for these gender effects and interactions were not provided by the authors of these studies and remain to be drawn, particularly as they relate to the underlying social, motivational, or cognitive processes involved. For example, it is possible that males have a greater comfort level (less anxiety) when they sit at the computers, and thus feel more confident to "take charge" of them.

Some researchers investigated the effects of learner-controlled instruction on one particular type of attitude measure called *continuing motivation* (Maehr, 1976; Seymour, Sullivan, Story & Mosley, 1987), which indicates how likely is a student's ongoing willingness to return to a learning activity at a later time without external pressure, essentially a variable measuring the student's desire to learn voluntarily. Kinzie and Sullivan (1989) found positive effects on the students' desires to pursue science activities following computer-assisted instruction, generally, and following learner-controlled CAI, specifically. However, this effect was not replicated by López and Harper (1989), who found no advantage for learner control over program control on continuing motivation in science. López and Harper (1989) do not offer any specific explanation to reconcile this discrepancy, but they imply that there might be characteristics of the population studied (high-risk Hispanic students), which had a unique bearing on the findings in their study.

Lastly, a few early studies investigated the effects of learner-controlled computer-based instruction on student state (i.e., temporary) anxiety, with mixed results. Judd (1972) recaps one study that shows a reduction in anxiety as a result of learner-controlled CBI. J. B. Hansen (1974) also found a lowering of initial state anxiety as a result of learner control over computer-delivered feedback. However, neither Judd, O'Neil, and Spelt (1974b), nor Judd, Daubek, and O'Neil (1975), were able to lower state anxiety as a result of their particular types of learner control (control over access to mnemonic devices in the first case, and control over access to pictures in the second case).

33.5.4 Summary of the Effectiveness of Learner Control of CBI

After reviewing all of these findings for the various types of dependent variables, we are presented with an apparent dilemma: Given the rationale for learner control provided earlier, there are good reasons to believe that learner control is a desirable instructional approach. However, the bulk of studies conducted to assess that notion found that students left on their own do not uniformly make good use of such strategies. Duchastel (1986b) sums up the frustrating ambiguity of learner control research:

> . . . the research leads one to be cautious about the general learner control hypothesis, namely, that the student is the best judge of the instructional strategy to be adopted. Some results in instructional research indicate that not all students are capable of making appropriate educational decisions. Other results, however, indicate the tremendous benefits of learner control in particular situations. The sophistication of the learner and the type of objectives pursued, as well as the particular context of the system, will probably impact on the nature and effectiveness of learner control in given situations (p. 391).

But there are problems with the research itself, which also limits the conclusions we might draw from this body of literature. Reeves (1993) presents a very thorough critique of the bulk of learner control research, suggesting that the lack of unambiguous findings is in fact due to bad research. He lists a variety of shortcomings with the literature spanning four crucial areas. First, he presents some problems in many studies with the definition of learner control used. That is, many authors fail to provide adequate operational definitions of their learner control treatments, and so end up with, at best, muddy and ambiguous experimental designs. Secondly, he discusses the lack of adequate theoretical foundations undergirding the experiments. Studies often proceed, he says, without even a tenuous connection with the literature of basic learning or instructional theories. (Whether this type of uninformed research activity is necessary for the "theory-building" phase required of any school of systematic scientific investigation, or instead bluntly demonstrates intellectual expedience or laziness on the part of researchers, is a matter of separate debate.) The last two problem areas he finds in the learner-control literature are methodological and analytical, with researchers too seldom using adequate designs (often including poor instrumentation, control of procedures and sampling; see 39.2.1) and procedures for analyzing the data (e.g., improperly employing quantitative paradigms when qualitative approaches would make more sense; see 39.4.1.2).

As an example, a typical problem in learner-control research is the confounding of learner-control or program-control treatments with the amount of instruction students see during the lesson, a problem mentioned earlier in this chapter. That is, as Lepper (1985) points out, the often-repeated failure to demonstrate the effectiveness of learner control might simply be a function of the fact that less instructional material is selected by those students; hence they received an "incomplete" lesson compared with their program-controlled counterparts. In other words, learner-control ineffectiveness would be an artifact of the particular set of instructional events they experienced (or, more likely, did not experience).

Indeed, Ross and Rakow (1981), C. L. Tennyson et al. (1980), Tennyson (1980), and Tennyson and Buttrey (1980), all showed that students in the learner-controlled treatments saw many fewer instructional examples than did students under program control. However, in these studies, lower amounts of instructional material were inextricably confounded with the learner-control treatments. Carrier and Williams (1988) experimentally controlled the amount of material seen, and found a positive effect for amount of material separate from learner-control or program-control effects. In a study by Morrison et al. (1992), amount of instructional material was controlled for by having two program-controlled versions: one with "minimum" instructional support, one with "maximum." They found that the students under learner control actually performed poorer than those with the "minimum" program-control treatment. The type of studies that attempt to control for amount of instruction separately from learner control have been fairly rare, but they do allow for a clearer examination of the effects of learner choices independent from amount of instruction.

These criticisms also prevent researchers from conducting statistical meta-analyses on the literature as a way to provide a little more concrete basis for making statements about the effectiveness of learner control. Because the studies about learner control are so incredibly varied (each study seems to offer unique operationalizations, instrumentations, designs, and analyses), it would be practically impossible to arrange the studies into sets of reasonably equivalent dependent and independent variables, and to conduct a meta-analysis so as to avoid the concerns Slavin (1986) has voiced about improper use of the meta-analysis technique.

Similarly, a "best-evidence" approach (Slavin, 1986) to synthesizing the learner-control literature would also be difficult to defend, because the criteria for inclusion of studies in such a synthesis (e.g., relevance, minimal bias, external validity) are frequently not met, as Reeves (1993) has forcefully presented. If a best-evidence synthesis were attempted, it is likely that after gleaning from the literature the studies worthy of examination, there might not be that many "clean" articles left that could provide any useful information for inclusion in the synthesis.

If, as seems amply demonstrated by Reeves (1993), there are problems that prevent us from drawing confident conclusions from the domain of learner-control research in CBI, the next logical question would be, "Is there anything we *can* say from looking at these studies?" Depending on the research perspective taken, reviewers might reject the body of research to date (because of the flaws); or they might conduct a type of salvage operation, examining the studies post mortem for clues and commonalities across the papers that might help both explain the diverse findings previously cited, and to provide new researchable questions. Kinzie (1990), for example, provides a very helpful mapping of some research findings in the learner-control literature, with various theoretical perspectives in motivation, individual differences, social psychology, and self-regulated learning. However, as with all post hoc types of examinations of literature (including this chapter), it is important to stress that conclusions drawn should be considered in large part to be conjectures, inferred from the studies, and which remain to be a priori tested in their own right.

33.6 THE ROLE OF LEARNER CHARACTERISTICS

Educators know that individual learner characteristics play a huge role in how fast and how well overall learning occurs. Generally speaking, since its inception CBI has continually been held up as a promising vehicle able to somehow tailor instruction to meet the individual needs of each learner (Suppes, 1966; U.S. Congress, Office of Technology Assessment, 1988). Just how these instructional adaptations are best concocted, however, is a matter of debate.

Some models for adaptive CBI are largely program controlled and attempt to present to each student appropriately matched instructional events according to some relevant individual difference variable. Examples of such approaches include regression models that assign optimized instructional conditions based on either stable trait variables (McCombs & McDaniel, 1981; see also 22.3) or on-task state variables (Rivers, 1972; Ross & Morrison, 1988; see also 22.5) and schemes to branch instruction according to some optimizing mathematical model (R. C. Atkinson, 1972; Holland, 1977; Smallwood, 1962; Tennyson, Christensen & Park, 1984; see also 22.4). Few of these approaches have made it into commercially produced CBI, however.

On the other hand, for reasons of feasibility, attractiveness, and understandability, most of the CBI found in school software libraries has at least some learner-controlled features that their manufacturers tout as helping to accommodate the learning needs of each individual student. The idea, as Merrill (1973, 1975) and Federico (1980) have propounded, is that students will make their own decisions throughout a lesson so as to best match their own learning styles, personality, or other relevant traits.

As we have seen, however, learner control does not seem to be a superior overall instructional strategy. A closer examination does seem to indicate differential student effectiveness of instructional choices, although perhaps not in the way the software producers had intended. That is, some students are able to use learner control to their advantage; others, however, use it actually to their detriment.

33.6.1 Paradigms

It is useful at this point to review the major paradigms employed in research that focuses on the relationship between learner characteristics and learner-controlled CBI. There are several methods available to researchers wishing to study such interactions. One common approach adopts an "aptitude-by-treatment interaction" or ATI perspective (see 22.5; Carrier & Jonassen, 1988; Cronbach & Snow, 1977). That is, students' stable cognitive and personality "trait" variables are viewed as possibly interacting with predetermined instructional features to produce differentially effective learning, particularly within a learner-controlled context (Snow, 1980). One example (Judd et al., 1974a) found that the personality variable of "achievement via independence" predicts certain behaviors under learner control (see 22.3.4.6). Snow (1979) also takes an ATI approach and presents some data using various statistical profiling techniques that appear to be fairly successful at sorting college students enrolled in a BASIC programming course into good and poor options selectors according to their scores on a variety of aptitude measures.

The usual aim of ATI studies is to find instructional treatments that would somehow benefit students possessing different learner characteristics or profiles. However, in spite of Federico's (1980) suggestion that learner control might allow students to select effectively instances based on their own cognitive requirements, there is ample evidence that learner control serves to magnify student differences rather than eliminate them. Wilcox (1979), for instance, presents a review of non-computer–based ATI studies and concludes that learner control tends to exacerbate problems arising from individual differences instead of minimizing them. Snow (1980), too, argues that a learning environment that allows learners to control instruction might possibly produce stronger relationships between individual differences and learning to the degree that these individual differences are free to operate than would "fixed" instruction. In a variation on ATI approaches, which Tobias (1976) calls "achievement-by-treatment interactions" (see 22.3.7), differential results have also been found for effectiveness of options selection for students with differing amounts of prior knowledge (Ross & Rakow, 1981; Tobias, 1987a).

Merrill (1975) discusses several frequently invalidated assumptions regarding "aptitudes" and "treatments" in a typical ATI model. He points out that quite often the most germane learner characteristics are actually unstable, varying from moment to moment during instruction. Likewise, treatment effects may similarly not always hold under the variety of conditions present in typical educational settings. Lastly, he argues that instead of instruction being adapted to the individual, we should allow students to adapt the instruction for themselves. This forms one of the bases for the inclusion and importance of learner control in his theory of instruction.

While standard ATI approaches seek to understand the differential effectiveness of learner control with individual differences measured *prior* to instructional intervention ("trait" variables), other approaches choose to explore learner variables measured *during* the instructional task, so-called "within-task" variables (Federico, 1980) or situational "state" variables. These presumably reflect momentary variations in certain learner characteristics that also could interact with the specific instructional situation. Tennyson and Park (1984) discuss the need to investigate the phenomena of moment-by-moment interactions of instruction and individual differences, in particular within learner-controlled environments.

Studies by Seidel, Wagner, Rosenblatt, Hillelsohn, and Stelzer (1975) examining students' ongoing expectancies of success, by Fisher, Blackwell, Garcia, and Greene (1975) on momentary changes in attributions for success and failure, and by Goetzfried and Hannafin (1985), Johansen and Tennyson (1983), Tennyson (1981), and Tennyson and Buttrey (1980) investigating on-task mastery self-assessment by students, illustrate the utility of variables that occur during the course of learner-controlled CBI.

However, still another possibility not discussed by either Carrier and Jonassen (1988) or Merrill (1975) is to not necessarily adapt instruction to fit the student, but rather to attempt to change the student to optimally use the instruction. That is, if we can identify modifiable characteristics of the students which typically produce dysfunctional interactions with instructional treatments, we might attempt to alter those characteristics so that the student and instruction are better matched. Suggested approaches using this paradigm are presented later in this chapter.

Thus, both person and instruction variables can be considered either stable or unstable, perhaps reciprocally changing throughout the course of instruction. This paradigm also allows for the occurrence of aptitude-by-treatment "corrections" (Gehlbach, 1979), that is, selecting treatments to eliminate the effects of individual differences rather than to accommodate them.

This expanded "adaptive instruction" paradigm presents a revised set of larger questions to the researcher: When might instruction respond to variations (both stable and unstable) in individual learners, and how might learners react and respond to changes (macro and micro) in the instruction? Within this framework, there seems to be sufficient theoretical, empirical, and practical justification for investigating the mutual relationship between learner differences and instruction under some degree of learner control.

33.7 INSTRUCTIONAL CHOICE

A fundamental question that should guide investigators of learner control is: Why do students make the choices they do? Learner-controlled instruction is, by definition, instruction in which students are required to make decisions at various points. In order to guide the design and use of learner control, it is necessary to understand the composition of such decisions: that is, can we specify the precursors and effects of the decisions students will make? However, as has been argued by Reeves (1993), very few learner control studies have been grounded on such learning-theoretical questions. Rather, in the simple pursuit of the winner in the contest between learner control and program control, too much learner-control research has proceeded in the absence or ignorance of relevant basic psychological research that might clarify the actual phenomenon being studied, namely, the act of learner choice.

We seek at this point to identify the different kinds of person variables that, it is conjectured, in combination with the actual choices made (i.e., the instructional materials encountered), help to account for the unevenness of learning found under learner-controlled instruction.

As was pointed out earlier, Reigeluth and Stein (1983) advocate the use of "*informed* learner control by *motivated* learners" [emphases added]. This statement suggests two qualitatively different sets of individual difference variables that could influence the effectiveness of learner-controlled instruction.

We should first be interested in a student's capacity to make rational choices (i.e., an "informed" student). "Rational" means how adequately they can appraise both the demands of the task and their own learning needs in relation to that task in order to select appropriate instructional support. Tennyson and Park (1984) seem to call this the student's "perception of learning need," and also point out the need for its further study in order to be of use in effective learner-controlled instruction. These perceptions of learner need, too, will vary across learners.

Secondly, because both motivation and learner-controlled instruction are, at least in part, defined by choice activities, individual differences in motivational variables might also contribute to our understanding of the differential effects of learner-controlled instruction on learning. In contrast to attempting to specify some rationally based determinants of choice, here we need to ask if there are certain emotion-related characteristics of the student that would allow us to predict how inclined (i.e., motivated) a person is to make a particular choice. We are particularly concerned here with identifying "gut-level" predispositions, tendencies, and preferences of the students that operate to direct a choice toward one alternative or another.

The remainder of this review examines the relationships between students' rational understanding of their learning needs, their motivations to choose on an emotional level, their on-task performances, and learning when offered instruction to some degree under their control. First, the rationally-cognitively oriented variables are presented. Following that is a discussion of emotional-motivational variables that influence choice and learning.

33.8 RATIONAL-COGNITIVE ASPECTS OF CHOICE AND LEARNING

Several reviews of learner control in instruction (Hannafin, 1984; Milheim & Martin, 1991; Steinberg, 1989) have identified two kinds of cognitive traits, prior knowledge and ability, which may explain some of the negative results of providing learners with choices during instruction. The relationships of learner control with achievement and with ability are presented in turn, together with some hypothetical instructional prescriptions that could take advantage of these relationships.

33.8.1 Prior Knowledge

The review presented earlier in this chapter amply demonstrates that learners given control over their instruction too often make suboptimal choices. One possible explanation for these findings is that individuals do make appropriate decisions, but within their own perceptions of the problem at hand, not according to some optimal outside decision rules. This view suggests that an increase in an individual's accuracy of perception of his or her learning state in relation to the learning task should result in the individual's making more appropriate choices. Students are therefore expected to make instructional choices that are rational only to the degree they have accurate information about their current learning state. This suggests an approach based on learner prior knowledge or achievement.

There is substantial evidence that, left on their own, both children and adults very often overestimate how much they know about a given topic, and, indeed, those with more knowledge are often better able to judge their knowledge level than people fairly ignorant in that area (Flavell, 1979; Lichtenstein & Fischhoff, 1977; Nelson, Leonesio, Shimamura, Landwehr & Narens, 1982).

This finding that students are generally poor at estimating their current state of knowledge has been found also in computer-based contexts. Lee and Wong (1989) found students unable to predict their own learning of both general and specific types of knowledge. Additionally, Garhart and Hannafin (1986) and Relan (1991) found little correlation between self-rating of knowledge and performance on several tests. Garhart and Hannafin (1986) use this finding to explain plausibly why many students under learner-controlled conditions tend to terminate instruction prematurely.

It could very well be, then, that people often really don't know what they don't know, and that those who know very little know even less about what they don't know. (Apologies for the last sentence.) If this is the case, one might predict that students with higher levels of knowledge would make better (more judicious) instructional decisions than those with lower knowledge levels. Evidence for this phenomenon is provided by Seidel et al. (1975) and Fredericks (1976). In these learner-control CBI studies, high performers were much more able than low performers to estimate their performance capabilities prior to their taking quizzes on the lesson material.

The notion that poor performers are incapable of judging how much they know has implications for the idea of instructional support, as well. That is, if students are unable to estimate their current state of knowledge, they may also be unable to assess whether they need additional instruction when given the chance to choose more. This would imply that a pretest given prior to instruction could predict the success of students given learner-controlled instruction, an extension of the achievement-treatment interaction paradigm of Tobias (1976, 1981), but here the instructional support is controlled by the learners. Such an interaction has indeed been found in studies by Gay (1986), Ross and Rakow (1981), and Ross, Rakow, and Bush (1980), although neither of these last two studies occurred in a computer-based environment. In all cases, college students scoring higher on a pretest performed as well under learner control as similar students under program control. This was not the case for low-prior-knowledge students who performed much worse under learner control. It is plausible that low-prior-knowledge students were not as able to judge the instructional support they needed as were higher-prior-knowledge students.

Additional evidence within a CBI context is provided by Tobias (1987a), who found that knowledgeable students (as measured by a pretest) opted to see more review material than did less knowledgeable students. He states, ". . . the presence of instructional support is no guarantee that less-knowledgeable students will use it frequently or effectively to improve learning" (p. 160). This is echoed by Judd et al. (1970), who found a similar result in their early study, namely, that students who needed additional instructional support tended to avoid seeking it.

In another paper, Lee and Lee (1991) found that, consistent with the prior-knowledge hypothesis, students with the lowest levels of prior achievement related to their lesson topic performed poorest on a posttest when given learner control during the beginning phase of the lesson, the phase designed for learners to acquire their initial knowledge of the content area. However, another group of learners, also with low pretest scores, who were given learner control during a review phase of the lesson, performed the best of all the students in the study, even better than both program-control groups (both in the initial knowledge acquisition and in the knowledge review phases). They clarify the distinctive findings for the two lesson phases:

> In other words, the LC strategy cannot function effectively when learners have to learn new materials. It makes intuitive sense that when LC subjects have to learn new materials [initial knowledge acquisition], they would work through CAL sessions under the pervasive influence of their previous knowledge base. Learners' management of learning activities is less influenced by previous knowledge differences when they have some grasp of the target knowledge [knowledge review] (p. 496).

In sum, prior achievement has been found to be a major factor affecting the effectiveness of learner-controlled instruction. Additionally, unlike many learner-control studies on other factors, this area of research is well grounded in relevant theory. Generally, it seems that students with some knowledge about the topic being taught seem better able to sense at any given choice point what they need from instruction and to choose additional instructional support accordingly. Here the key instructional variable seems to be amount of instructional support. Students with low amounts of topic knowledge have inaccurate perceptions of what they know, and consequently make poor use of needed instructional support.

Three possibilities are suggested for improving the effectiveness of learner control in relation to learner prior knowledge: (a) informing learners directly of their progress (i.e., supplanting the self-monitoring function); (b) instructing students to try to gauge their current knowledge (i.e., activating the self-monitoring function); and (c) training the students to better monitor their learning.

The students' continual estimation of their level of knowledge (a metacognitive strategy, according to Flavell, 1979) affects the effectiveness of their choices. Without feedback data from the instruction about their knowledge level, students with more prior learning seem better able to assess what they do and do not know, and therefore how much more or what kinds of instruction (i.e., optional material) they need to see. Hannafin (1984), Milheim and

Martin (1991), and Steinberg (1989) each suggests that learner control that regularly informs learners of the state of their learning might provide an aid, perhaps in the form of coaching or advisement to the students, in deciding whether they need more instruction. Additionally, Steinberg (1989) suggests that instruction should gradually wean the student from such crutches in order to promote more internalization of the metacognitive processes. Such information supports to the learner fall under the category of "decision aids," which have been shown to be quite useful in helping people make judgments and select appropriate courses of action (Pitz & Sachs, 1984).

Studies by Arnone and Grabowski (1992), Holmes et al. (1985), Schloss et al. (1988), Tennyson (1980, 1981), and Tennyson and Buttrey (1980) support the contention that providing students with updated information as to their moment-by-moment mastery level would improve the effectiveness of learner control over providing no such information. Here the researchers provide students under learner control with such information and show beneficial effects in comparison to students not given such information. A related study by Steinberg, Baskin, and Hofer (1986) showed that providing informative feedback to students during the course of a CBI lesson increased the chances that learner-controlled memory tools would be used. That is, students were able to use the feedback information to help them decide when and how to use the memory tools.

Results are not unequivocal, however. Ross et al. (1988) did not find an interaction between student selection of density of text displayed on the computer screen (high and low densities) and student pretest scores. Additionally, Goetzfried and Hannafin (1985) did not replicate in a CBI setting the achievement-by-treatment interaction that was demonstrated by Ross and Rakow (1981) in a non-CBI setting.

An additional wrinkle is suggested in results reported by Pridemore and Klein (1991), who compared selection of feedback by students (see 32.5.5.4) under two learner-controlled conditions differing in the elaborateness of feedback information provided. They found generally that students in the less-elaborate condition selected less feedback than those in the more-elaborate condition. The authors suggest that the amount of information contained in the feedback message helps students decide whether choosing to see such feedback is worthwhile. This might imply that students select their instructional support only to the degree they perceive it will help them. It's possible, then, that students choose to experience more instruction, not just on their perceived learning need but also on the perceived usefulness of the material to be offered. Instruction then, designed for learner control, should have as its goal the expansion and clarification of the student's own perception of the task as well as their progress toward it, particularly for those who are deficient in the accuracy of their self-monitoring. This notion builds on the prior-knowledge hypothesis, in that because students with low knowledge of an area tend to bypass additional optional instructional support, an improvement in the accuracy of perception of students as to their own knowledge level or to the task requirements would be expected to result in better decision making during learner-controlled instruction.

However, it is not known at this point whether students even need to be aware that self-monitoring of knowledge is important in learner-controlled instruction as a type of learning strategy (Garner & Alexander, 1989). It might be that simple directions to the student to think about what or how much they know might be enough to dislodge them from more habitual "mindless" activity. If we could somehow activate the learner's own untapped self-monitoring skills, it is speculated, then, that it may be unnecessary to inform them directly of their mastery using some decision superstructure (e.g., Bayesian probabilities; see 22.4.2.3; Tennyson & Rothen, 1979). This approach, however, has not been explored in learner-controlled CBI contexts.

In addition to supplanting a student's monitoring activities, or activating existing monitoring strategies, instruction might attempt to actually improve the student's conscious use of metacognitive strategies. This would involve some type of strategy training (see Garner & Alexander, 1989, for a review of some of these training approaches). Tobias (1987a) supports metacognitive strategy training, indicating that many students might need to be taught when and why to use various instructional supports. Kinzie (1990), too, advocates an approach to help the learners become better managers of their learning with the suggestion that perhaps,

> . . . students should be given the training to become self-managers as well as instructional assistance in self-management, and that those without a strong knowledge base should be assisted in making the links that will help establish the structure for new knowledge.

However, at this point, metacognitive strategy training has not been much investigated in a learner-control CBI context.

33.8.2 Learning Strategies and Ability

In addition to the prior-knowledge hypothesis and related issues just discussed, there is another explanation for the general ineffectiveness of providing instructional options. This notion begins with the suggestion that individuals have developed either good or poor strategies for dealing with learning problems. The metacognitive self-monitoring processes mentioned in the previous section on prior knowledge in fact represent a subset of a larger collection of cognitive processing strategies most often called *learning strategies*. Jonassen (1985) reviews some of the research on learning strategies, and describes four classes of strategies, all of which have clear implications for learner-controlled instruction:

- Metacognitive strategies are those processes by which students tell themselves how much they know. It is often described as "self-monitoring," and reflects a sense of both knowledge and ignorance.

- Information-processing strategies make up the largest group of learning strategies. These strategies include developing readiness, reading/viewing for meaning, recalling material, integrating it with prior knowledge, expanding or elaborating on the material, and finally reviewing what has been learned. These strategies seem to correspond to what Merrill (1984) calls "conscious cognition" processes.
- Study strategies (occasionally called *study skills*) are explicit techniques to help learners actively process information. These consist of such activities as note taking, outlining, underlining, and the identification and noting of patterns in the new material.
- Support strategies relate to the mental climate or attitude at the time of learning, such as the degree students can internally motivate themselves and stay on-task during the instruction. Jonassen (1985) says these last strategies are a sine qua non for learning, and are required in order for the other strategies to be effective.

When many people using both good and poor strategies are averaged in a study, a less-than-ideal picture is painted of the effectiveness of decision making as a whole. Some researchers suggest that the use of such learning strategies as Jonassen (1985) presents is linked closely with the concept of general intelligence (Snow & Yalow, 1982). It is not unreasonable to imagine that higher-ability students might have a greater repertoire of strategies to draw on when faced with a learning problem. In fact, as Snow and Yalow (1982) point out, very often the concept of ability is equated with the capacity to learn.

If indeed we can infer that (a) higher-ability students consciously or unconsciously bring to bear the mental resources appropriate to the learning task and avoid using inefficient ones, (b) lower-ability students somehow either lack or don't know how or when to activate their learning strategies, and (c) the success of learner control depends to a large degree on students judiciously applying their mental resources to the learning problem, then we can begin to explain the mixed results of learner control of instruction as being to a degree a function of learner ability, with higher-ability students capitalizing on learner control and lower-ability students left floundering.

An opposing viewpoint that higher ability will predict use of better learning strategies comes from Clark (1982). From a review of aptitude-treatment interaction studies, he first hypothesizes that high-ability students would profit most from activating or cueing methods, that is, techniques that prompt the student to adopt appropriate mental strategies from their repertoire of strategies for a given problem. Second, he suggests that low-ability students would do best under the supplanting or modeling methods, which are techniques that do not rely on the student to use his or her own mental resources, but rather explicitly guide the student through the optimal learning strategies. But regardless of what high-ability students would need, he suggests that they would prefer to choose supplantation or modeling, while low-ability students would *prefer* activating or cueing methods. Each group does so because that is the method perceived to be the lowest "mental workload" for the student. In this case, he proposes, neither group would select an appropriate strategy.

There is the additional question, however, of what the patterns of "optimal" choices would look like in a learner-controlled lesson. Would the best students generally choose more options, regardless of the specific type of instructional event put under their control? In this case, "more" of anything would be perceived by students as being "better." Or would their effective strategy use lead them to select only those specific types of options they feel would produce the greatest benefit? In this case, we would be able to see only some kinds of options being chosen by higher-ability students, while by others, perhaps not at all. Lower-ability students would perhaps manifest converse types of options-selection patterns, or maybe even random patterns.

It is possible to examine the notion of ability being related to overall amount of options selection only in those studies that offer a variety of options to the student. Otherwise, for studies that offer only one type of selectable instructional event, it is difficult to conclude anything about selective strategy choice and ability level. Of studies that do offer several types of options to students, Carrier et al. (1985) did find a strong positive relationship between a measure of general ability and general amount of options selected, regardless of the type of instructional event. This was not replicated in a follow-up study, however (Carrier et al., 1986), which included some additional motivational feedback in one of the treatments. Perhaps the presence of encouraging feedback (which did increase overall options selection in the study) was a more salient factor affecting decisions by the students to choose or to skip over material, so much so that ability affects were minimized. Other studies, too, found little or no relationship between overall level or frequency of options selection and ability measures. Snow (1979), for example, found near-zero correlations between standard ability and achievement measures and frequency of choice of instructional options. Reinking and Schreiner (1985), too, found no differences between low- and high-reading ability groups in any type of options selected. Another study by Morrison et al. (1992), although more indirect in its implication about ability level relationships, reports no association between amount of instructional support selections made by students under learner-controlled conditions and their posttest performance (posttest performance also being assumed to be generally related to student ability level). From these findings, it is difficult to conclude that higher-ability students make indiscriminately more frequent use of any and all instructional options that they might be offered.

Connections between ability and selective use of specific types of options seem a little more evident in the literature. In a study that looked for a possible curvilinear connection between options use and ability, Carrier and Williams (1988) found that students with the highest ability levels chose medium frequency levels of instructional options. The suggestion they made was that high-ability students do not act compulsively, indiscriminately selecting all options presented to them, but rather act more reflectively, choosing some as needed, but skipping over others deemed not useful. Another study by Sasscer and Moore (1984) found that when students in a TICCIT lesson were given the option of terminating the lesson, the dropout rate was related to the types of options chosen. The students who left the lesson early typically chose the "easier" kinds of options in the lesson. Snow (1979) found that aptitude measures of fluid-analytic ability and perceptual speed predicted the choice activities of successful college students in a BASIC programming task. The best choice activities he described as indicating a reflective and thoughtful style, and were more frequently selected by high-ability students. (Some caution is urged in reading this study, however, as the data analysis presented is sketchy and contains too few subjects to trust unequivocally the stability of the multivariate analysis employed.)

A couple of other studies are worth mentioning, although they offer somewhat qualified tests of associations between ability and type of options selected. For example, a study by Kinzie et al. (1988) found that students higher in reading ability selected a high proportion of options to review material than did lower-ability students. This was the only type option offered to subjects in the study, but because it was highly germane for the particular lesson, higher-ability students seemed perhaps better able to gauge the benefits of frequently selecting it. Additionally, if we use posttest performance as a type of surrogate ability measure, we find in a reanalysis of data presented in Seidel et al. (1975, p. 29, Table 6) that while low-posttest performers selected overall more options, high performers selected proportionally more of certain types of options—namely, options to take quizzes—than did low performers. This was not the case for options to recap or review material presented in the lesson. This finding seems not to have occurred for Holmes et al. (1985), however, who found no relationship between pretest scores (here taken as a surrogate ability measure) and particular strategy use—in their case, either opting to take unit tests before proceeding through the lesson, or going through instruction first before taking the tests.

There is also evidence that ability plays an important role on the attrition of students in large instructional units. An early example, the TICCIT system (Merrill, 1973) offered college students a great deal of choice in selection of both content and strategy. Results showed a high dropout rate, but positive effects on achievement for those who persisted. Those who stayed were generally higher-ability students to begin with (O'Shea & Self, 1983, p. 92).

The mixed results from these studies, while indicating the potential for ability and learning strategies to explain overall performance in learner-controlled CBI, also demonstrate that more research needs to be done. The hypothesis of Clark (1982) that higher-ability students will probably seek more instructional support (even though they do not need it) appears supported in some studies, but not in others. There is also some evidence that high-ability learners have some capacity to choose their instructional support with some circumspection and discrimination, rather than wholesale. It might be that the specific type of tasks presented to the students need to be more precisely matched to the specific learning strategies with which they most correspond. Overall, though, ability measures do not seem to have the power to differentiate the more relevant learning strategies adopted by a given student at a given time.

Some types of instructional interventions do appear to work to compensate for the poor use of mental resources in low-ability learners. Jonassen (1985) presents within the four learning strategy categories listed earlier several suggestions for improving the use of strategies in computer-based instruction. Most of these approaches have yet to be tried in learner-control CBI studies, however.

Ability appears to predict, in addition to the individual's perception of need for instructional support (a metacognitive strategy), other types of mental learning strategies in which the student might engage. Although the relationship between ability and choice seems more tenuous than that of prior achievement and choice, there still seems cause to believe that appropriate choice strategies can be made salient to the learners when these learners lack the inclination to spontaneously make their own decisions, perhaps via simple instructions or suggestions, and perhaps by changing the attractiveness of the various choices to be made. Additionally, the types of options selected appear more related to ability than quantity of options chosen.

Only two instances were found of learner-controlled CBI studies that attempted to improve students' strategy use. Elementary school students in Jacobson and Thompson's (1975) study were given prompts at various points to help them make appropriate instructional decisions. Although the instructional treatments used in the study were quite large and in many ways not comparable, the authors still conclude that such strategic prompting can help students to make appropriate decisions. In another study by Relan (1991), three types of strategy-training groups (comprehensive, partial, or no training) were experimentally crossed with two levels of learner control over review of material (complete or limited). She found that, for the immediate posttest at least, both strategy-training groups did improve performance, but only for the limited learner-control treatment group. She hypothesizes that the complete learner-control group with strategy training added on top was simply overloaded. The implication is that strategy training might be most effective when close attention is paid to matching appropriately that training to the context of the lesson.

Reigeluth (1979) proposed that learner-controlled instruction offer students an "advisor" option, a sort of prescriptive "help" feature, which would suggest to the student various so-called "optimal" strategies for how to process information or what to do next in the lesson. The potential flaw in this proposal is that students might not know how or when to access the optional advisor. Another intervention system is proposed by Allen and Merrill (1985), which provides to the learners varying amounts of learning-strategy suggestions depending on their aptitudes for accomplishing the learning tasks. For students of low abilities, for example, the computer would provide explicit processing representations for the students to follow; for medium-ability students, the system would "guide" the learner to use certain previously learned strategies; high-ability students would be left with the most freedom to select and apply their previously acquired processing strategies without external suggestions or interference from the computer system. This type of system has not yet been tested.

The idea behind all these approaches is to promote the conscientious and mindful use of instructional options according to individual needs for instructional support. The following section shifts the examination from the rational predictors of learner choices to the emotional or affective predictors.

33.9 EMOTIONAL-MOTIVATIONAL ASPECTS OF CHOICE AND LEARNING

"Motivation" is a very slippery concept. J. M. Keller (1983) defines motivation as the "magnitude and direction of behavior. In other words, it refers to the choices people make as to what experiences they will approach or avoid, and the degree of effort they will exert in that respect" (p. 389). Both intuition and research (Tobias, 1987b) inform us that poorly motivated students are also very often poor performers in educational settings, too. However, the derivation of instructional prescriptions to help students improve their motivation to learn requires a much more detailed exploration of both the determinants of motivated behavior and the effects of motivation on choice and learning. That is, we need to uncover the reasons (motives) behind particular choices a student may make, to clarify which variables determine, or at least predict, both general patterns and levels of choice and situation-specific choices students will make. Additionally, we need to investigate the relationship between motivation and learning. In path-analytic terms, both direct and indirect (via the actual instructional choices made) relationships of motivation and learning require clarification.

A terminology issue needs to be raised at this point. Many researchers would argue that a "motivated" behavior might be based on rational, logical decision-making processes, and thus is not best described in terms of "emotional-motivational" processes. This is true to a large extent (although some could argue it is moot). However, for clarity's sake in this chapter, learner "motivation" refers primarily to the emotional states and reactions (and their consequent overt behaviors) experienced before, during, and after instruction which have an impact on learning and choice. So-called "rationally" motivated behaviors were discussed earlier in this paper.

A large body of research and several psychological theories exist that attempt to describe and explain the relationships among emotional-motivational variables, choice, and learning, and will only be touched on here. Instead, the implications of these findings about motivation and learning for the design of learner-controlled instruction will be explored. (For further discussion of motivation issues in educational technology, see also 32.5.5.)

33.9.1 Achievement Motivation and Learner-Controlled Instruction

The history of motivation research contains a sizable body of literature concerning what is called *achievement motivation*—in simple terms, a person's desire to perform and achieve. J. W. Atkinson (1974b) presents a theory, sprung from a behaviorist tradition, which connects so-called "motivated behavior" with performance based on what he calls "resultant achievement motivation." This construct has been defined and operationalized in many ways, but according to Heckhausen, Schmalt, and Schneider (1985), the measures of achievement motivation which tend to yield the most fruitful research are those indicators that are most overt, such as an individual's tendencies to persist (J. W. Atkinson, 1974a) or otherwise exert effort (Revelle & Michaels, 1976; Thomas, 1983) at some task or tasks. Because "achievement motivation" is largely defined by overt behaviors such as persistence and perseverance, there would seem to be at least on the surface clear reasons to attempt to extend experimental findings from the theory into the domain of learner-controlled instruction, so to try to provide more grounded explanations of student behaviors in such situations.

In J. W. Atkinson's theory (1974b), a person's level of achievement motivation at any given time is described as being the function of several variables. The first set of these variables includes motive to succeed and motive to avoid failure. The second type of variable influencing achievement motivation is the perceived probability of task success (also called *expectancy*). Last, extrinsic motivational factors (such as rewards or social approval) also play a role in the level of resultant achievement motivation. Various combinations of these variables produce both *approach* tendencies (i.e., a person's inclination to engage in some type of performance situation) and *avoidance* tendencies (i.e., a person's likelihood of shunning a particular performance situation). It is these two tendencies that taken together indicate a person's level of achievement motivation.

Expanding on the achievement-motivation tradition, Lepper (1985) suggests a link between motivation and achievement which is related to covert states in the learner. It is possible that a person's level of motivation during the performance of a learning task affects key components of information processing related to learning, a position also taken by Salomon (1983). Emotional-motivational variables may influence the direction and intensity of attention processes, arousal, depth of processing, and problem representation. Even though Lepper (1985) points out that many of these information-processing ideas are at present hypothetical, there does seem to be an emerging unification of the underlying mechanisms linking motivation and achievement (Humphreys & Revelle, 1984).

Some researchers suggest that the relationship between persistence or effort and achievement is generally linear (Revelle & Michaels, 1976; Salomon, 1983). That is, they say that highly achievement-motivated individuals will usually outperform those with lower motivation levels. However, theorists following J. W. Atkinson's original model (1974b) treat motivation as having a curvilinear (inverted-U shape) relationship with learning performance (Brophy, 1983; Humphreys & Revelle, 1984; J. M Keller, 1983). That is, both excessively low and high motivational levels can have dysfunctional effects on learning. This effect is moderated depending on either task difficulty or task complexity (J. W. Atkinson, 1974b; Humphreys & Revelle, 1984).

Given this relationship, it would be interesting to look for interactions of level of motivation and learner- or program-controlled instructional treatments. Such an ATI has been found by Carrier and Williams (1988). Using task persistence as the overt motivational index, they found that under two program-controlled treatments (with low and high amounts of instruction) students performing best were those in the middle levels of persistence; under learner control, however, the best performers had the highest levels of persistence. In other words, the curvilinear relation between motivation and learning was found under program control, but a mostly linear relationship was found under learner control. (Similar data were collected in a study by Morrison et al., 1992. However, they only reported on a posited linear relationship—none found—between task persistence and achievement. It would be interesting to reanalyze their data to see if such a curvilinear relationship emerges.)

A possible explanation for these differential treatment effects can be inferred from a paper by Humphreys and Revelle (1984). Following their theory describing the underlying relationships between effort and performance, it is speculated that the students in the Carrier and Williams (1988) study behaved as though learner control were an easier or less complex condition; i.e., it placed fewer demands on their learning resources. In addition, it's possible the learner-controlled treatment produced less overall anxiety that could have interfered with learning. This interpretation is also consistent with Salomon's (1983) general notion of "perceived demand characteristics" of instructional treatments.

Although still hypothetical, three instructional factors are proposed here which might be expected to interact with a person's average general level of achievement motivation: learner or program control, task complexity, and extrinsic motivation variables.

Learner- and program-controlled treatments might be perceived by different students to be easier or more difficult to manage. It is possible that general motivational level could have an influence on performance by interacting with these treatments in a linear or curvilinear fashion, depending on the perceived "ease" of learning under the treatment.

Second, fairly simple tasks given under both learner- and program-controlled treatments might find no differences for highly motivated students. However, for difficult tasks, or those tasks requiring careful and deliberate thinking, one might expect learner control to surpass program control, at least for highly motivated (persistent) students. It is not clear yet what to expect for students of low or middle levels of motivation under tasks of varying difficulty or complexity.

Last, the object of using extrinsic motivators would be to try to increase the learner's persistence or effort expenditure through instructional manipulations, particularly for those students with low motivation levels. J. W. Atkinson (1974a) lists as examples of extrinsic motivators authority, competition, social approval, and external rewards. Several studies from the learner control literature support the use of these extrinsic motivators. Tennyson and Buttrey (1980) and Tennyson (1981) found that providing students under learner control with computer-delivered *advisements*—that is, instructional recommendations about whether they should select more material (based on a mastery diagnosis)—did result in higher amounts of material chosen and in learning equivalent to the program-controlled version. In this case, the computer can be viewed as an extrinsic motivator because of the presumed authority its recommendations carry to the learner. Peters (1988), too, found that students receiving advisements requested more practice and answered more practice questions correctly on the first attempt than did students with no advisements, although there were no differences on posttest performance. Similarly, Carrier et al. (1986) found that simple encouragements within a learner-controlled treatment did increase the amount of material chosen by the students over a learner-controlled treatment without encouragements. Hicken, Sullivan, and Klein (1992) employed another external incentive approach by varying the type of task orientation in a lesson (i.e., students were told either that simply completing the lesson was sufficient to receive credit, or that a performance criterion level of 70% was required). The result was that students in the performance criterion condition, even without selecting any additional options or by spending more time-on-task, outperformed the group with the less-stringent conditions. The authors suggest that this extrinsic type of instructional manipulation functions to improve students' effort or concentration levels. There is evidence, then, that the type of task orientation given or simple instructional guidance in learner-controlled settings can alter performance, or at least the overall level of task persistence and other on-task behaviors.

33.9.2 Emotional-Motivational Patterns and Learner-Controlled CBI

The remainder of this section attempts to peer beneath the overt motivational variables (e.g., persistence) to see how learner emotional states might have direct or indirect impacts on learner-control effectiveness. Dweck (1986) and Dweck and Leggett (1988) offer a useful integrative approach to understanding student behaviors in terms of the student's own internal beliefs about the nature of their performances and their striving to confirm those beliefs. In their model, students are continually forming implicit theories about themselves which orient them to seek particular goals related to confirming these theories. Dweck (1986) describes so-called *adaptive* (or "mastery-oriented") and *maladaptive* ("helpless") motivational patterns. The maladaptive pattern is characterized by an avoidance of challenge and a deterioration of performance in the face of obstacles. Students who exhibit an adaptive pattern, in contrast, tend to seek challenging tasks and the maintenance of effective perserverance under failure circumstances.

What follows is an example of one avenue of promising theory, to date fairly unresearched within CBI contexts, which holds promise for explaining the heretofore mixed effects of learner-controlled CBI and suggesting means of improving instructional designs that adopt learner control. The investigation of other related theoretical frameworks is encouraged, however, as well. Kinzie (1990), for example, folds into her discussion of self-regulation and learner control another promising avenue of motivation theory, namely, self-efficacy (Bandura, 1986), and suggests ways of pursuing the topic in future research. But regardless of the stance on motivation research an investigator might adopt, the idea is to try to understand the nature of emotional states the learner experiences which produce healthy (*adaptive*) or dysfunctional (*maladaptive*) expression in terms of choices, persistence, and perseverance during learner-controlled instruction.

33.9.2.1. Attribution Theory and Learner Control. A major portion of Dweck and Leggett's (1988) model is based on research in the area of student *attributions* of their success and failures. Here the conception of motivation becomes that of a somewhat unstable factor affected on a moment-by-moment basis by the person's perception of events happening during instruction and their own inferred role in those events. Generally, an "attribution" refers to an individual's perceived causes of his or her own success or failures. Early conceptualizations by Kukla (1978) and Weiner (1974) explain that the degree to which students ascribe the causes of their own success or failures to ability, effort, task difficulty, or luck will differentially predict whether or what kinds of subsequent performance opportunities the student is likely to select voluntarily. These four variables can be grouped along two primary dimensions: internal versus external (analogous to, but not the same as, the familiar "locus of control" dimension of Rotter, 1966); and stable versus unstable.

Other researchers have recently extended, refined, and reconceptualized attribution theory. For example, Covington and Omelich (1984a, 1984b, 1985) attempt to frame student attributions in terms of emotional states they imply, such as pride, shame, guilt, and humiliation. Additionally, Dweck and Leggett (1988) present a model that seeks to explain the precursors of an individual's attributions along the "controllability" dimension. That is, they attempt to explain why some individuals feel more in control of their performances outcomes and others feel more "helpless." These developments in attribution theory have potentially important consequences for the design of motivational interventions during instruction.

Very few studies have explicitly examined attribution-like variables in connection with learner-controlled CBI. Treating perception of internality/externality of reinforcement (or "locus of control"; Rotter, 1966) as a predictor variable has yielded generally unimpressive results in differentially predicting learning under several instructional conditions (Tobias, 1987b) and in predicting overall choice levels or learning in learner-controlled instruction (Carrier et al., 1985, 1986; Gray, 1989; Klein & Keller, 1990; López & Harper, 1989; Santiago & Okey, 1992). In fact, López and Harper (1989) conclude that there is little to be gained by further research investigating Rotter's locus-of-control construct in connection with learner-controlled instruction. Nevertheless, these negative findings could be masking potentially valid discriminations within groups broadly labeled *externals* or *internals*. For example, the differences between the two internal attribution styles, ability and effort, might be expected to affect options selection in either adaptive or maladaptive ways.

One early study (Fisher et al., 1975) treated various attributional variables as dependent variables under conditions of learner- and program-controlled problem selection. The authors found that subjects in the choice group made significantly more internal and stable attributions during or following instruction than did students in the program-controlled group. They also found no treatment differences for an attribution variable they called *control–no control,* but they do not provide an operational definition of this variable to aid interpretation. Additionally, even though these researchers did not take baseline measures of attribution, nor plot the changes in attributions occurring over time, their study still supports the short-term modifiability of attributions as a possible result of treatment variables.

Within J. M. Keller's ARCS model of motivational design (1983, 1987a, 1987b), both attribution theory and learner control would potentially play useful roles when attempting to improve student confidence. In some strategies, Keller suggests, students might receive attributional feedback to enhance the feeling of that "they can do it." Additionally, they could be given some degree of control over their learning situation to enhance feelings of their own self-efficacy. The attributional feedback would seem to apply mostly to situations under learner control where students are asked to choose performance-related options. These options could include the selection of such specific instructional events as optional practice items, feedback, test situations, and, possibly, remediation or review following test conditions.

However, J. M. Keller's model is fairly nonspecific about the types of attributional feedback that should be offered to students and under which circumstances it would function optimally. Milheim and Martin (1991), too, suggest the utility of attribution theory for explaining the mixed effects found in the learner-control literature, but they, too, offer few specific suggestions for possible instructional design strategies that incorporate the theory.

Manipulations directed toward attaining these treatment goals would seem to fall into three classes of instructional strategies: (1) those affecting an entire lesson condition; (2) those preceding specific choice situations, taking the form of guidance, advice, or recommendations; and (3) those immediately following performance situations, taking the form of interpretations and attributions of success or failure generated by instruction.

The first strategy class includes attempts to adapt instruction to whatever overall attributional style a person seems to possess. Here, diagnosis of attribution levels would take place once, prior to the start of the lesson. All instruction might be subsequently modified accordingly in the manner of an ATI.

Additionally in this class, instruction could at the outset inform learners that they have control over what they see, and that their performance will be determined by how much they try. Given this, it would be necessary that the instruction monitor performance throughout the lesson and adjust task difficulty so as to minimize the discouraging effects of frequent failure.

Also in this class are manipulations related to task or ego involvement. Norm-referencing (ego-involving) suggestions to the student by the instructional system could be presented to students with high success rates. Examples of such presentations might be general statements that a student's performance will be compared to others, or perhaps comments to the students that they did better than most people on a particular task. Low-performing students might be best placed under task-involved conditions that encourage value placed on task improvement.

The second class also subscribes to a typical adaptive instruction paradigm, although here we are dealing with microinstructional adaptations of task-specific attributions. In particular, strategies in this class are forward looking, and include encouragement and advisement techniques such as those mentioned in the earlier section on achievement motivation. Some specific techniques might include recommending to the student that they choose a task of hard-difficulty (medium, easy) level depending on what the student's current performance level and attributional tendencies are at the moment. They might also include such motivating statements as "try harder on this one . . .," or "the next task is an easy one. . . ." Another possibility might be to describe a subsequent task in terms compatible with the student's attributional style, but again on a very local level.

In the last class of instructional manipulations, the instruction could make evaluative and interpretive comments on a student's performance immediately following the success or failure of the task. The goal of these reflective or backward-looking instructional strategies is to alter attributions intentionally. Comments to the student might attribute failure to his not trying hard enough or, when appropriate, to a task being difficult. Successful performance would always be attributed by the instruction to an internal factor. A study by Carrier et al. (1986) gave students a variety of backward-looking encouraging feedback (though not attributionally related) and found positive effects for task persistence. It is expected that feedback engineered more specifically to counteract maladaptive attributional patterns in the students would be even more fruitful.

A doctoral dissertation conducted by this author (Williams, 1992) examined the impact of attributionally related feedback on learners of differing attributional tendencies (or styles) within learner- and program-controlled conditions. The type of feedback employed in the study was specifically intended to affect students' temporary perceptions of the causes of their learning successes and failures, that is, their *attributions* of their performance outcomes, so to minimize the dysfunctional behaviors of learners with maladaptive attributional styles. Providing specific attributionally related feedback to learners in an attempt to alter attributions temporarily has a well-established research base (Andrews & Debus, 1978; Barker & Graham, 1987; Borkowski, Weyhing & Carr, 1988; Dweck, 1975; Fowler & Peterson, 1981; Graham & Barker, 1990; Medway & Venino, 1982; Meyer & Dyck, 1986; Schunk, 1982, 1983, 1990a; Schunk & Cox, 1986) which hitherto had not been investigated in a computer-based context.

Findings from the study generally support the notion that, overall, certain types of attributional styles are maladaptive. (Examples of types of these maladaptive attributional styles include tendencies to attribute personal success to external causes, or to attribute personal failure to lack of ability.) That is, students who exhibit such motivational patterns tend not to exert as much effort or mental investment in their learning activities, and thus are prone to perform poorly.

The study by Williams (1992) also showed that the granting of a relatively small degree of learner control within the CBI lesson succeeded in improving the performance of students who otherwise showed certain types of maladaptive motivational patterns, namely, those who attribute their successes to either effort or to external causes. Also, students who attributed their successes to external causes, a generally maladaptive attributional style, showed markedly improved performance when given appropriate attributionally related feedback following their on-task performances. Such feedback was designed in accordance with recommendations from researchers on attribution theory, and consisted of reflective interpretations given by the computer to the student that a particular successful performance on the first try was due to ability (e.g., "You seem to know this material well!"), and on a second try was due to effort (e.g., "Terrific! It pays to try a little harder the second time."). Similarly, a failed performance on the first try was ascribed by the computer to lack of effort (e.g., "Perhaps you weren't concentrating enough on the question."), and on a second try to external causes (e.g., "You made a good try. That question was particularly hard."). In other words, giving these types of attributional feedback moderated the maladaptive tendencies of these students.

The Williams (1992) study supports the utility of the adaptive instruction paradigm of Gehlbach (1979). In this framework, unlike the classic ATI approach of Cronbach and Snow (1977), students who are deficient in some relevant aptitude are administered an instructional treatment intended to "correct" the difficulty, not operate around it or on top of it. In the current case, students who exhibited suboptimal motivational patterns were provided with appropriate feedback in an attempt to encourage more healthy emotional self-perceptions and hence more functional behaviors.

To summarize, the previous section posits that the general ineffectiveness of learner-controlled CBI can be explained, at least in part, by the fact that some learners have acquired maladaptive motivational tendencies and as a result exhibit dysfunctional or suboptimal choices (e.g., showing low persistence or perseverance, or terminating a lesson early). There is some evidence, although scant, that one particular motivational theory, namely, attribution theory, can be exploited to improve the on-task motivational behaviors for learners within learner-controlled situations. Other related theoretical approaches, e.g., learned helplessness and self-efficacy, also need explicating as to their potential relationships with learner-control effectiveness. The goal is to increase both motivation to achieve, where such motivation is low and motivational patterns are maladaptive, and to help students optimize their selection of instructional support.

33.10 SUMMARY

This paper has reviewed many studies comparing various forms of learner-controlled, computer-based instruction with program-controlled CBI. These studies had been theoretically predicted to show learner control superior to program control. However, empirical findings related to these predictions have been disappointing.

A closer examination of these studies showed that a number of mediating factors were likely responsible for the poor performance under learner control. It was found that many students simply were not capable of making good use of the control they were given. Two large categories of individual difference variables were suggested to be important in identifying these students: rational-cognitive variables and emotional-motivational variables.

In particular, both student prior knowledge and ability were found to predict student success under learner control. Prior knowledge was found to be related to the capacity of the students to estimate the amount of instructional support they would need. Students with little knowledge were not able effectively to monitor their comprehension, and thus were not able to gauge the degree of instructional support they would need. Additionally, student ability was viewed as related to the learning strategies individual students bring to bear when faced with a learning problem. Lower-ability students typically do not have the repertoire of learning strategies available to them that higher-ability students do. Some suggestions were offered for accommodating these differences within learner-controlled instruction.

The student's level of motivation was also found to be a potentially important variable in explaining the overall effects of learner control. In particular, attributional theory was offered as an example of a well-grounded framework for understanding motivated student behaviors and effort, and for adapting instruction to meet the needs of students with maladaptive attributional patterns.

33.11 AN INSTRUCTIONAL THEORY OF LEARNER CONTROL?

Can a comprehensive, integrative, deductive, prescriptive, and testable theory of learner control be developed? I suspect not, not if we demand of such a theory (any more than any other educational theory) that it be falsifiable in the Popper (1968) sense. An alternative question, however, is whether we can still develop instructional prescriptions for the use of learner control which are at least pragmatic and are grounded in some reasonable psychological and educational principles. I suspect we probably can. In fact, work to develop such prescriptions can be found in many of the existing learner-control reviews.

Steinberg (1984), for example, lists a range of these events that might be offered within a learner-controlled lesson, together with some conditions that might mitigate their success: which topics to study and in what order, number of exercises to practice and their level of difficulty, presentation of review or supplementary materials, or the option not to answer questions. Other activities, too, could be made optional: amount or kind of feedback to see following practice questions, whether to exit the instruction, mode of presentation (e.g., verbal or graphic), and even the option of whether to allow further learner control at all.

Laurillard (1987) presents another assortment of computer-based learning strategies of which learners might judiciously be given control. One category of these strategies, *control of content sequence,* includes provisions for the student to skip forward or backward a chosen amount or to retrace a route through the material, and options to control when to view such features as content indexes or content maps. [A rather remarkable early example of learner control of content sequence in computer-based instruction comes from Grubb (1968). He describes a system whereby the student, with the aid of a light pen and a content map on the screen, is able to point and jump to any subtopic in the lesson. This approach presages the current "hypertext" environments in which students proceed through instruction in a nonlinear "browsing" fashion.]

Another category presented by Laurillard (1987) is called *control of learning activities,* and includes options for the student to see examples, do exercises, receive information, consult a glossary, ask for more explanation, and take a quiz. Most of her list of learner-controlled activities is included in Steinberg's (1984) list, but Laurillard's seems more complete and grounded in educational-psychological theory.

Milheim and Martin (1991) discuss when and how to prescribe three types of variables for which students might be granted control: *control of pacing,* that is, the speed of presentation of instructional materials; and *control of content,* permitting students to skip over certain instructional units. They suggest that these categories, in addition to *control of sequence* (similar to Laurillard's *control of content sequence*), represent the most germane sets of instructional variables affecting the success or failure of learner-controlled CBI.

Recently others, most notably Chung and Reigeluth (1992), have worked to synthesize an empirically based and pragmatic listing of instructional prescriptions that link a variety of learner-control strategies (over content, sequence, pace, display/strategy, internal processing, and use of advisor systems) to instructional conditions (learner characteristics, learning objectives or domains, and instructional systems) and broad outcomes (learning achievement, transfer, and retention, time efficiency, cost efficiency, and attitudes toward learning and instruction). These authors recognize the multidimensional nature of learner control, and provide a helpful set of do's and don'ts for deciding when to employ which learner-controlled instructional events. Their recommendations are many, and only a few are presented here as illustrations of their approach.

For example, they recommend that students should be offered control of content when they have significant previous knowledge in the content area, because presentation of already known material could be irrelevant and interesting. If students are already prepared with some content knowledge, they can more effectively manage their own content. Additionally, content control might be given when the learning objectives are of a higher-order type, as opposed to factual information.

Similarly, they list conditions that allow for learner control of sequence, such as when the instructional program is quite lengthy (sequence control can help maintain learner motivation and interest), or when they are familiar with a topic. Likewise, students should not be given control over sequence when learning objectives have a clear prerequisite order, or when it would be impractical to break up and resequence existing materials.

In a similar vein, they provide many conditions for using learner control of specific instructional elements such as pacing, displaying information or using instructional strategies, internal processing (including some metacognition strategies), and use of advisory systems. To justify many of these prescriptions, Chung and Reigeluth (1992) cite empirical studies from the learner-control literature; many others, however, are derived from current instructional theories (e.g., Gagné, 1985; Merrill, 1983) and need empirical validation in their own right. Given the overall structure they give to their instructional prescriptions, essentially a series of "if-then" conditions, it would be interesting to see developed a type of computer-based decision tree or expert system based on the "mix and match" combinations of instructional strategies, outcomes, and conditions presented in their paper. Such a prescriptive system of learner control might then be validated with research across a variety of instructional systems and contexts, and would provide some tests of the generalizability of their recommendations.

All of the categorization schemes providing advice on if, how, and when to use learner control in CBI overlap to a large degree and differ primarily in perspective or orientation. And all provide useful information for designers attempting to decide whether and how to include learner-controlled events in their instructional designs. None, however, is comprehensive or definitive.

33.12 RECOMMENDATIONS FOR FUTURE RESEARCH

Several researchers recently have apparently stopped asking this research question: "Which is better: learner- or program-controlled CBI?" It seems that enough research has been produced to date to justify conclusions of "it depends" or "take your pick." Rather, these researchers fundamentally alter the question to read, "How can I make learner-controlled CBI effective?" Within their experimental studies, these investigators do not include a program-control treatment at all, deciding instead to focus on the question of how to improve the design of instruction, given learner control. For example, a study by Santiago and Okey (1992), investigating various forms of advisement conditions all under learner control, provides a good example of how research might be conducted with the aim of improving learner-controlled instruction. Another good example of this framework is shown in a study by Pridemore and Klein (1991), who looked at variations in feedback elaborations, each operating within the same learner-controlled feedback structure. Another study by Hicken et al. (1992) investigated whether within a completely learner-controlled lesson, options to skip material in a "full" lesson might be more beneficial than learner options to see more material in a "lean" lesson. The likelihood is that the number of this type of study will continue to grow.

Additionally, many other specific issues that might be pursued include the following:

1. What specific instructional events are most or least amenable to providing or withdrawing learner control? That is, of the many instructional strategies, methods, activities, and events from which designers may draw upon to build lesson designs, which ones are most promising? Theoretical work by Laurillard (1987), Milheim and Martin (1991), and Steinberg (1989) go a long way toward providing prescriptive guidelines for designers; however, more specific recommendations need to be explored. I also strongly concur with the suggestion of Milheim and Martin

(1991) to conduct more empirical and theoretical work on the nature and role of learner motivations in learner-controlled CBI settings.

2. What exactly is the nature of a learner's mental processes as he or she proceeds through learner-controlled instruction? If we can better understand both the rational-cognitive thought processes and the emotional-motivational states of the learner, we might be able to devise means to encourage optimal processes and perhaps attempt to alter or at least compensate for dysfunctional processes. This type of investigation has been suggested before (Clark, 1984; Robson, Steward & Whitfield, 1988) but has not yet been adequately pursued, perhaps because of the inherently qualitative nature of the data and the lack of comfort with such methodologies by many learner-control investigators. Reeves (1993) goes so far as to suggest that, "Perhaps a moratorium should be called on the types of quantitative studies described in this [Reeves's] paper, replacing them with extensive, in-depth efforts to observe human behavior in our field and relate the observations to meaningful learning theory that may later be susceptible to quantitative inquiry" (p. 44). (See also 40.1.)

3. Related to the previous suggestion, it is time investigators more closely examined the social nature of learner-controlled activities. Anyone who has observed classroom situations where students navigate through instruction has informally noticed that there can be a great deal of discussion among students, both those sitting at separate computers and those working at the same computer. Rather than attempt to eliminate such interactions in order to investigate the "pure" effects of learner or program control, researchers may wish to adopt methodologies closer to field studies or naturalistic inquiry to study how learners can feed off each other's comments and actions during instruction. Although some experimental studies have been conducted to try to sort out the relative effects of learner control or program control for cooperative groups or for individual students (Hooper, Temiyakarn & Williams, 1993; Temiyakarn & McDonald, 1993), more work remains to be done before general conclusions, if any, can be drawn. (See also 35.9.4.)

4. A perhaps erroneous assumption undergirding most learner-control research is the implicit value placed on an individualistic and internally referenced system of control over instruction. That is, we tend to say that it is a good thing for learners to develop a capacity for intelligent control over their instructional experiences. This assumption might, however, be culture dependent. There is the additional question of whether the psychological bases discussed earlier (cognitive-rational and emotional-motivational) will operate similarly for students of differing cultural backgrounds. Wong (1988), for example, found that for students in a study conducted in Singapore, those who were under learner-controlled conditions selected more instructional options than students received under program control, a finding contrary to most learner-control research. Cross-cultural studies of learner control are sparse, but are needed to shed light on the question of whether learner control can be viewed with the same assumptions for children of different cultural backgrounds and values.

5. Learner control should be much more closely investigated under other common or developing types of computer-based environments, such as simulations, hypertext/hypermedia (including browsing through internet systems such as the World Wide Web), on-line databases (such as electronic encyclopedias), on-line help and other support tools, and distance education. All of these contexts (possibly excepting distance education), by definition, intrinsically allow learner control to a greater or lesser degree. And it is likely that these types of computer-based experiences will soon be more frequent experiences for students than standard tutorials or "drills & practice." However, research to sort out the peculiar learner-control factors, each of which needs attention or support in these instructional systems, is still in its infancy (Trumbull, Gay & Mazur, 1992; McGrath, 1992; Saba & Shearer, 1993). Nevertheless, Chung and Reigeluth (1992) have given a jolt to this area of investigation by providing some useful instructional prescriptions for the use of learner control in hypermedia learning systems which they induced from the standard learner-control literature.

6. There needs to be a greater link made between learner-controlled CBI research and a growing body of literature on the topic of *self-regulated learning*. Briefly, this area of investigation, contributed to notably by McCombs and associates (McCombs, 1982, 1984; McCombs & Marzano, 1990) and by Zimmerman and associates (Zimmerman, 1990; Zimmerman & Martinez-Pons, 1986, 1988, 1990) conceptualizes students as "metacognitively, motivationally, and behaviorally active participants in their own learning processes" (Zimmerman & Martinez-Pons, 1988, p. 284). Although the research so far has primarily focused on understanding on a rather macro level the mental strategies occurring during successful self-regulated learning, this literature has clear implications for the inclusion of motivational variables in the design of learner-controlled instructional systems. In fact, some investigators have recently begun to explicitly address motivational variables operating in self-regulated learners (e.g., Schunk, 1990b; Zimmerman & Martinez-Pons, 1990). Additionally, there is beginning to emerge an interest in the application of self-regulated learning models to other formats of CBI, such as computer programming (Armstrong, 1989; Fischer & Mandl, 1988). Finally, a recent integrative paper by Kinzie (1990) provides a much-needed conceptual framework for discussion of the related areas of self-regulation, continuing motivation, and learner control.

7. The constructivist paradigm for learning would seem to have great implications for both the explanation of findings from the existing literature on learner control as well as to offer suggestions for new types of research questions based on the perspective it brings. Lebow (1993), in fact,

suggests that constructivism provides a much-needed framework for interpreting the often confusing results from learner-control research. These reinterpretations of the learner-control literature from this point of view remain to be done, however. Additionally, he points out, as do others (e.g., Jonassen, Wilson, Wang & Grabinger, 1993; see also 7.4.5), that constructivist instructional perspectives are associated with a high degree of learner control and imply many new types of research questions. Indeed, Jonassen et al. (1993) discuss how constructivist approaches and learner control are inextricably linked, "The more learner-controlled the instructional systems are, the more generative they are; that is, they require learners to generate or construct their own knowledge" (p. 87). Certainly future investigators who adopt this type of philosophy would ask questions that are far removed from "Which is better: learner or program control?"

33.13 CONCLUSION

Lepper and Chabay (1985) succinctly summarize the problem of differentially providing learners with control over their own instruction: "It is unlikely that any choice of level of control will be optimal for all students, or even that the same level of control will be optimal for a single student for all activities or in all situations" (p. 226). Of the many approaches for accommodating differences among learners, one is to allow them to adapt the instruction themselves to meet their own needs as they see fit. Instruction would not be linear and lockstep; that is, all students could receive different instructional events. This strategy is not as highly prescriptive or determined or complicated as branching or other adaptive schemes sometimes found in computer-based approaches. Rather, learner control is a way of allowing individual differences to exert a positive influence without trainer control or intervention based on these individual differences. However, great care needs to be exercised by designers in constructing their learner-controlled lessons to optimize effectiveness for all types of learners.

In sum, after all that has been written about the virtues of giving trainees control over their own learning, such activities alone offer no guarantee of successful learning. This might have been forecast by Dewey, that strong proponent of experiential education, who voiced concerns about unconditional learner self-management: "The ideal aim of education is creation of the power of self-control. But the mere removal of external control is no guarantee for the production of self-control" (1938, p. 64).

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