Examination of Cognitive Style FD/FI as a Learner Selection Criterion in Formative Evaluation

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Abstract: The selection of students to provide feedback for reviewing and revising instructional materials, during the developmental stages is critical. However, there is little empirical evidence regarding the most appropriate students' selection criteria for the process. This paper describes the experimental phase of a study designed to examine the effects of using the cognitive style construct field-dependent/field-independent (FD/FI) as a student selection criterion for evaluating prototypical materials. A prototype version of a computer assisted instruction was evaluated and revised on the basis of feedback generated by field-dependent/independent students. Results for achievement indicated significant main effects for treatment and cognitive style. The revised version of the instructional material was more effective than Its prototype. Mean achievement scores of FD and FI students exposed to the prototype were significantly different. However, the evidence observed did not support a differential effect of the revised instructional material for FD and FI students. No significant main effects of treatment and cognitive style were found for study time and attitude.

INTRODUCTION

In spite of considerable progress made in the field of instructional development, through the adoption of systematic instructional design process, practitioners still have difficulty in producing efficient and effective first draft products (Dick & Carey, 1985; Gagne & Briggs, 1979). Conscious of this inherent difficulty, and recognizing that the design process is not foolproof instructional developers have included a formative evaluation component in their models (Baggaley, 1986; Geis, Weston, & Burt, 1984; Weston, 1986). The purpose of formative evaluation is to provide instructional developers with an opportunity to identify errors and problems within a set of instructional materials while they are still in a developmental stage (Baker & Alkin, 1984; Dick & Carey, 1985; Gagne & Briggs, 1979; Geis, 1987; Sanders & Cunningham, 1973). Nathenson and Henderson (1980) note that the formative evaluation of instructional products is an essential activity in the design and development of instruction, due to a lack of a comprehensive theory of learning

CJEC, VOL. 19, NO. 1, PAGES 19 - 39, ISSN 0710 4340

to guide practice. Two broad questions are addressed by formative evaluation. The first relates to content and technical quality of the material, and the second pertains to how easily it can belearned. The evaluation ofcontent and technical quality is addressed through expert verification and revision, whereas it is generally believed that students are most qualified for providingfeedback data to assess ease of learning.

Dick and Carey (1985) suggest a three stage sequential approach for evaluating instructional materials using students' feedback data:

1) one-to-one;
2) small groups; and
3) field testing.

The one-to-one evaluation occurs in the earliest phase of product development. The purpose is to try out draft materials with individual students in order to identify and revise most obvious errors and problems. The small group evaluation is performed with small groups of students when the materials are almost in the final form. The intent is to: (a) validate modifications made to the materials during the one-to-one evaluation, and (b) identify and correct any additional errors and problems in the materials. When the materials are in semi-final form they are field tested to verify the effectiveness of previous verifications and revisions performed during earlier phases of evaluation. Field testing is conducted in a setting which approximates the actual context for which the materials were designed (Weston, 1987). The process helps to ascertain if the materials will function smoothly, and whether they will be accepted by students, teachers, and administrators.

Although the importance of formative evaluation is well documented in the literature, the state-of-the-art is still an underdeveloped and under-conceptualized field of inquiry. There is a paucity of research in formative evaluation, and many aspects of the process still need the illumination of sound research efforts (Baker & Alkin, 1984; Cambre, 1981; Geis, 1987). One aspect of formative evaluation which has received little research attention is the student selection criteria for participation in the process (Dick, 1980; Wager, 1980). Dick (1980) argues that the characteristics and profiles of students participating in earlier stages of formative evaluation are critical for improving instructional products. Only two studies have investigated the student selection criteria for the one-to-one formative evaluation. Berthelot (1978) studied the student's level of verbalization, and Wager (1980) examined the student's ability level as selection criteria.

The cognitive style construct field-dependent/field-independent (FD/FI) constitutes an important dimension of individual differences among students, regarding their preferences for various modes of gaining, storing, processing and using information (Messick, 1985). This construct should be an important student selection criterion, with promising potential for the one-to-one formative evaluation process. However, it has so far been overlooked by researchers

and practitioners in the field of instructional design and development (Ausburn & Ausburn, 1978). The purpose of this study was to determine the effectiveness of the cognitive style construct FD/FI as a student selection criterion for the one-to-one formative evaluation. More specifically, this study attempted to answer the following questions:

1) Is an instructional material revised on the basis offeedback generated by FD and FI students in the one-to-one formative evaluation process more effective than its original prototype? and
2) Is an instructional material revised on the basis offeedback generated by FD and FI students in the one-to-one formative evaluation process, effective for both FD and FI students?

CONCEPTUAL FRAMEWORK

The conceptualization of the theoretical framework for this study emerged from the review of literature and research on the cognitive style construct field-dependent/independent, instructional material effectiveness, and paradigms of inquiry The most significant literature and research in these three areas are briefly reviewed in this section.

Cognitive Style FDIFI

A considerable body ofknowledge that has been accumulated on cognitive style (Witkin & Goodenough, 1981), and various cognitive styles have been identified. One of the cognitive style dimensions which has been most extensively researched is the field-dependent/independent construct. FD/FI refers to the psychological differentiation which describes the source of experiences that is used when a person enters a new situation (Witkin, Moore, Goodenough, & Cox, 1977). It represents "a global versus an analytical way of perceiving. It entails the ability to perceive items without being influenced by background" (Kirby, 1979, p. 52). Research has shown the FD and FI students differ in important ways with respect to personality factors, perceptual patterns, and social interaction (Ausburn & Ausburn, 1978).

Field-dependent individuals are drawn to people and like to have people around them. They exhibit more non-verbal behaviors; prefer occupations which require involvement with others (e.g., social sciences); and demonstrate a preference for academic areas that are people oriented (e.g., teaching, selling). In contrast, relatively field-independent persons demonstrate a preference for impersonal and abstract school subjects (e.g., mathematics and physical sciences); they are more impersonal and prefer occupations in which interaction with others is less important (e.g., astronomy, engineering, mathematics, sciences and architectural domains) (Witkin & Moore, 1974). Relatively field-dependent persons have a global perception and take a long time to solve problems (Witkin & Moore, 1974). They use "external referents for self-

definition, make less use of mediators in the coding process of knowledge acquisition and prefer a spectator approach to concept attainment" (Caliste, 1985, p. 26).

Furthermore, individuals who are very field-dependent are extremely alert to social cues, have highly developed interpersonal skills, and like to study in groups. In addition, they are extremely sensitive to social criticism and are extremely influenced by others around them (Witkin & Goodenough, 1981; Witkin & Moore, 1974). In contrast the relatively field-independent persons are more abstract-analytical, tend to solve problems rapidly and learn better when content is abstract (Witkin & Moore, 1974). They use "internal referents for self-definition, make frequent use of mediators and engage in a hypothesis-testing approach to concept attainment" (Caliste, 1985, p. 26). The field-independent individuals tend to be "aloof, theoretical and not sensitive to others around them. They will restructure any random or non-hierarchically presented information for better retention and retrieval" (Wallace & Gregory, 1985, p. 22).

Earlier studies (Witkin, Lewis, Hertzman, Machover, Meissner, & Wapner, 1954) indicated that the cognitive style FD/FI was related to gender. Males appeared to be more field-independent than females. However, evidence from more recent studies indicates that gender differences in field-dependence is inconclusive (Naditch, 1976).

The cognitive style FD/FI appears to have important implications for formative evaluation. Ausburn and Ausburn (1978) state: "cognitive style is important as a learner characteristic relevant to instructional design because it influences the ability to process information or learning" (p. 344). Ragan & others, (1979) argue that since cognitive style determines the way information is acquired and processed, "an individual may encounter tasks thatrequire the processing of information in a way that they are unable to accomplish, simply because their cognitive style restricts the availability of the processing technique" (p. 2). This argument suggests that instructional materials can be cognitive style based.

The cognitive style FD/FI has some other particular characteristics which makes it an important variable as a student selection criterion:

1) it is stable over time and across tasks;
2) it is value neutral and bipolar; and
3) it correlates with students' performance in various school subjects. In addition, valid and reliable instruments which can be easily administered and scored are available for assessing the construct (Witkin & Goodenough, 1981).

Instructional Material Effectiveness

Instructional material effectiveness can be viewed within a framework encapsulating three major elements: 1) achievement; 2) study time; and 3) student attitude toward the material. Previous studies have shown that

formative evaluation can significantly improve achievement (Abedor, 1972; Baker, 1970: Gropper, 1967; Kandaswamy, 1976; Rosen, 1968; Silberman, Coulson, Melargno, & Newmark, 1964; VanderMeer, Morrison & Smith, 1965; Wager, 1980), and improve performance, while keeping study time constant (VanderMeer, 1964;VanderMeer &Montgomery, 1964; VanderMeer & Thorne, 1964; Sulzen, 1972). Abedor (1972) and Silberman et al., (1964), found that formative evaluation can also lead to improved achievement with a decrease in study time. Studies conducted by Abedor (1972), Stolovitch (1975), and Wager (1980) indicate that students tend to have a more positive attitude toward revised instructional materials as compared to prototype versions. Romiszowski (1986) however, argued that the novelty effect can confound measures of students' attitudes in formative evaluation.Additionally, Nathenson and Henderson (1980) indicate that it is difficult to quantitatively assess students' attitude toward an instructional product.

Paradigms of Inquiry

The methodological difficulties commonly encountered in conducting research in formative evaluation can in part be attributed to the basic axiomatic assumptions of the rationalistic paradigm of inquiry (Berthelot, 1978; Dick, 1977; Geis et al., 1984). Shrock (1984) argues that the rationalistic paradigm of inquiry is constraining, and that instructional developers should consider alternate paradigms which are more facilitating. She strongly advocates a shift to the naturalistic paradigm of inquiry. The interest for the naturalistic inquiry has emerged because the rationalistic approach has apparently failed to provide enlightenedinformation and explanations related to highly complex problems, involving human interactions and values (Lincoln & Guba, 1985).

The rationalist assumption regarding the relationship between knower and known is problematic and constraining in formative evaluation research. One inherent problem associated with this assumption is the reviser's effect. Critics of formative evaluation research argue that in the majority of these studies it is impossible to partial out how much of the revisions which contributed to the effectiveness of the materials were guided by students' feedback data, and how much by the evaluators'intuitions, finesse, perspective and insights (Baker, 1970; Baker & Atkin, 1984; Nathenson & Henderson, 1980). Additionally, the observation that different revisers can produce differentially effective revisions (Kandaswamy, Stolovitch & Thiagarajan, 1976), is also problematic under the rationalistic paradigm.

One-to-one formative evaluation is a highly interactive process between the evaluator, test subjects and instructional The rationalist assumption regarding the relationship of knower to known is not amiable to formative evaluation research. On the other hand, the naturalist claim for subject-object interrelatedness provides a better fit to process. Lincoln and Guba (1985) argue that: "the inquirer and the 'object' of inquiry interact to influence one another, knower and known are inseparable" (p. 37). The

inquirer cannot be removed from the phenomena, objects or subjects being studied. Guba (1979) argues:

> . ..it is fruitless to act as though that interactivity were not there; a more intelligent approach requires understanding the possible influences of such interactivity and taking it into account. (p. 270)

Guba further indicates that the naturalistic inquirer can capitalize on the richness of interactivity to acquire a better understanding of the phenomena being studied.

Lincoln and Guba (1985) have also identified a set of strategies to guide naturalistic inquirers in establishing the trustworthiness of the inquiry process. These strategies are: member check, peer debriefing, triangulation, referential adequacy and audit checks.

METHODS

Instructional Material

The instructional material used in this study was a prototype version of a computer-assisted instruction (CAI), entitled Superelevation. This material was designed to teach the application of the principles of superelevation in road design, to third-year university students enrolled in a Landscape Architecture course.

This CAI package was designed as a self contained tutorial, consisting of 1) a set of objectives; 2) the linear presentation of subject matter content, and 3) a quiz on the content. All major concepts presented were supported by colour graphics and animations.

Several factors influenced the selection of Superelevation as an instructional treatment for this study. First, this material dealt with several abstract concepts. Research has shown FI students tend to outperform FD students in learning abstract concepts (Witkin et al., 1977). Secondly, the delivery medium was the computer assisted instruction. Research indicates that CAI appears to be more effective for FI students (Post, 1984). Thirdly, Superelevation is self-contained, therefore many extraneous variables were eliminated or controlled. Additionally, this material was reviewed and judged appropriate for this study by four expert judges.

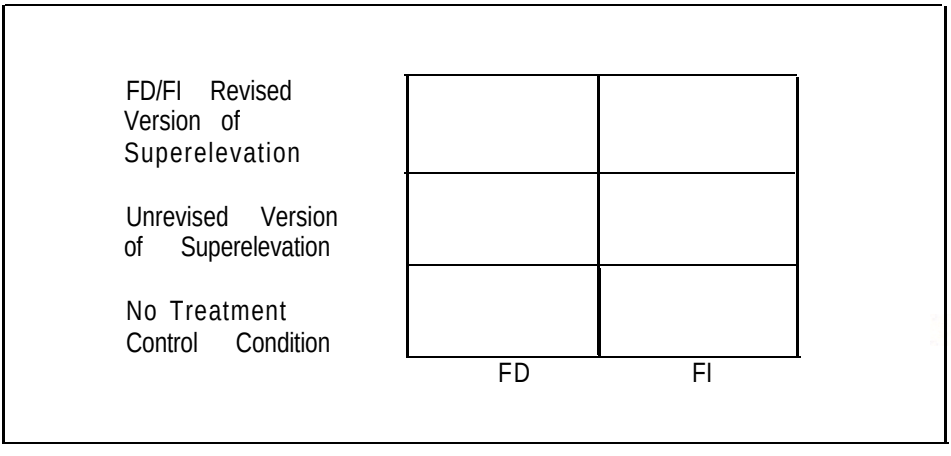
Research Design

A two-stage approach was used to test the hypotheses formulated for this study. During the first stage the prototype version of Superelevation was evaluated and revised on the basis of feedback generated by FD and FI subjects, using the naturalistic inquiry paradigm (Lincoln & Guba, 1985). During stage two, the revised version of Superelevation was validated to determine any gain in effectiveness over the original prototype.

A paradigm mix (naturalistic and rationalistic) was found to provide a good fit for this formative evaluation study. Because of the highly interactive nature (subject/evaluator) of one-to-one evaluation, the rationalistic paradigm of inquiry was found to be too constraining (Berthelot, 1978; Geis et al., 1984), and the naturalistic inquiry emerged as a paradigm of choice, which was more facilitating. However, the rationalistic paradigm appeared to be more amenable to the experimental phase of the study, which was designed to evaluate the overall effectiveness of the revised product.

The second research stage was conducted as an experiment. A two factor treatment by block design with an outside no-treatment control group (Keppel, 1982) was used. This design is depicted in Figure 1. The treatment factor had three levels: 1) revised version of Superelevation; 2) unrevised version of Superelevation; and 3) no treatment control condition. The second factor had two levels representing the subjects cognitive style dimension: 1) field-dependent and 2) field-independent. The factors were fixed and completely crossed.

Figure 1.
Treatment x Block Design.



The dependent variables for this study were: 1) student achievement as evidenced by the group mean achievement scores on an objective type posttest; 2) study time operationalized as the mean time that each group spent interacting with the instructional treatment; and 3) student attitude toward the instructional material was measured as the mean scores on a Likert-type attitude questionnaire (1 - Strongly Disagree; 2 - Disagree; 3 -Agree; and 4 - Strongly Agree). The reliability of the posttest and attitude questionnaire was .78 (Spearman Brown) and .91 (Cronbach Alpha) respectively.

Research Hypotheses

One research hypothesis was formulated for each of the three indicators of instructional material effectiveness identified in the literature: a) achievement; b) study time; and (c) attitude. It was hypothesized that there will be significant differences between FD and FI students interacting with the prototype and a revised version of Superelevation (modified on the basis of feedback generated by FI and FD subjects) in: a) achievement; b) study time; and c) attitude toward the materials. These three hypotheses were tested at the .05 level of confidence.

Subjects

Subjects for this study represented of the entire population of third-year university students (N = 46) enrolled in a Landscape Architecture course, during the Fall session, 1986. This population was treated as a sample in time of a broader population for which Superelevation was specifically designed. The Hidden Figures Test (HFT) (Ekstrom, French, Harman & Derman, 1976) was administered to the population to determine their cognitive style dimension. Subjects were classified as FD and FI using a median split technique.

A purposive sample consisting of 2 males and 2 females (one FD and one FI each) was selected from the population for the one-to-one formative evaluation stage. Subjects were selected on the basis of their extreme HFT scores. The remaining subjects were assigned to six equal groups (3 FD and 3 FI), using a randomized blocking procedure.

PROCEDURE

Evaluation and Revision

Formative evaluation data on Superelevation were gathered while each of the four subjects individually interacted with the material during the one-to-one tryouts. Subjects were requested to read aloud and to verbalize their thought process as they interacted with the content. This think aloud procedure was used to provide insights into the information processing demands that the material imposed upon the subjects.

Subjects were encouraged to ask questions whenever they had any difficulty. Furthermore when the researcher sensed that a subject was having difficulty which was not verbalized, he probed for additional feedback.

During the one-to-one evaluation sessions, data were also gathered through informal observation of non-verbal behaviours exhibited by the subjects while interacting with Superelevation. Additionally, all subjects were debriefed at the end of the evaluation sessions.

The researcher recorded all feedback provided by subjects. The feedback were interpreted and taken back to the subjects for confirmation and refinement. When errors and problems requiring minor revisions were identified, the researcher immediately made the necessary modifications on hard copy of

the corresponding screens. The revised segment was presented again to the subjects in order to confirm the correct interpretation of their feedback data, and to validate the revision decisions.

Each evaluation session was audio taped. These tapes provided vivid episodes of the evaluation. All tapes were also transcribed for content analysis.

Following each evaluation session the researcher wrote field notes and was debriefed by a peer, who in this instance was also the designer of Superelevation. Data collected were analyzed and translated into revision decisions for modifying Superelevation. The subjects' feedback data along with proposed revisions were taken to the peer for confirmation and validation. Appropriate modifications were made when any discrepancy was observed. The major themes evolving the analysis of feedback data as well as the corresponding revision decisions are outlined in Table 1.

The prototype material was revised by the designer. The revised version of the material, the student feedback data and the corresponding revision decisions were taken to an audit for a final confirmation and validation. A graduate student knowledgeable in the field of instructional design and with training in qualitative research methods was used as audit.

Experimental Phase

The three experimental conditions (revised/unrevised versions of Superelevation and no treatment control) were randomly assigned to each of the three groups of FD and FI subjects. The treatment was administered to all subjects under the instructional treatment conditions. Immediately following, the posttest and attitude questionnaire were administered to each subject. Study time data (time spent interacting with Superelevation) for each subject were recorded. No constraints were placed on study time since it was a dependent variable.Aone hour time limit was allowed for the completion of the posttest which was also administered to subjects in the two control groups. All data gathering instruments were collected and hand scored by the researcher.

RESULTS

Cognitive Style

Subjects' scores on the HFT ranged from .75 to 31, the maximum possible score being 32. No significant difference in performance on the HFT was found between males (M = 17.60) and females (M = 15.60) t (44) = .5456, p. < .05.

Achievement

The means and standard deviations for achievement are presented in Table 2. The analysis for achievement revealed no significant treatment by cognitive style interaction, (F (2,36) = .77, $p > .05$, Table 3). However, main effects for both treatment (F (2,36) = 52.31, $p < .001$) and cognitive style (F (1,36) = 5.20, $p <$ were significant.

TABLE 1
Central Themes Evolving From Feedback Data and Corresponding Revision Decisions

Source of Feedback FD	FI	Themes Generated From Feedback	Revision Decisions
	X	Spelling errors.	Correct spelling.
x	x	Difficulty in relating explanations in text to graphics.	Label graphics.
	X	Frustration when graphics are not related to text.	Delete or replace graphics.
x	x	Graphics do not communicate.	Modify graphics.
	X	Use arrows, colours and moving objects.	Use attention getting strategies, colours and animation to enhance comprehension.
		Clarity problems.	Modify to improve clarity of instruction.
		Provide summary of main points.	Summarize main ideas at the end of each unit of instruction.
		Provide practice problems and model answers.	Built in practice and feedback at the end of each block of instruction.
		Use of unfamiliar terms.	Define unfamiliar terms.

TABLE 1 (cont'd.)
Central Themes Evolving From Feedback Data and Corresponding Revision Decisions

Source of Feedback		Themes Generated From Feedback	Revision Decisions
FD	FI		
X	X	Inaccurate assessment of entry behaviours.	Reassess prerequisite skills, provide additional instructions to compensate for deficiencies in entry behaviours.
X	X	Misconception and inaccurate interpretation of instruction.	Modify instruction to remove ambiguities and improve clarity.
X		Difficulty in processing information.	Modify instruction to reduce information processing demands and facilitate processing of the same.
X	X	Difficulty in relating previously learned concepts to new ones presented.	Provide review of previously learned concepts and transition to facilitate linkages with new concepts.
X	X	Provide meaningful examples.	Provide examples that can be associated with previous experiences.
	X	Contradictory instruction.	Modify to remove contradiction and keep consistent.

TABLE 2
Means and Standard Deviations of Posttest Scores by Treatment Group and Cognitive Style

Treatment Groups(a)	Mean(b)	Standard Deviation
FD Control	7.00	2.76
FI Control	8.00	5.94
FD Unrevised	16.28	6.94
FI Unrevised	22.00	5.32
FD Revised	25.00	4.93
FI Revised	29.00	3.26
TOTAL	17.88	9.62

aNote: n = 7 for each group.
bNote: maximum score 38.

TABLE 3
Analysis of Variance of Posttest Scores

Source	df	ss	MS	F	Eta Square
Treatment	2	2695.19	1347.59	52.31**	0.70
FD/FI	1	133.93	133.93	5.20*	
Treatment/ FD/FI	2	39.86	19.93	0.77	
Error	36	927.43	25.76		
TOTAL	41	3796.40			

*$p < .05$, **$p < .001$.

Follow-up analysis (Tukey studentized range, Honest Significance Difference, Table 4) of the main effects for treatment revealed that the mean posttest scores of subjects interacting with the revised, and the unrevised versions of the material were significantly higher than that of subjects under the no treatment control condition, ($p. < .05$). The learning gains could therefore be attributed to the instructional treatments. Results also indicated that subjects exposed to the revised version of the material scored significantly higher on the posttest than those exposed to the prototype,($p. <$ The null hypothesis for achievement was therefore rejected.

TABLE 4
Tukey Studentized Range (HSD) Hypothesis-wise Test on Poshest Scores by Treatment Conditions

Treatment Group(a)	Mean
Control	7.50*
Unrevised	19.14*
Revised	27.00*

*minimum significant difference = 4.6891, p < .05.
aNOTE: n=14 14 for each group.

Additional follow-up comparisons (Least Significance Difference, Table 5) of the cell means for the two instructional treatment conditions (revised and unrevised version) revealed the FI subjects scored significantly higher than the FD subjects, on the unrevised version ($p < .05$). However, no significant difference in achievement was found between FD and FI subjects exposed to the revised version of the material. The evidence observed did not support a differential effect of the revised instructional material for FD and FI subjects.

TABLE 5
LSD* Pairwise Comparison of Mean Posttest Scores by Treatment Group and Cognitive Style

Group	Mean	Group	Mean
FD Unrevised	16.28	FD Revised	25.00*
Fl Unrevised	*22.00*	Fl Revised	29.00*
FD Unrevised	16.28	Fl Unrevised	22.00*
FD Unrevised	16.28	FI Revised	29.00*
Fl Unrevised	*22.00*	FD Revised	*25.00*
FD Revised	*25.00*	FI Revised	29.00

*LSD = 5.5023, $p < .05$.

Study Time

Table 6 (see next page) shows the means and standard deviations for study time. The analysis of data for study time revealed no significant treatment by cognitive style interaction F (1,24)= 0.08 (Table 7, see next page). In addition, no significant main effects for treatment (F (1,24) = 0.00), and cognitive style (F (1,24)= were found. The mean study time for subjects exposed to the revised and unrevised versions of the material was not significantly different. Therefore, the null hypothesis for study time was retained.

TABLE 6
Means and Standard Deviations of Study Time by Treatment Group and Cognitive Style*

Treatment Group (a)	Mean	Standard Deviation
FD Unrevised	78.57	19.73
FI Unrevised	77.14	17.04
FD Revised	80.00	11.18
FI Revised	82.14	17.04
TOTAL	79.46	15.71

*All time data in minutes.
aNOTE: n = 7 for each group.

TABLE 7
Analysis of Variance of Study Time

Source	df	ss	MS	F
Treatment	1	0.89	0.89	0.00
FD/FI	1	72.32	72.32	0.26
Treatment x FD/FI	1	22.32	22.32	0.08
Error	24	6571.43	273.81	
TOTAL	27	6666.96	369.35	

Attitude

There were little variations in the mean attitude scores between FD and FI students exposed to the revised and unrevised version of Superelevation (Table 8). Data analysis for the attitudevariable disclosed no significant treatment by cognitive style interaction, (F (1,24) = 0.05), (Table 9). Main effects for treatment (3' (1,24) = 0.16) and cognitive style (F (1,24) = 0.49) were not significant. The mean attitude scores of subjects interacting with the revised and unrevised versions of the material were not significantly different. Therefore, the null hypothesis for the attitude variable was retained.

Students' Feedback Data

The analysis of FD and FI feedback data generated during the one-to-one evaluation sessions revealed some interesting findings. These subjects were able to identify major gaps (practice and feedback) in the events of instruction.

TABLE 8
Means and Standard Deviations of Attitude Scores by Treatment Group and Cognitive Style*

Treatment Group (a)	Mean	Standard Deviation
FD Unrevised	3.14	**0.43**
FI Unrevised	3.17	**0.26**
FD Revised	2.98	**0.66**
FI Revised	3.09	**0.33**
TOTAL	3.09	**0.43**

(a)NOTE: **n = 7 for each group.**

TABLE 9
Analysis of Variance of Attitude Scores

Source	df	SS	MS	F
Treatment	1	**0.03**	**0.03**	**0.16**
FD/FI	1	0.09	0.09	0.49
Treatment x FD/FI	1	0.01	0.01	**0.05**
Error	**24**	**4.81**	**0.20**	
TOTAL	**27**	**4.95**	**0.34**	

Their feedback also revealed inaccurate assessment of prerequisite skills, information processing difficulties, and the need for attention getting strategies. The think aloud process used during the one-to-one evaluation helped to identify misconceptions formed in the processing of information presented.

DISCUSSION

Results indicated that a revised version of the instructional material was more effective than its prototype. This observation supports earlier findings regarding the effectiveness of formative evaluation (for a thorough review, see Nathenson & Henderson, 1980). In this study, FI subjects exposed to the prototype of the CAI obtained a significantly higher mean posttest score than did the FD subjects exposed to the same material. This result is in agreement with findings of other studies (Post, 1984; Smith, 1985), which suggest that the FI subjects benefit more from CAI. However, in this study, no significant differences in achievement were found between FD and FI subjects exposed to

the revised version of the CAI program. It is likely that the revisions made to the material on the basis of FD and FI feedback helped to minimize differential learning gains.

Previous studies attempting to provide for individual differences in learning due to cognitive style have focused on matching instruction to students' cognitive styles (e.g., Greco & McClung, 1979; Elliot, 1976; Grieve & Davis, 1971). Results of this exploratory study suggest that a cognitive style (FD/FI) focused formative evaluation can significantly improve the effectiveness of an instructional material. The effects of revising instructional materials on the basis of feedback generated by FD and FI are likely to minimize differential learning gains due to cognitive style. It appears that a unique instructional material can be produced, that is likely to be effective in terms of achievement (at least not detrimental) for both FD and FI students. However, this finding must be interpreted with caution, until more conclusive evidence is obtained from additional research conducted with larger samples.

No significant difference in study time was found between subjects exposed to the revised and unrevised versions of the material. This result is consistent with findings from earlier research (VanderMeer, 1964; VanderMeer & Montgomery, 1964; VanderMeer & Thorne, 1964, and Sulzen, 1972) indicating that formative evaluation could successfully improve performance on posttest, while keeping study time constant. It is noteworthy in the present study that while study time for the revised and unrevised version of the material was not significantly different, the amount of material was substantially increased in the revised version. The revisions made to the instructional material have most likely facilitated the information processing, thus enabling the subjects to cover more material in approximately the same amount of time.

Analysis of the attitude data failed to reject the null hypothesis of no significant difference between subjects interacting with the revised and the unrevised version of the instructional material. Similar results were obtained by Berthelot (1978). Other researchers (Abedor, 1972; Stolovitch, 1975; Wager, 1980) have found that students tend to have a more positive attitude toward revised instructional materials as compared to unrevised prototype. Romiszowski (1986) notes that the novelty effect can confound findings related to student attitude. In this study, CAI was a novel experience for all subjects. Consequently, the novelty effect may have influenced the results.

Implications of the Study

The cognitive style construct field-dependent/independent constitutes an important dimension of individual differences among students. These differences relate to the psychological and personality factors, perceptual patterns and social orientation. Cognitive style FD/FI also relates students' preferences for various modes of gaining, storing, processing, using information and solving problems. Differences in information habits between FD and FI students is a source of considerable variations in learning (Witkin, Moore, Goodenough & Cox, 1977). Some students cannot accomplish a task simply

because they lack the information processing demands imposed upon them by a particular task (Ragan et al., 1979). This construct has some important educational implications, yet it has so far been overlooked by instructional designers.

The literature supports that theoretically the cognitive style FD/FI has promising potential in formative evaluation. The question raised in this study was whether the construct is an effective criterion for selecting test subjects for the one-to-one tryout. Qualitative results indicate that the feedback data generated by FD/FI test subjects can help to identify important deficiencies in instruction. The subjects were able to identify major gaps in the event of instruction, inaccurate assessment of prerequisite skills, information processing difficulties and the need for attention getting strategies.

Quantitatively results indicated that the instructional material revised on the basis of feedback generated by FD and FI test subjects was significantly more effective than its prototype in terms of achievement. Results also indicated a significant difference in achievement between FD and FI students interacting with the prototype version of the material. However, the evidence observed did not support a differential effect of the revised version of the material for FD and FI students. It is possible that the effect of revising the instructional material on the basis of feedback generated by FD and FI subjects has reduced the differential learning gain between FD and FI students without being detrimental to either group. However, more conclusive evidence is required from further investigations to support such inference.

Qualitatively and quantitatively it appears the cognitive style construct FD/FI is an effective criterion for selecting test subjects for the one-to-one formative evaluation. However, these implications should be considered as base line, hypothesis generating, and interpreted with caution, since results of this study are limited by the instructional material, design, test subjects and evaluator. Additionally, the observed non significant difference on posttest scores between FD and FI students interacting with the revised version of the material must be interpreted with caution as further revisions could have perhaps pushed the scores higher.

Although the cognitive style FD/FI appears to be a viable student selection criterion for formative evaluation, some problems associated with its implementation by practitioners in real settings, must be considered. Firstly, most cognitive style assessment instruments are still research based, and their use is restricted to trained researchers. Secondly, the short turn around time usually allowed for evaluation and revision may restrict the feasibility of implementing the cognitive style variable in formative evaluation. Finally, the difficulty in getting test subjects for participation in formative evaluation activities may also be a deterrent to the use of FD/FI construct.

Hopefully, further studies will provide stronger support for the use of this construct, which will by far offset some of the limitations.

SUGGESTIONS FOR FURTHER RESEARCH

The insights gained during this investigation have led to the identification of a number of related problems that warrant further research.

This study used a small population of university students and a computer assisted instruction program as a treatment. Similar research in this area is recommended with different populations, and different modes of delivery, covering various subject matter. Results generated from such research may provide more generalizable principles for formative evaluation. Additional research is also recommended to compare the effectiveness of other cognitive style variables, as student selection criteria.

Research has indicated that cognitive style affects the way teachers teach and students learn. No study investigating the impact of the designer's cognitive style on the effectiveness of instructional material was found. The instructional material used in this study was designed by an extreme field-independent individual. Results indicated a significantly higher achievement score for the field-independent students exposed to that prototypical material. Therefore, a study investigating the impact of designers' cognitive styles on the overall effectiveness of an instructional material is recommended. Since evaluators play a major role in the revision process, similar research should be conducted to investigate the impact of their cognitive styles in the evaluation process and on the effectiveness of the revised product.

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