Formative Evaluation of Instructional Materials: An Overview of Approaches

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Abstract: Formative evaluation during materials development has been shown to improve the effectiveness of instructional products. However, suggestions on how to conduct formative evaluation vary widely. This article describes and compares the most common approaches to formative evaluation. Most of these approaches include gathering feedback from students as critical to the success of materials development. A range of recommendations for how data can be effectively acquired is presented and one approach is described in detail.

Brian Mulroney benefitted from formative evaluation. His political slogan, "Together we can do better," was tried out with a group of supporters during his 1984 campaign for Prime Minister of Canada. The test group said,"We don't believe that Mulroney can do better than ... anyone else. We don't buy that ...But what we want to do is we want to believe that we can *be* better..." (Tierney,1984). The original slogan was changed to, "Together we can be better." Brian Mulroney won. Sneak previews are another example of formative evaluation. Representatives of the major television networks stand on 5th Avenue in New York and hand out free passes to sneak previews of new shows. Based on reactions of the test audience, the chararacters, music, title or the overall strategy of a new program may be changed before it ever goes on the air. Formative evaluation is a process used in politics, business, industry as well as in education to collect data about a product during its development so that the product can be improved before final production.

When Michael Scriven (1967) coined the term formative evaluation he was referring specifically to the evaluation of educational programs during their developmental phase; an evaluation for the purpose of improvement. This phrase so aptly expressed a concept that has been practiced intuitively for years (e.g., see Cambre, 1981) that it has been almost universally embraced by the educational community. A recent ERIC search for the period 1966-1985 using formative evaluation as a primary descriptor yielded over one thousand

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citations. Included were articles about formative evaluation of curriculae, of programs, of teachers and teaching, and of materials. This paper will focus on formative evaluation as it is applied to the development of instructional materials.

FORMATIVE EVALUATION ADVOCATED FOR MATERIALS DEVELOPMENT

When Andrews and Goodson (1980) reviewed 40 instructional design models they found 38 which recommended that instructional materials be tried out and revised before implementation. This iterative process of try-out and revision is often referred to as formative evaluation; its purpose is the improvement of instructional materials during their formative or developmental stage before their final production or release. It is argued that the product will be more effective in producing learning if materials are evaluated and modified during development and if the data for revision are gathered from students or representatives of the target population.

Stolovitch (1982) compared activities within 12 instructional development systems models and found that 11 of the 12 internationally employed models prescribe or imply the use of students to tryout materials as part of the development process. This commitment to the use of student feedback in materials development tends to be supported by research. In a study by Baker (1970) several instructional programs were prepared and each tried out with three different learner groups. Programs were revised using the formative evaluation data. These revised programs were more effective in producing student learning than original programs. Abedor (1971) tried out materials with small groups of students using general feedback, posttest scores, and information from an attitude survey and debriefing session as data for revision. Student scores improved after the materials were revised. In a study by Kandaswamy, Stolovitch and Thiagarajan (1976) materials were revised using feedback from group and one-to-one try-out sessions. Posttest scores for all revised versions were significantly higher than for the original versions. There was not a significant difference between materials revised using group and individual methods. Similarly, Wager (1983) compared small group and one-to-one methods of gathering data from students for use in revision. One set of revised materials was as effective as the other, but both were superior to the unrevised materials. In general, there does not seem to be an indication that any one method of gathering student feedback is superior to another, only that the materials that had undergone formative evaluation with students were superior to unrevised versions.

While some reseachers are trying to define the kind of students to use and the most effective methods of gathering data from them, others have suggested that it may not be at all necessary to include in formative evaluation the expensive process of collecting data from students. In an early study, Rosen (1968) found that any kind of formative evaluation improved the effectiveness of instructional materials. Two groups of instructional designers were asked to revise materials. One group was given data gathered from student try-outs; the other group, given no data, was told to use intuitive criteria for revision. Both sets of revised materials were more effective in producing student learning than were the unrevised materials. In a more recent study, Golas (1982) had writers revise materials in two ways: one group used student data and the other used only instructional editing guidelines which incorporated the attributes of effective instruction. No significant difference was found in instructional effectiveness of materials revised using the two methods. Montague, Ellis and Wulfeck (1983) also found that materials revised using editing guidelines produced significantly higher test results than did the original materials.

There doesn't seem to be any doubt that formative evaluation of instructional materials improves the effectiveness of the final product. There does seem to be doubt

about the best way to do formative evaluation. There is not a single set of heuristics, or guidelines. There is not a single algorithm. There are several approaches that share certain features in common but which differ along various dimensions. It is the intent of this paper to describe the most common variants of formative evaluation, defining components and examining the relationships among them.

COMMON VARIANTS OF FORMATIVE EVALUATION

Up to this point the term formative evaluation has been employed to refer in general to any try-out and revision of instructional materials. Upon reviewing the literature, one notices that other phrases often are used to refer to what seems to be a version of formative evaluation. Some common, related descriptors have evolved because they more accurately describe a particular approach to formative evaluation: expert review, developmental testing, the three-stage model, and learner verification and revision. All are involved with collecting data about a product that can be used to improve the product.

Formative Evaluation

The general approach to formative evaluation specifies the collection of empirical and non-empirical data during formative stages of product development (e.g., see Cambre, 1981). Students are not considered to be the only source of data for revision. Any review done for the purpose of improving the materials before production is formative evaluation. This would include a self-critique of one's own material, a review done by a colleague or try-outs done with students. The cycle of test-revise-test-revise theoretically ends when the materials consistently produce satisfactory results. Materials are then produced in final form and released for implementation.

Expert Review

The expert review approach to formative evaluation proposes that an expert or a series of experts review prototype materials during development and suggest improvements (e.g., see Montague et al., 1983). Student feedback is not obtained for use in revision. The materials are revised based on the expert review, are produced in final form and are released for use. There is a new interest in this variant because it is more cost effective than approaches which require that data be gathered from a number of learners.

Developmental Testing

Another approach to formative evaluation is developmental testing, which again advocates that draft materials be tried out and revised before a final version is produced (e.g., see Henderson & Nathenson, 1976). In contrast to expert review, developmental testing requires that learners be used as the primary source of feedback for revision. Horn (1964) indicates that in developmental testing the try-out of materials should be done only in one-to-one sessions with individual learners. Geis, Weston & Burt (1985) also include testing sessions with groups of learners as part of the developmental testing approach. In any case, after a series of try-out and revision sessions, the materials are produced in final form and released for use.

Three-Stage Model

Some authors (e.g., Dick & Carey, 1985) suggest that formative evaluation be done in three sequential stages of learner try-out and revision. First, the draft materials are tested with individual students and revised. Second, the revised draft materials are tried out with

small groups of learners, revised and produced in an almost final form. Third, the semifinal materials are tested in the "field" -- in a setting which is a close approximation of the actual situation for which they were designed. Revisions are made again, the materials are produced in final form and are implemented.

Learner Verification and Revision (LVR)

The learner verification and revision approach to formative evaluation (e.g., see Komoski & Woodward, 1985) is similar to developmental testing and the three-stage model in that it requires that learners individually or in groups be used as the primary source of feedback for revision. LVR is unique, however, among all other approaches to formative evaluation in its recommendation that the cycle of try-out and revision be continued for the life of the materials. It is recommended that publishers use LVR on a continuous basis to monitor the effectiveness of commercial material (EPIE Institute, 1975). Results of extended testing may suggest the need for revision and reproduction of the materials or utilization procedures. This may be an expensive proposition in the short-run but one which will extend the life of the materials.

DIFFERENCES AMONG VARIANTS

The differences among the various approaches to formative evaluation seem to be related to the recommended duration of the try-out/revision cycle, the primary source of data for revision and the developmental state of the materials being tested. A chronology of evaluation activities as suggested by Thiagarajan (cited in Kandaswamy, 1980) provides a useful construct for elaboration of the relationships among variants along the above mentioned dimensions. (Minor modifications that have been made in the original technology are noted parenthetically).

The six phases (stages) of evaluation that are proposed - self-evaluation, expert review (professional jurying), one-to-one (individual) testing, group testing, field testing and extended testing - "begin very early in the developmental history of the instructional materials and continue well into the diffusion and implementation stage" (Kandaswamy, 1980, p. 23).

In self-evaluation developers revise their own work. Although this may be a useful first step, the obvious subjectivity of this method makes it difficult to see gaps, inconsistencies and problems in one's own work. For this reason it is recommended that, in addition to self-critique, evaluation be sought from an external source.

At the expert review stage a subject matter expert, a curriculum expert, an instructional designer and/or a technical expert is asked to review the instructional materials (usually in draft form) in order to judge those factors which fall within their area of expertise, such as accuracy, completeness, instructional sequence and technical quality. While they should be uniquely qualified to evaluate these features, which may be invisible to a student, subject matter experts should not be expected to anticipate problems students might have with the materials. It seems desirable that evaluators be given guidelines to help with the review, as was done by Montague et al. (1983), since Rothkopf (1963) found a negative correlation between expert ranking of instructional materials and student achievement. For this reason their reviews should be considered jointly with student data.

In one-to-one testing an individual student works through draft or prototype materials with a developer. It is at this stage that major instructional problems are usually identified resulting in revisions such as a change in the instructional strategy or overall organization of the instruction. To minimize identifying problems that are idiosyncratic to a single

learner it is often suggested that at least three individual testing sessions be held.

In group testing a group of learners works through draft materials with a developer. Recommended size of groups varies, for example: Bell and Abedor (1977) recommend groups of 4-6 learners, Dick and Carey (1985) suggest 8-20 and Friesan (1973) suggests that 30 is appropriate for larger groups. Patterns of errors or problems in the instruction can be identified. As well, a greater amount of data can be gathered during the session.

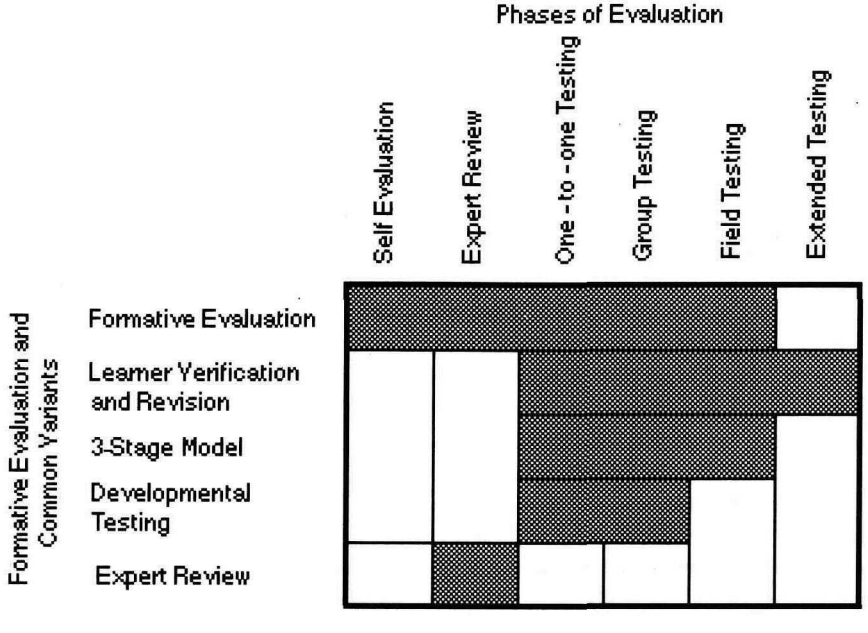
During field testing, materials which have been revised and are in semi-final form are tried out in a setting which models as closely as possible the actual use situation. Information is gathered primarily from students but also from instructors and anyone else who is directly involved in the instruction. It is often during field testing that utilization procedures are first tested and use problems are discovered. For example, it may become evident that while the procedure for doing a chemical experiment is clear, the location of the equipment has been overlooked as a critical prerequisite to performing the experiment. At this stage it can be determined how well the instructional package functions as a unit.

In extended testing, data are gathered primarily from learners but also from other potential information sources, such as teachers, in order to determine if produced materials that are currently in use continue to be effective. Extended testing can reveal deterioration of desired learning outcomes and can identify appropriate modifications. Kandaswamy (1980) suggests that is is also appropriate at this time to test the material with other than the target population to determine if perhaps it could be adapted for use with other groups of learners.

A comprehensive formative evaluation of instructional materials might include all six phases of evaluation in consecutive order; each successive phase beginning with materials that had been revised based on data gathered during the preceding evaluation phase. In fact, neither formative evaluation nor any of the variants presented here explicitly includes all six phases. As is shown in Figure 1, each approach includes a unique combination of evaluation phases; a combination which for each defines the recommended duration of the try-out/revision cycle, the primary source of data for revision and the developmental state of materials during testing.

FIGURE 1.

Stages of Evaluation Included in Formative Evaluation and Common Variants.



Since formative evaluation implies any kind of review and revision that is done before materials are produced in final form it can span the phases from self-evaluation through field testing. This of course means that the author of the materials, experts and learners are acceptable sources of data for revision. While formative evaluation can include the first five phases, no particular sequence for evaluation is implied. Any single phase, or any combination of phases in any sequence, could be used. It may be for this reason that more clearly defined variant approaches to formative evaluation evolved. Learner verification and revision includes only those phases of evaluation that use learners as the primary source of feedback. It is the only variant that includes extended testing for the life of the materials which also means it is the only approach that tests materials which have been released and are implemented. The three-stage model as well spans those phases that use learners as the primary data source. However, since this approach applies only to materials being developed, it terminates with field testing. Developmental testing, the narrowest learner based approach to formative evaluation, theoretically terminates before field testing. Expert review, which includes only one phase, has the shortest duration of formative evaluation activities and is the only variant which uses experts or editors as the sole source of data for revising materials.

OBTAINING FEEDBACK FROM STUDENTS

With the exception of expert review, approaches to formative evaluation indicate that feedback from learners should be obtained for use in improving instructional materials. There are a number of issues which must be considered when using learners as a source of data for revision. Geis, Burt and Weston (1984) searched the literature for guidelines to follow when testing out materials with learners. The guidelines found were variable and at times inconsistent, but could generally be grouped into a set of organizing categories. Four of these categories will be considered in this discussion: the type of learner to use in testing, the role of the learner during testing, the role of the developer during testing and the kind of data to collect.

Learners used to try out materials should at least be representative of the population for whom the materials are designed so that comments and reactions can be considered typical. Enthusiastic, highly verbal individuals who are not timid about expressing their opinion are often desirable as they are usually willing to proffer criticism. The aptitude of learners selected for the try-out sessions also might be considered. Wager (1983) found that high aptitude subjects were able to identify broader content inaccuracies while low aptitude subjects identified problems such as vocabulary. Scores on materials revised from mixed aptitude feedback were higher than scores on materials revised with feedback from just the high or low aptitude groups. This tends to suggest that a combination of high, medium and low aptitude students should be used for testing.

The role of the learner during testing can range from passive to very active. A passive learner would be asked simply to work through the materials and take tests. The use of the word "passive" should not be misunderstood. The instruction being tested may require student activity, such as doing a chemical experiment; however the student is passive in regards to giving intentional feedback. At the other end of the continuum a student in the critic's role would ask questions actively, make comments and suggest or actually make revision on the materials.

The role of the developer can also range from passive to active. The developer can act simply as an administrator, for example, hand out materials and generally manage the session. In the most active role, the developer as tutor would explain, rephrase or give

examples to clarify the material as well as suggest and make revisions.

Various kinds of data can be collected to be used as the basis for revising materials. Written or audio records should be kept of learner/developer interactions (verbal as well as non-verbal) so that the details of the try-out session will be available for reference during revision. Pretest and posttest scores can be collected as a measure of student learning. An attitude questionnaire can be used to gather information about the learner's affective response to the learning experience. Debriefing sessions can be used as a follow-up technique to probe learners about specific difficulties, gather additional commentaries, and summarize results of the sessions.

Table 1 (see next page) presents a summary of the range of recommendations for the type of learner, roles of the learner and the developer, and the kinds of data to collect when trying out instructional materials with learners.

One Approach to Student Based Formative Evaluation

What particular combination of roles and data collection should be used to obtain feedback from learners? Currently there are no rules to aid in this decision. Instructional materials developers present various combinations which apparently have been developed over time, based on experience. Our research team is investigating those procedures that are most commonly used by practitioners in an attempt to determine which combinations are most effective for obtaining from learners the data that are necessary for revision, but the research is not yet completed.

Figure 2 presents a combination of roles and data for student-based formative evaluation which the author has found to be effective.

FIGURE 2.
One Approach to Student-Based Formative Evaluation.

	Role of Learner				Role of Developer				Data Collection			
	Passive	Semi-passive	Active	Critic	Administrator	Passive	Active Intervener	Tutor	Test Scores	Attitude Survey	Debriefing	Records of learner/ developer interaction
Individual Testing	o	+	+++	+++	+	++	+++	+++	o	+	+	+++
Group Testing	o	++	+++	++	+	++	+++	++	+	++	++	+++
Field Testing	+++	++	+	+	+++	+++	+	o	+++	+++	+++	+

KEY: +++ Usually, ++ Occasionally, + Seldom, o Never

TABLE 1
Range of Recommendations for Obtaining Student Feedback

Type of Learner	Role of Learner	Role of Developer	Data Collection
- Representative - Enthusiastic, verbal -Not timid - High, medium and low aptitude	Passive - works through materials - takes test Semi-passive - responds to tester's questions - asks questions when necessary - comments occasionally Active - questions - comments - explains problem Critic - suggests revisions - makes notes and revisions on materials	Administrator - administers session Passive -observer - recorder Active intervener - responds to verbal and non-verbal cues - probes for difficulty - suggests revisions Tutor - revises - remediates -teaches	Written or audio records of: - learner questions comments suggestions - developer explanations suggested revisions teaching required Pretest Posttest Attitude Survey Debriefing

One-to-one testing is used to identify major problems in the instruction. The most active learner roles seem to be most effective for obtaining maximum feedback. Usually the learner is asked to question, comment or criticize any aspect or detail of the materials. The tests are reviewed for clarity, vocabulary and so forth, in the same way as are the learning materials. The active learner role requires that the developer also be active as an intervener and/or tutor. At this early stage, the documentation of the learner-developer interaction is critical. Comments, suggestions and revision are collected. Sometimes a written attitude survey and debriefing are used to search for additional data, however results may duplicate findings from the testing session.

Group testing is used in two ways: instead of one-to-one testing and in addition to one-to-one testing. When group sessions are used as an alternative to individual try-outs, the purpose is the identification of major instructional problems. Therefore, the more active learner and developer roles are again encouraged. Due to the group setting, however, in depth tutoring and criticism can become difficult. An advantage of group testing is that a great deal of information can be collected at one time. A disadvantage is that group discussions can tend to persevere with particular details of the materials to the exclusion of other equally important problems. Data collection becomes more complicated as the number of learners increases. In order to preserve the maximum information about the learner-developer interaction a tape recorder is invaluable. In addition, notes and revisions are made directly on the materials. A debriefing session is often used to summarize group comments and revision suggestions. An attitude survey is also useful for summarizing group reactions.

When group testing is used as a follow-up to one-to-one testing, the structure of the session changes. The group works with materials that have been revised based on individual testing and therefore the focus is often on seeing if the materials function more smoothly. For this reason, a semi-passive learner role is used at the outset of the session. The learners are told that their comments and reactions are important in order to improve the materials but are not necesssarily encouraged to criticize. The developer then starts the session in a passive role, observing learner response. If problems arise, as they often do, then the developer actively intervenes or tutors as the learner becomes a more active commentator. The group interaction is again recorded. Debriefing and attitude surveys are used to gather additional data. If the session goes well, (i.e., few problems arise) the learners are asked to complete the tests to determine if the desired learning has occurred.

Field testing is used to determine how the materials function in actual use. In order to obtain an accurate picture, the learners are usually asked to take the actual learner role, working through the materials and tests as designed. The developer may administer the session or unobtrusively observe and record. Occasionally, when problems arise, the developer actively questions or probes students thus moving them into a more active role. Since the learner-developer interaction tends to be minimal in field testing, there is less emphasis on documenting this aspect. Debriefing students after the session is critical. An attitude survey is almost always used to collect information about reactions. Pretest and posttest scores are collected as a measure of the effectiveness of the materials.

SELECTING AN APPROACH

The question should not be whether to include formative evaluation as a part of materials development (it clearly does make a difference!) but rather how to include it. Selection is often based upon practical constraints. Available resources (e.g., time, money, personnel, facilities) can affect the decision. One-to-one testing, for example, takes a great

deal of time, usually a minimum of one hour per session of tester and student time. Individual testing costs more than expert review; for example, the former requires multiple copies of materials, the latter only one copy. For a series of three individual sessions, three students (minimum), one developer (minimum), and one observer (optional) will be necessary; only one expert (minimum) is necessary for expert review. Preference of the developers also affects the selection. Some developers are comfortable in a highly interactive individual session where the student acts as critic. Others prefer a more subdued, controlled situation with the student in a semi-passive role and the tester primarily in a passive role as an observer and recorder.

The selection should be based first upon the type of data that is being sought. One-to-one testing yields in-depth information about students' interactions with materials being developed. Expert review guidelines can incorporate the attributes of effective instruction in materials but will never reveal a student's response to the materials. Field testing shows the effectiveness of materials when placed in the actual use situation. Consider the type of information being sought and select the combination of formative evaluation strategies that will best deliver those data.

REVISING

After data have been collected the developer is faced with the dilemma of revision. Prescriptions are few. Usually one is simply told to revise appropriately. This apparently is better than nothing since even materials that are revised intuitively are more effective than unrevised materials (Rosen, 1968). Sometimes revisions seem obvious, such as the addition of an example to help clarify a concept. Sometimes the appropriate revision is not so obvious. The following list provided by Debert (1979, p. 20) is one of the most comprehensive summaries of types of revisions that are made in instructional materials after formative evaluation:

Addition:

- Add instruction on prerequisite skills and knowledge.
- Add training on the use of the material or the method.
- Add training for teachers or trainers who will use the materials.
- Add a preview (advanced organizer).
- Add illustrations.
- Add performance aids.
- Add examples.
- Add activities.
- Add feedback.
- Add transfer exercises.
- Add test items.
- Add motivation.
- Add variety.

Simplification:

- Reduce the level of complexity.
- Simplify the language.
- Use smaller units.
- Combine materials into larger units.
- Rearrange the sequence.

- Remove irrelevant information.
- Remove irrelevant activities.

Others:

- Make examples more relevant.
- Change the instructional medium.
- Change the instructional design format.
- Change the target population.
- Abort the project.
- Make no changes.

This can be a valuable checklist to keep at hand when selecting revisionary tactics.

APPLYING FORMATIVE EVALUATION TO ANY MEDIUM

Formative evaluation specifies that materials must be tried out while in a draft or prototype form. Most probably this is because the developer's willingness to revise seems to decrease as the time and energy that has been invested in a product increases. As well, learners seem to be more willing to criticize rough materials that clearly require work. Due to this draft form requirement, it is often thought that only print based materials lend themselves to formative evaluation. Certainly it is easy to conceive of presenting learners with, for example, a handwritten version of text with rough sketches or even a clean typewritten copy prepared on a word processor. In fact, the formative evaluation process should be applied to materials being developed in any format (e.g., CAI, slide-tape or videotape) although it may be more difficult to conceive of a first draft form of these materials. The following anecdotal accounts may serve to exemplify the possibilities.

A branching CAI program was developmentally tested in draft form. The developer placed each frame of the program (text and/or sketches of graphics) on a separate note card. The learner was then presented with the frames, one by one. Based on the learners oral response to critical embedded questions, the developer supplied a set of cards which provided the appropriate branch of the program. Changes that were to occur within frames, such as additions to graphics, were provided by the developer in both oral and written form. Major problems were identified and corrected before the developer became attached to a package that had already been programmed.

Slide-tape and videotape programs have been successfully tried-out while in storyboard form. Instead of viewing the programs, at this early stage the learners "read" through the images and narration. Each planned visual was sketched or described in words. The accompanying audio was written next to each sketch, and when necessary an audiotape presented examples of music and sound effects. In one case, a rough draft videotape was produced based on the results of the storyboard try-out. The developer used only portapak equipment.

Developers often feel that it will be impossible for learners to make any sense out of the instruction when it is presented in a form that is so different and distant from the final product. In fact, properly prepared learners never cease to amaze us with their astute ability to overcome the form and concentrate on the content. Regardless of how first draft materials are presented, it is important that they be in a form not only that one feels willing to revise, but in a form that is so rough that revision is mandatory.

SUMMARY

Formative evaluation of instructional materials can be done using various approaches. Though the purpose is always the improvement of materials before they are produced in final form, the guidelines for try-out and revision are sometimes vague and sometimes inconsistent. However, this is not an excuse for excluding formative evaluation from the materials development process. Even the busiest instructional developers can find the time to review and revise their own work, or have someone else review and revise it. If more time is available, students should be asked to try out the materials to provide data for revision. The evidence is consistent; any kind of formative evaluation, any kind of preliminary review improves the instructional materials and improves student learning.

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