# Guidelines for Using Locus of Instructional Control in the Design of Computer-Assisted Instruction

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**Abstract.** Computers offer a variety of instructional control options to designers of computer-assisted instruction. However, the amount and type of instructional control is affected by both the nature of the learning task and learner characteristics. The purposes of this paper are to present empirical evidence on locus of instructional control, and to present guidelines for determining learner versus lesson control in computer-assisted instruction.

The computer as an instructional delivery system offers the designer a myriad of options. Instruction can be designed using a variety of presentation formats, interaction options, feedback techniques, and instructional management options. Computers, as a consequence, have been praised for their capabilities and the power offered as an instructional technology. Knowledge of how and when to use these capabilities, however, has been considerably slower to develop.

One of the most powerful and important features of the computer is the virtually unlimited range of instructional control options available to designers of computer-assisted instruction (CAI) (Burke, 1982). Although substantial research has been conducted related to instructional control and CAI, little of this information has affected the instructional design and development profession. A variety of factors affect the decision of how much, or what type of, instructional control is desirable. The purposes of this paper are to examine several factors that should be considered, and to present a set of guidelines for determining the instructional locus of control in CAI.

## Instructional Locus of Control and Computer-Assisted Instruction

Locus of control as a psychological construct has been studied extensively. Instructionally, however, locus of control has assumed a different meaning. Typically, instructional locus of control has been examined by manipulating instructional features such as method of lesson pacing (Ross & Rakow, 1981), management and evaluation decisions in instruction (Hannafin, 1981), en route decisions regarding need for additional instruction (Tennyson, 1981), and selection of other instructional features (Carrier, Davidson, Higson, & Williams, 1984). Instructional locus of control can be thought of as a continuum ranging from fully externally controlled to completely internally controlled. Instruction is considered to be more externally controlled with fixed rate, linear delivery systems such as slide-tape presentations; instruction is thought to be more internally regulated in delivery systems where the learner exercises significant control over the contingencies of the lesson, such as in certain CAI lessons.

In this paper, *external locus of control* is defined as instruction in which all learners follow a predetermined path established by the designer without exercising individual judgement as to the appropriateness of the path. *Internal locus of control* is demonstrated in lessons where individuals control the path, pace, and/or contingencies of the instruction, typically by specifying choices among a range of designer-embedded options. While combinations of internal and external control are perhaps most common, this paper will focus on each type separately.

### Empirical Perspectives: External vs. Internal Control

External control does not necessarily connote linearity. While linear CAI designs are an instance of externally controlled instruction, externally controlled lessons more typically offer a variety of branching options—all of which are executed under fixed lesson rather than learner control. Several researchers have developed successful externally controlled adaptive strategies (Park & Tennyson, 1983; Ross & Rakow, 1980, 1982; Ross, Rakow, & Bush, 1980; Rothen & Tennyson, 1978; Tennyson, Christenson, & Park, 1984; Tennyson & Rothen, 1979). In such designs, contingencies are typically established which control the need for, or selection of, systematic branching. One student may learn all intended information rapidly, and never branch for review or remediation. A different learner, however, may experience difficulty throughout the same lesson, and the lesson will adapt and branch the learner to appropriate lesson segments as needed. In each case, movement through the lesson is dictated by the designer, and presumably by an overriding justification for routing learners through preselected paths. Such strategies have proven effective for teaching a variety of skills and for reducing instructional time (Kulik, Kulik, & Cohen, 1980; Edwards, Norton, Taylor, Weiss, & Dusseldorp, 1975). One of the principal criticisms of such designs, however, is the tacit assumption that the designer is the best judge of when, where, and how much instruction is needed to learn a given skill. Since learners cannot control directly the instructional sequence, frequency of examples, or number of practice items, faster learners may be required to complete instructional sequences that are unnecessary or inappropriate given their individual learning styles.

A wide range of internal, or learner control, strategies have also been developed and studied (Bunderson, 1974; Caffarella, Cavert, Legum, Shtogren, & Wager, 1980). In many cases, however, learner control in CAI has proven less successful (Steinberg, 1977). Despite the inconsistencies, Snow (1980) has argued that while performance has rarely been optimized under learner control in the past, the conditions of effective learner control still warrant study.

To this end, a variety of "coaching" procedures have been studied (see, for example, the extensive study reported by Ross and Rakow and their associates, and Tennyson and his associates). Researchers have successfully developed procedures that offer guidance upon which individual learner's decisions can be based. Learners may be advised as to the number of practice items or examples recommended, based upon the individual learner's past, current, or cumulative performance, during a lesson. However, the learner maintains control over the instructional decisions by accepting or rejecting the advice offered during the lesson, and proceeding as individually deemed appropriate. In effect, learners make informed judgement regarding their instructional sequence, as opposed to making an uninformed decision.

### Other Findings

A number of additional patterns have emerged from the study of instructional control in CAI. Externally controlled CAI has proven effective in a variety of drill and practice tasks (Kulik, Bangert, & Williams, 1983; Merrill & Salisbury, 1984; Saracho, 1982). This may result since such lessons typically reinforce previously taught information rather than teach new instructional content. In cases where standards for mastery are already established, external control can force learners through the mandated number of practice trials and require learners to demonstrate desired levels of mastery during the lesson, thereby ensuring the quality of performance. It is unclear, however, whether or not externally controlled CAI is *necessary* for learning under such circumstances, or if learner controlled instruction could prove more effective or efficient than externally controlled instruction. It is possible that a significant amount of control could be transferred to the learner with equal or greater success.

Although the findings are inconsistent, learner age and ability have also been found to affect the extent to which learner control strategies can be effectively applied. Whereas most CAI studies have been conducted using college students, who are older and generally capable academically, recent studies suggest that younger and less able learners may not perform well under internal instructional control (Goetzfried & Hannafin, in press). Older and more able learners may have more effective and refined cognitive strategies to apply during instruction, and are likely to be better at estimating the accuracy of learning, the presence of confusion, and the need for additional instruction than younger and less able learners. In effect, providing the option for control to older and more able learners may enable them to apply individually developed cognitive strategies to sort and to assimilate information in ways that are uniquely effective. Younger and less able students, on the other hand, may have neither the refined cognitive strategies nor the self-evaluation skills to apply during a lesson. For these reasons, structured, externally controlled CAI may provide a superior organization of to-be-learned information, while eliminating the need for self-evaluation, for younger and less able learners.

The effect of choice on learner attitudes has also received attention. It has been suggested that learner control may be related more to learner attitude than to achievement (Dalton & Hannafin, in press; Hannafin, 1982). Researchers have reported positive effects of different CAI lessons on attitudes toward both the information studied and the computer itself (Fowler, 1983), toward the learning experience offered by the computer (Lawton & Gerschner, 1982), and, in some cases, compared with competing delivery systems (cf. Kulik, 1983). However, the comparative effects of different CAI control options on attitudes have not been studied extensively. This is a particularly interesting and important issue, since the computer offers the potential to provide as much, or as little, control to learners as appropriate and desirable. Presently, there is insufficient empirical evidence to support the comparative superiority of internally, or externally, controlled CAI on learner attitude.

Two related issues, studied less often but of potential importance, are the extent to which learners select paths that are different from designer imposed paths, and the extent to which such choices affect learning. Nested within these issues are several fundamental questions concerning instructional locus of control in CAI. If, for example, learners are proven to make choices that are different from those a designer might impose, do such choices improve resulting learning? With what frequency and effectiveness are the options provided actually used? Are there benefits apart from learning that support learner or lesson control? What are the learner and instructional task variables that affect the locus of instructional control decision? Can the science of lesson design be improved through the study of the choices and effectiveness of internally controlled CAI? The answers to these questions may offer insights into the design of CAI in the future, an indeed may help to determine whether the need for different control options is more real than imagined.

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### Practical Concerns

One of the most important considerations in the instructional control decision may be the ease, or difficulty, of design and development of internally versus externally controlled CAI. Internally controlled lessons are generally more time-consuming, and consequently more costly, to design and to develop than externally controlled lessons. This is due largely to the extent to which the designer must anticipate a range of learner options, each with a corresponding set of unique response contingencies. Internally controlled CAI designs tend to require a more complex set of branching options than externally controlled designs where instructional contingencies are typically established across learners.

## Tentative Guidelines for Determining the Locus of Instructional Control in CAI

Although the answers to the preceding, and other, questions have not been conclusively demonstrated with CAI, a number of tentative guidelines may be proposed. The following guidelines are based upon research in the instructional design, learning and cognition, and CAI fields, as well as the author's experience. The guidelines pertain to learner age and ability, the nature of the learning task, the use of coaching procedures, the inclusion of structural guidance, and procedures for monitoring lesson implementation.

1. *Older students perform more effectively under guided learner control; younger students perform best under lesson control* (c.f., Fischer, Blackwell, Garcia, & Green, 1975 vs. Goetzfried & Hannafin, in press). The overwhelming majority of the published experimental research on control of instruction has been conducted with older learners (see, for example, the studies by Tennyson and associates and Ross and associates). While internal strategies, especially those using some form of coaching, have been successful with college-age learners, there is simply an inadequate basis for generalizing these findings to younger learners. Internal control by younger students *may* eventually be demonstrated, either through certain lesson options and structure, or by training individuals in making control decisions, a stronger case can be presently advanced supporting external control for younger learners.

2. *More able students perform best under learner control; less capable students perform best under lesson control* (Goetzfried & Hannafin, in press). Given the opportunity to apply well-cultivated strategies to learning from the computer, more able learners appear capable of processing information in uniquely efficient and effective ways. The use of computer guidance, for example, tends to be more effective than for less able learners. Less able learners, on the other hand, are likely to profit more from the instructional presentation logic of a knowledgeable designer. Such students may be less effective at evaluating the learning process, and consequently may be inadequate at selecting practice, examples, and the need for reinstruction.

3. *Locus of instructional control is dependent upon the nature of the learning task* (cf. Gagne & Briggs, 1979):

a. *Procedural tasks are best taught using lesson control.* When a sequence of steps or tasks must be learned, the order among the steps must be controlled. Whereas some learners may learn procedural tasks effectively under internally controlled instruction, a greater proportion of learners will likely profit from an established instructional sequence.

b. *Verbatim learning tasks are best taught using lesson control.* Where verbal information of a verbatim or literal nature is to be learned, the need for control over the exactness of the presentation increases. External strategies provide a greater degree of certainty of exactly what has been learned, since it is possible to validate learning through mandatory skill checks.

c. *Contextual and substantive information are best taught using learner control.* Though not established conclusively for CAI, internal strategies may yield greater depth of processing of presented information. Internal designs permit the learner to form individually relevant associations among prior and current information, thereby deepening and enriching the level at which instruction is processed.

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d. *Lower-order intellectual skills are best taught using lesson control; higher order skills may be best taught using learner control.* In general, lower order intellectual skills tend to be readily and uniformly classified. Considerable agreement exists, for example, for simple discriminations, concrete concepts, and rules. Such skills may be addressed very efficiently by presenting the basic bodies of instruction to learners under imposed program control. On the other hand, higher order intellectual skills, such as those involving problem solving, require a greater level of abstraction, integration, and application of information. As such these skills may be more amenable to the application of individual judgements as to when and what type of instruction is needed.

e. *Lesson control is desirable for learning tasks with established performance of mastery criteria; for tasks that do not have specified mastery criteria, imposed lesson control is useful for tutorial, and internal control useful for drill and practice.* The ability to establish mastery of instructional objectives makes external control desirable under many circumstances. When no fixed mastery criteria exist, however, there is little to lose and potentially a great deal to gain in increasing learner control.

f. *Imposed lesson control is more effective for unfamiliar learning tasks, and learner control more effective for familiar learning tasks* (Ross & Rakow, 1981; Tobias, 1981). The degree to which learners have familiarity with to-be-learned information affects the accuracy with which they can make informed control decisions. As familiarity decreases, the amount of structure and explicitness of the instruction needs to be increased. As learners become increasingly familiar with the information to be presented, they appear to become more adept at evaluating their performance, and can make more effective choices.

g. *Students who perceive themselves as internally governed, i.e., assume personal responsibility for their performance and behavior, perform best under internally controlled CAI; students who perceive themselves as externally governed, i.e., respond to imposed instructional demands, respond best to externally controlled CAI* (see Carrier et al., 1984; Holloway, 1978). Although the findings are not definitive, the orientation of the learner, that is the extent to which the learner believes that s/he is affected more by external versus internal events, may be a useful consideration in determining who might be a receptive candidate for transfer of instructional control. If a learner is already oriented to assuming personal responsibility for their learning, internal control techniques might be an effective instructional technique. Students who are not oriented this way, however, may experience greater difficulty when required to monitor their learning, make decisions regarding options, and otherwise adapt to a learner control procedure.

4. *Internal control strategies should include some form of coaching to assist learners in making informed decisions* (Ross, 1984; Tennyson & Buttrey, 1980). Learner control is not compromised by coaching on such topics as cumulative performance, comparisons to expected standards, recommendations for examples, and a variety of other topics. To the contrary, failure to provide meaningful guidance can prove frustrating to learners in that they may be unable to make intelligent, informed choices.

5. *Internally controlled lessons should include a "catch net" to identify ineffective learners.* It can become not only ineffective, but also frustrating, for students who experience difficulty to attempt to proceed through a learner-controlled lesson indefinitely. In the author's experience, the inclusion of error detection procedures, designed to make alert the student and the instructor to problem learners, are desirable. As a fail-safe, learners who are struggling during internally controlled lessons should be identified, advised in strategies to improve their judgements, or counseled to consider externally imposed options.

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6. *Internally controlled lessons should include the "exemplar path" normally prescribed by the designer for external control.* Assuming a designer has identified a path deemed to be most effective, common sense alone dictates that internally controlled lessons provide at least the same option. It would appear senseless to exclude the instructional sequence and activities advocated by a professional designer in order to defer entirely to an open-ended learning sequence. Learners should be advised as to which options are thought to be most effective at each decision point.

7. *Structural guidance, such as provided through the Events of Instruction (Gagne, Wager, & Rojas, 1981), should be provided in both internal and external control designs.* Regardless of the CAI control procedures adopted, rational, time-tested instructional components should be included. Learners in internally controlled lessons should be encouraged to participate in key lesson components, such as practice and feedback, in order to improve the probability of learning intended information.

8. *Conventions in the use of locus of instructional control should be consistent; changes in control procedures should be explained to the learner.* Uniform protocol in CAI is important not only to screen-face design (Heines, 1984), but also to response expectations (Hannafin & Peck, in press). Learners should develop consistent expectations of the control orientation of instruction. If changes in procedures are made, learners should be advised in order to ward off possible frustration.

9. *If initial learning is ineffective under one control strategy, switch to the other control option (if available).* In the author's experience, an initial, but unsuccessful, pass through a lesson often helps to orient the student to review or remediation. Learners who interact with externally controlled lessons are likely to have learned from their initial exposure to the information. In such cases, they may be capable of making very well-informed choices as to where additional instruction is needed. Correspondingly, learners who have experienced difficulty with a learner-controlled lesson format may profit from the macro-organization provided through the externally controlled lesson. Alternating formats may also reduce perceived repetition.

10. *Monitor the frequency of usage, and the effectiveness, of different instructional paths for both internally and externally controlled CAI lessons.* The issue of how many, and what types, of lesson control options to include is unresolved. In a preliminary study regarding instructional path selection and effectiveness conducted by the author, effective and more able learners were found to be more consistent in their use of examples, practice, and repetition than ineffective and less able learners. However, the effectiveness, and necessity, of such options for high achievers has been questioned (Clark, 1982). Recording the control choices of learners will help to identify unnecessary options, as well as those options that are most frequently used by effective versus ineffective learners. It is easier to evaluate and to revise existing lessons, as well as to plan future lesson options, based upon such information.

## Closing Comments

These guidelines should provide a basis for further study. Certainly, the guidelines require validation across a variety of settings and subject areas. It is also possible, as suggested in related instructional research (Hannafin, 1981), that locus of control effects may be related to factors other than achievement. For example, the effects of learner versus lesson control on non-achievement measures such as attitude, persistence, and continuing motivation, should be addressed.

As an instructional medium, the computer offers options that are tempting, but perhaps unnecessary and even contraindicated in many cases. The importance of harnessing the instructional potential of the computer cannot be overstated. Instructional technologists have been accused of promoting hardware rather than intelligent and informed instructional applications. The emergence of the computer, and the range of its instructional capabilities, makes the computer a unique challenge. Consideration of the proposed guidelines, while offering no guarantee of effectiveness, will provide a start in assisting designers to apply the capabilities of the computer in a well-informed, systematic manner.

## References


Burke, R.L. (1982). *CAI sourcebook.* Englewood Cliffs, NJ: Prentice Hall, Inc.

Bunderson, C.V. (1974). The design and production of learner controlled courseware for the TICCIT system: A progress paper. *Journal of Man-Machine Studies, 6,* 479–491.

Caffarella, E.P., Cavert, C.E., Legum, S.E., Shtogren, J.A., & Wager, W.W. (1980). Factors affecting instructor/student ration for self-paced instruction. *Technology, 20(12),* 5–9.

Carrier, C., Davi G., Higson, V., & Williams, M. (1984). Selection of options by field independent and field dependent children in a computer concept lesson. *Journal of Computer-Based Instruction, 11*, 49-54.

Clark, R.E. (1982). Antagonism between achievement and enjoyment in ATI studies. *The Educational Psychologist, 17(2)*, 92-101.

Dalton, D.W., & Hannafin, M.J. (in press). Examining the effects of varied computer-based reinforcement on self-esteem and achievement: An exploratory study. *Association for Educational Data Systems Journal.*

Edwards, J., Norton, S., Taylor, S., Weiss M., & Dusseldorp, R. (1975). How effective is CAI? A review of the research. *Educational Leadership, 33*, 147-153.

Fischer, M.D., Blackwell, L.R., Garcia, A.B., & Greene, J.C. (1975). Effects of student control and choice on engagement in a CAI arithmetic task in a low-income school. *Journal of Educational Psychology, 67*, 776-783.

Fowler, J.F. (1983). Use of computer-assisted instruction in introductory management science. *Journal of Experimental Education, 52*, 22-26.

Gagne, R.M., & Briggs, L.J. (1979). *Principles of Instructional Design* (2nd ed.). New York: Holt, Rinehart, and Winston.

Gagne, R.M., Wager, W.W., & Rojas, A. (1981). Planning and authoring computer-assisted instruction lessons. *Educational Technology, 21*, 17-26.

Goetzfried, L., & Hannafin, M.J. (in press). The effects of the locus of CAI control strategies on the learning of mathematics rules. *American Educational Research Journal.*

Hannafin, M.J. (1981). Effects of teacher and student goal setting and work evaluations on mathematics achievement and student attitudes. *Journal of Educational Research, 74*, 321-326.

Hannafin, M.J. (1982, May). *Student attitude and instructional locus of control.* Paper presented at the Annual Meeting of the Association for Educational Communication and Technology, Dallas, TX.

Hannafin, M.J., & Peck, K.L. (in press). *The design, development, and evaluation of computer-assisted instruction.* New York: John Wiley & Sons.

Heines, J. (1984). *Screen design strategies for computer-assisted instruction.* Bedford, MA: DIGITAL press.

Holloway, R.L. (1978). Task selection and locus of control in two ability groups' recall. *Contemporary Educational Psychology, 3*, 118-126.

Kulik, J.A. (1983). Synthesis of research on computer-based education. *Educational Leadership, 41*, 19-21.

Kulik, J.A., Bangert, R.L., & Williams, G.W. (1983). Effects of computer based teaching on secondary school students. *Journal of Educational Psychology, 75*, 19-26.

Kulik, J.A., Kulik, C.-L.C., & Cohen, P.A. (1980). Effectiveness of computer-based college teaching. *Review of Educational Research, 50*, 525-544.

Lawton, J., & Gerschner, V. (1982). A review of the literature on attitudes towards computers and computerized instruction. *Journal of Research and Development in Education, 16(1)*, 50-55.

Merrill, P.F., & Salisbury, D. (1984). Research on drill and practice strategies. *Journal of Computer-Based Instruction, 11*, 19-21.

Park, O., & Tennyson, R.D. (1983). Adaptive computer-based instructional models: A review. *Contemporary Education Review, 2*, 121-135.

Ross, S.M. (1984). Matching the lesson to the student: Alternative adaptive designs for individualized learning systems. *Journal of Computer-Based Instruction, 11*, 42-48.

Ross, S. M., & Rakow, E. A. (1980). Adaptive design strategies for the teacher-managed course. *Journal of Instructional Psychology, 7*, 13-19.

Ross, S. M., & Rakow, E. A. (1982). Adaptive instructional strategies for teaching rules in mathematics. *educational Communications and Technology Journal, 30*, 67-74.

Ross, S. M., & Rakow, E. A. (1981). Learner control versus program control as adaptive strategies for selection of instructional support on math rules. *Journal of Educational Psychology, 73*, 745-753.

Ross, S. M., Rakow, E. A., & Bush, A. J. (1980) Instructional adaptation for self-managed learning systems. *Journal of Educational Psychology, 72*, 312-320.

Rothen, W., & Tennyson, R. D. (1978) Instructional adaptation for self-managed learning systems. *Journal of Educational Psychology, 72*, 312-320.

Saracho, O. N. (1982) The effects of a computer-assisted instruction program on basic skills achievement and attitudes toward instruction of Spanish-speaking migrant children. *American Educational Research Journal, 19*, 201-219.

Snow, R. E. (1980). Aptitude, learner control, and adaptive instruction. *Educational Psychologist, 15*, 151-158.

Steinberg, E. R. (1977). Review of student control in computer-assisted instruction. *Journal of Computer-Based Instruction, 3*, 84-90.

Tennyson, R. D. (1981). Use of adaptive information for advisement in learning concepts and rules using computer-assisted instruction. *American Educational Research Journal, 18*, 425-438.

Tennyson, R. D., & Buttrey, T. (1980). Advisement and management strategies as design variables in computer-assisted instruction. *Educational Communications and Technology Journal, 28*, 169-176.

Tennyson, R. D., Christenson, D. L., & Park, O. (1984). The Minnesota Adaptive Instruction System: An intelligent CBI system. *Journal of Computer-Based Instruction, 11*, 2-13.

Tennyson, R. D., & Rothen, W. (1979). Management of computerbased instruction. *Journal of Computer-Based Instruction, 5*, 126-134.

Tobias, S. (1981). Adapting instruction to individual differences among students. *Educational Psychologist, 16*, 111-120.