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Toward a Typology of Learning Styles and Learning Environments: An Investigation of the Impact of Learning Styles and Discipline Demands on the Academic Performance, Social Adaptation and Career Choices of MIT Seniors

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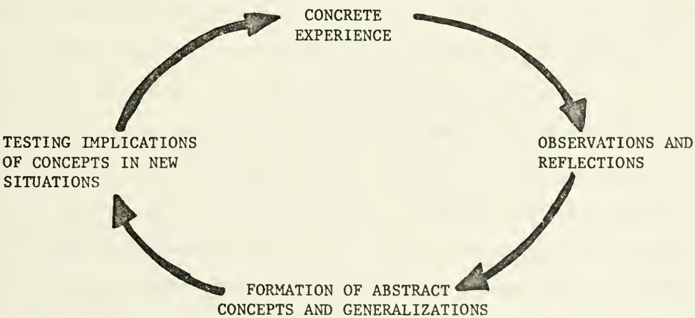
Any true educational technology must be soundly built on a valid model of the learning process. The past few years have seen a great burgeoning of educational techniques designed to assist the learning process; computer aided instruction, experienced based learning materials in math, science and psychology, programmed instruction, games, multi-media curricula, open classrooms, etc. While these techniques tend to be highly sophisticated and creative applications of their own particular fields of expertise; be it computer science, psychology or architecture: they are much less sophisticated about how their particular technique enhances human learning. The great weakness of nearly all of these techniques is the failure to recognize and explicitly provide for the differences in learning styles that are characteristic of both individuals and subject matters. While many of these educational innovations have been developed in the name of individualized education and self-directed learning, there has been little attempt to specify along what dimensions individualization is to take place. For example, although computer aided instruction and programmed learning provide alternative learning routes on branches for the individual learner, these branches tend to be based primarily on various elaborations of the subject matter being taught (e.g. a wrong answer puts the learner on a branch giving him more information about the question). Little has been done to provide the individual learner with branches that provide alternative learning methods (e.g. pictoral versus symbolic presentation) based on the individuals learning style. In addition there has been little research to assess how the effectiveness of various teaching methods is contingent on either individual learning styles or the type of subject matter being taught (two significant exceptions in the case of learning styles are the works of David Hunt, 1971, and Liam Hudson, 1966).

The Experiential Learning Model

To develop a theory of learning that is contingent on individual learning styles and specific subject matters, we need a typology of learning styles that can characterize both individual differences in learning styles and differences in the learning environment created by different academic disciplines or subjects. This paper and the research program of which it is a part attempts to develop and validate such a typology based on experiential learning theory. The theory is called "experiential learning" for two reasons. The first is historical, tieing it to its intellectual origins in the social psychology of Kurt Lewin in the 40's and the sensitivity training and laboratory education work of the 50's and 60's. The second reason is to emphasize the important role that experience plays in the learning process, an emphasis that differentiates this approach from other cognitive theories of the learning process. The core of the model is a simple description of the learning cycle, of how experience is translated into concepts which in turn are used a guides in the choice of new experiences.

The Experiential Learning Model



Learning is conceived as a four stage cycle. Immediate concrete experience is the basis for observation and reflection. These observations are assimilated into a "theory" from which new implications for action can be deduced. These implications or hypotheses then serve as guides in acting to create new experiences. The learner, if he is to be effective, needs four different kinds of abilities -- Concrete Experience abilities (CE), Reflective Observation abilities (RO), Abstract Conceptualization abilities (AC) and Active Experimentation (AE) abilities. That is, he must be able to involve himself fully, openly, and without bias in new experiences (CE), he must be able to reflect on and observe these experiences from many perspectives (RO); he must be able to create concepts that integrate his observations into logically sound theories (AC) and he must be able to use these theories to make decisions and solve problems (AE). Yet this ideal is difficult to achieve. Can anyone become highly skilled in all of these abilities or are they necessairly in conflict? How can one act and reflect at the same time? How can one be concrete and immediate and still be theoretical? A closer examination of the four-stage learning model would suggest that learning requires abilities that are polar opposites and that the learner, as a result, must continually choose which set of learning abilities he will bring to bear in any specific learning situation. More specifically, there are two primary dimensions to the learning process. The first dimension represents the concrete experiencing of events at one end and abstract conceptualization at the other. The other dimension has active experimentation at one extreme and reflective observation at the other. Thus, in the process of learning one moves in varying degrees from actor to observer, from specific involvement to general analytic detachment.

Most cognitive psychologists (e.g., Flavell, 1963; Bruner, 1960, 1966; Harvey, Hunt & Shroeder, 1961) have identified the concrete/abstract dimension as a primary dimension on which cognitive growth and learning occurs. Goldstein and Scheerer suggest that greater abstractness results in the development of the

following abilities:

1. To detach our ego from the outer world or from inner experience
2. To assume a mental set
3. To account for acts to oneself; to verbalize the account
4. To shift reflectively from one aspect of the situation to another
5. To hold in mind simultaneously various aspects
6. To grasp the essential of a given whole: to break up a given into parts to isolate and to synthesize them
7. To abstract common properties reflectively; to form hierarchic concepts
8. To plan ahead ideationally, to assume an attitude toward the more possible and to think or perform symbolically (1941, p. 4)

Concreteness, on the other hand, represents the absence of these abilities, the immersion in and domination by one's immediate experiences. Yet as the circular model of the learning process would imply, abstractness is not exclusively good and concreteness exclusively bad. To be creative requires that one be able to experience anew, freed somewhat from the constraints of previous abstract concepts. In psychoanalytic theory this need for a concrete childlike perspective in the creative process is referred to regression in service of the ego (Kris, 1952). Bruner (1966) in his essay on the conditions for creativity further emphasizes the dialectic tension between abstract detachment and concrete involvement. For him the creative act is a product of detachment and commitment, of passion and decorum, and of a freedom to be dominated by the object of one's inquiry.

The active/reflective dimension is the other major dimension of cognitive growth and learning. As growth occurs, thought becomes more reflective and internalized, based more on the manipulation of symbols and images than overt actions. The modes of active experimentation and reflection, like abstractness/concreteness, stand in opposition to one another. Reflection tends to inhibit action and <u>visa-versa</u>. For example, Singer (1968) has found that children who have active internal fantasy lives are more capable of inhibiting action for long periods of time than are children with little internal fantasy life. Kagan, <u>et.al</u>.(1964) have found, on the other hand, that very active orientations toward learning situations

inhibit reflection and thereby preclude the development of analytic concepts. Herein lies the second major dialectic in the learning process -- the tension between actively testing the implications of one's hypotheses and reflectively interpreting data already collected.

Individual Learning Styles and the Learning Style Inventory

As a result of our hereditary equipment, our particular past life experience, and the demands of our present environment most people develop learning styles that emphasize some learning abilities over others. Through socialization experiences in family, school and work we come to resolve the conflicts between being active and reflective and between being immediate and analytical in characteristic ways. Some people develop minds that excell at assimilating disparate facts into coherent theories, yet these same people are incapable of or uninterested in deducing hypotheses from their theory. Others are logical geniuses but find it impossible to involve and surrender themselves to an experience. And so on. A mathematician may come to place great emphasis on abstract concepts while a poet may value concrete experience more highly. A manager may be primarily concerned with the active application of ideas while a naturalist many develop his observational skills highly. Each of us in a unique way develops a learning style that has some weak and strong points. We have developed a simple self-description inventory, the Learning Style Inventory (LSI), that is designed to measure an individual's strengths and weaknesses as a learner. The LSI measures an individual's relative emphasis on the four learning abilities described earlier, Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE) by asking him, several different times, to rank order four words that describe these different abilities. For example, one set of four words is "Feeling" (CE), "Watching" (RO), "Thinking" (AC), "Doing" (AE). The inventory yields six scores, CE, RO, AC and AE plus two

combination scores that indicate the extent to which an individual emphasizes abstractness over concreteness (AC-CE) and the extent to which an individual emphasizes active experimentation over reflection (AE-RO).

The LSI was administered to 800 practicing managers and graduate students in management to obtain norms for the management population. In general these managers tended to emphasize Active Experimentation over Reflective Observation. In addition, managers with graudate degrees tended to rate their abstract (AC) learning skills higher.[2] While the individuals we tested showed many different patterns of scores on the LSI, we have identified four statistically prevalent types of learning styles. We have called these four styles -- the Converger, the Diverger, the Assimilator and the Accommodator.[3] The following is a summary of the characteristics of these types based both on our research and more informal observation of these patterns of LSI scores.

The Converger's dominant learning abilities are Abstract Conceptualization (AC) and Active Experimentation (AE). His greatest strength lies in the practical application of ideas. We have called this learning style the "Converger" because a person with this style seems to do best in those situations like conventional intelligence tests where there is a single correct answer or solution to a question or problem (cf Torrealba, 1972). His knowledge is organized in such a way that, through hypothetical-deductive reasoning, he can focus it on specific problems. Liam Hudson's (1966) research in this style of learning (using different measures than the LSI) shows that convergers are relatively

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[2]The details of the inventory construction along with preliminary reliability and validity studies are described in Kolb (1971). The inventory itself along with management norms appears in Kolb, Rubin and McIntyre, Organizational Psychology: An Experiential Approach, Prentice-Hall, 1971.

[3]The reason that there are 4 dominant styles is that AC and CE are highly negatively correlated as are RO and AE. Thus individuals who score high on both AC and CE or on both AE and CE occur with less frequency than do the other four combinations of LSI scores.

unemotional, prefering to deal with things rather than people. They tend to have narrow interests, and choose to specialize in the physical sciences. Our research shows that this learning style is characteristic of many engineers (Kolb, 1973).

The Diverger has the opposite learning strengths of the converger. He is best at Concrete Experience (CE) and Reflective Observation (RO). His greatest strength lies in his imaginative ability. He excells in the ability to view concrete situations from many perspectives and to organize many relationships into a meaningful "gestalt". We have labelled this style "Diverger" because a person with this style performs better in situations that call for generation of ideas such as a "brainstorming" idea session. Hudson's (1966) work on this particular learning style shows that divergers are interested in people and tend to be imaginative and emotional. They have broad cultural interests and tend to specialize in the arts. Our research shows that this style is characteristics of persons with humanities and liberal arts backgrounds.

The Assimilator's dominant learning abilities are Abstract Conceptualization (AC) and Reflective Observation (RO). His greatest strength lies in his ability to create theoretical models. He excells in inductive reasoning; in assimilating disparate observations into an integrated explanation (Growchow, 1973). He, like the converger, is less interested in people and more concerned with the practical use of theories. For him it is more important that the theory be logically sound and precise. As a result, this learning style is more characteristic of the basic sciences and mathematics rather than the applied sciences. In organizations this learning style is found most often in the research and planning departments. (Kolb, 1973, Strasmore, 1973).

The Accommodator has the opposite learning strengths of the Assimilator. He is best at Concrete Experience (CE) and Active Experimentation (AE). His greatest strength lies in doing things; in carrying out plans and experiments and involving himself in new experiences. He tends to be more of a risk-taker than people with the other three learning styles. We have labelled this style "Accommodator" because he tends to excel in those situations where he must adapt himself to specific immediate circumstances. He tends to solve problems in an intuitive trial and error manner (Growchow, 1973) relying heavily on other people for information rather than his own analytic ability (Stabell, 1973).

STUDY HYPOTHESES AND DATA COLLECTION

The research to be reported here used the Learning Style Inventory to measure the learning styles of MIT undergraduates in their senior year. We seek in this research to answer three questions. First, are students in different academic disciplines characterized by different learning styles. Secondly, is there evidence that students in their choices of career or further education follow a pattern of accentuation, i.e. those whose learning style fits the demands of a given discipline or career will tend to pursue that path while those who do not will choose other career paths. Thirdly, what are the consequences for the student's academic performance and adjustment of a mismatch between his learning style and the learning style demands of his discipline?

The first aim of the study is to ascertain if there is a correspondence between learning styles and academic speciality similar to that we found in our study of managers. By studying the correspondence between the learning style and departmental major of undergraduates just as they are completing their study we hoped to get a more accurate estimate of the learning style demands of different academic specialities particularly as they are projected by one educational institution. The study of managers and graduate students in management (Kolb 1973)

found that undergraduate majors in business tended to fall in the Accommodator quadrent of the LSI (concrete and active) while majors in English, history, psychology and political science tended to be Divergers (concrete and reflective). Engineers, the largest undergraduate major group in the management sample, tended to be Convergers (abstract and active). The Assimilator quadrent (abstract and reflective) held mathematics, physics and chemistry as well as economics and sociology. Our prediction was that this same general patterning of undergraduate majors would hold true for MIT seniors although the MIT seniors should on the average be less active than the group of managers who had selected themselves into active pragmatic careers. The MIT seniors should also be less abstract than the more mature management sample, most of whom held or were pursuing graduate degrees.

The second aim of the study is to test the hypothesis that career choices in general follow a path toward accentuation of one's learning style. The notion here is that the career development process is a product of the interaction between choices and socialization experiences such that one's choice dispositions lead him to choose socialization experiences that match these dispositions and the resulting experiences further reinforce the same choice disposition for later experiences. This process can be illustrated by the results of an unpublished pilot study we conducted on the choice of sensitivity training by MIT graduate students in management. When we tested the learning styles of students who chose an elective sensitivity training laboratory, we found that they tended to be more concrete (CE) and reflective(RO) than those who chose not to attend the lab. When these individuals with divergent learning styles completed the training sessions their scores became even more concrete and reflective, accentuating their disposition toward divergent learning experiences.

The current study seeks to describe this choice/experience career development cycle as it applies to the MIT senior's choice of graduate school and career field. After having identified a correspondence between learning style (choice disposition) and undergraduate major (experience) we will examine the LSI scores of those students from a given department who are planning to attend graduate school. If the accentuation process is operating, those who have chosen to continue with graduate work in their speciality should have learning styles that are more extreme than the mean of their department,e.g. mathematics majors who are planning to attend graduate school should be more assimilative, i.e. reflective and abstract.

To further understand this process we will examine in detail the students' future plans in four academic disciplines that seem to require the four typical learning styles; mechanical engineering (accommodation), humanities (divergence), mathematics (assimilation) and economics (convergence). Students whose learning style fits their respective discipline demands should be more likely to pursue careers in that discipline than those students whose learning style does not. In addition they should be more committed to these careers.

The third aim of the study is to ascertain if a student's learning style is central to his academic performance and social adaptation to university life. If individual differences in learning styles are important then this should be reflected in those situations where learning styles do not match the learning demands of an academic department. This hypothesis was tested in the four academic departments mentioned above, economics, mathematics, humanities, and mechanical engineering, by comparing students whose learning styles did not match on several variables relating to academic performance and social adaptation. These variables were (1) cumulative grade average, (2) student's perception of academic workload, his feelings of (3) anomie and (4) political alienation and (5) his degree of involvement with a peer group that is important to him. Our prediction was that the students whose learning styles did not fit their discipline would have lower

grades, would percieve their workload to be heavier, would feel anomie and political alienation and would tend not to be involved in an important peer group.

The data to test the above hypotheses were collected by means of a questionnaire that was sent to the 720 MIT sentios in March 1973. The only exception was cumulative grade averages which were obtained from the registrar's office. This study was conducted as part of a larger study on student adaptation to the university (Kolb, Rubin and Schein, 1972. The questionnaire sent to seniors may be found in Gerstein 1973). 407 students (575) responded to the questionnaire. Of these 342 (485) were complete enough to test the hypotheses in this study. The questionnaire included the Learning Style Inventory, two scales measuring political alienation and anomie, questions about plans for next year, career choice, degree of commitment to that career, undergraduate major, perception of acedemic workload, and involvement with peers. These variables will be described in detail as the results are presented.

RESULTS AND INTERPRETATION

Learning Styles and Academic Specialization

In Table I the Learning Style Inventory scores of the 342 MIT seniors who reported their departmental majors are summarized. As we expected, the MIT seniors on the average were less abstract (AC-CE=2.65) and less active (AE-RO=1.39) than the average person in our management sample (the mean scores for the management sample are AC-CE=4.5 and AE-RO=2.9). The expectation that MIT undergraduates would be less abstract than the older management sample, many of whom held graduate degrees, was based on our earlier work showing that abstractness was positively related to age and level of education (Kolb 1971). To test whether level of education was indeed a factor in producing average LSI scores that were more concrete for the MIT seniors; we compared the AC-CE scores of those students who were planning to attend graduate school in September 1973 with those who were not. As can be seen in Figure I those students who planned to attend graduate school were considerably more abstract (AC-CE=3.02) than those who had other plans (AC-CE=1.63, p 01).

Table 1. Mean Learning Style Inventory Scores of MIT Seniors by departmental major

Departmental Major	N	Concrete Experience Mean	Concrete Experience S.D.	Reflective Observation Mean	Reflective Observation S.D.	Abstract Conceptualization Mean	Abstract Conceptualization S.D.	Active Experimentation Mean	Active Experimentation S.D.	Abstract Concrete Mean	Abstract Concrete S.D.	Active Reflective Mean	Active Reflective S.D.
Total Sample	342	14.79	2.85	13.64	3.91	17.24	3.86	15.03	3.63	2.65	5.65	1.39	6.62
Civil Engineering	10	15.30	2.79	13.10	4.56	17.50	3.92	16.70	3.47	2.20	5.61	3.60	6.67
Mechanical Engineering	15	14.80	2.24	13.07	4.38	16.93	3.08	16.67	2.29	2.13	4.07	3.60	6.53
Metallurgy & Materials Sci.	6	16.67	2.34	10.33	2.58	17.00	3.63	16.33	3.27	0.33	5.00	6.00	5.10
Architecture	15	15.00	3.25	15.40	3.98	15.87	3.48	14.60	3.92	0.87	6.23	- .80	6.95
Chemistry	15	14.79	2.04	11.93	3.15	16.71	3.99	15.60	3.85	1.93	5.09	3.67	5.94
Electrical Engineering	87	14.73	2.94	13.45	3.94	17.16	3.77	14.98	3.57	2.43	5.52	1.53	6.72
Biology	45	14.62	2.81	14.80	4.11	16.11	3.98	14.98	3.47	1.48	5.73	.18	6.59
Psychology	2	16.00	4.24	9.00	2.83	17.50	.71	18.00	4.24	1.50	4.95	9.00	1.41
Chemical Engineering	13	14.69	2.17	11.98	2.63	16.92	3.04	17.08	2.29	2.23	3.88	6.00	3.85
Urban Studies & Planning	5	14.60	3.29	11.60	1.52	17.00	2.83	17.60	1.95	2.40	5.13	6.00	3.32
Earth & Planetary Sciences	14	14.50	3.18	14.43	3.94	17.14	2.71	14.29	4.05	2.64	4.97	- .14	7.13
Ocean Engineering	1	13.00	****	14.00	****	11.00	****	18.00	****	-2.00	****	4.00	****
Economics	12	13.67	2.01	12.58	4.01	18.83	4.13	15.33	3.80	5.17	5.81	2.75	6.44
Management	20	15.05	3.25	13.65	4.77	16.45	3.98	15.60	3.05	1.40	6.75	1.95	7.24
Aeronautics & Astronautics	6	13.50	1.87	16.67	4.08	18.67	1.51	13.83	4.02	5.17	2.56	-2.83	7.33
Political Science	3	14.00	4.36	13.00	2.65	17.00	5.57	13.00	6.24	3.00	6.93	0.0	8.00
Mathematics	27	14.81	2.83	14.59	3.18	18.89	4.70	13.04	3.52	4.56	5.73	-1.56	5.61
Humanities	11	16.73	3.41	14.73	3.00	17.82	3.76	11.45	3.24	1.09	6.65	-3.27	4.84
Philosophy	3	14.33	3.77	12.67	2.31	20.00	5.29	14.00	5.20	5.67	8.02	1.33	7.50
Artificial Inteligence	2	13.00	****	16.50	6.36	21.00	****	13.50	4.95	8.00	****	-3.00	11.31
Physics	30	14.83	3.13	13.43	3.64	18.03	4.29	15.53	3.55	3.20	6.74	2.10	6.40
Analysis of variance*		F = .65 P = NS		F = 1.70 P .05		F = 1.30 P = NS		F = 2.7[illegible] PC.01		F = .90 P = NS		F = 2.3[illegible] PC.01	

Figure 1. LSI Abstract/Concrete scores as a function of the students plans for next September and graduate degree objective

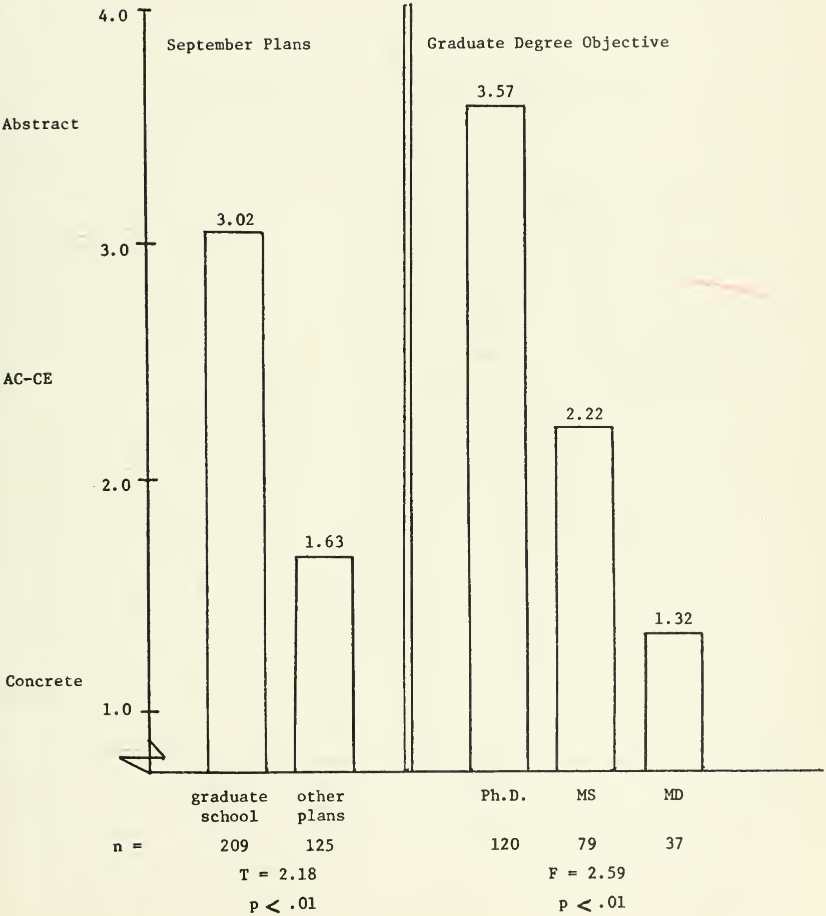
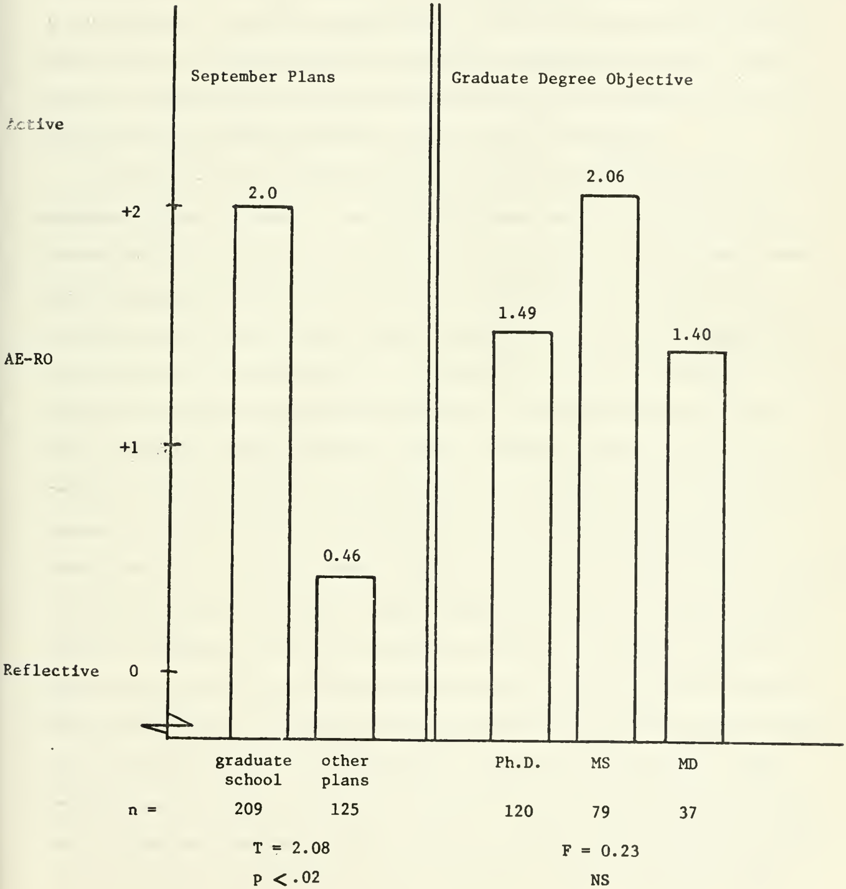


Figure 2. LSI Active/Reflective scores as a function of the students plans for next September and graduate degree objective



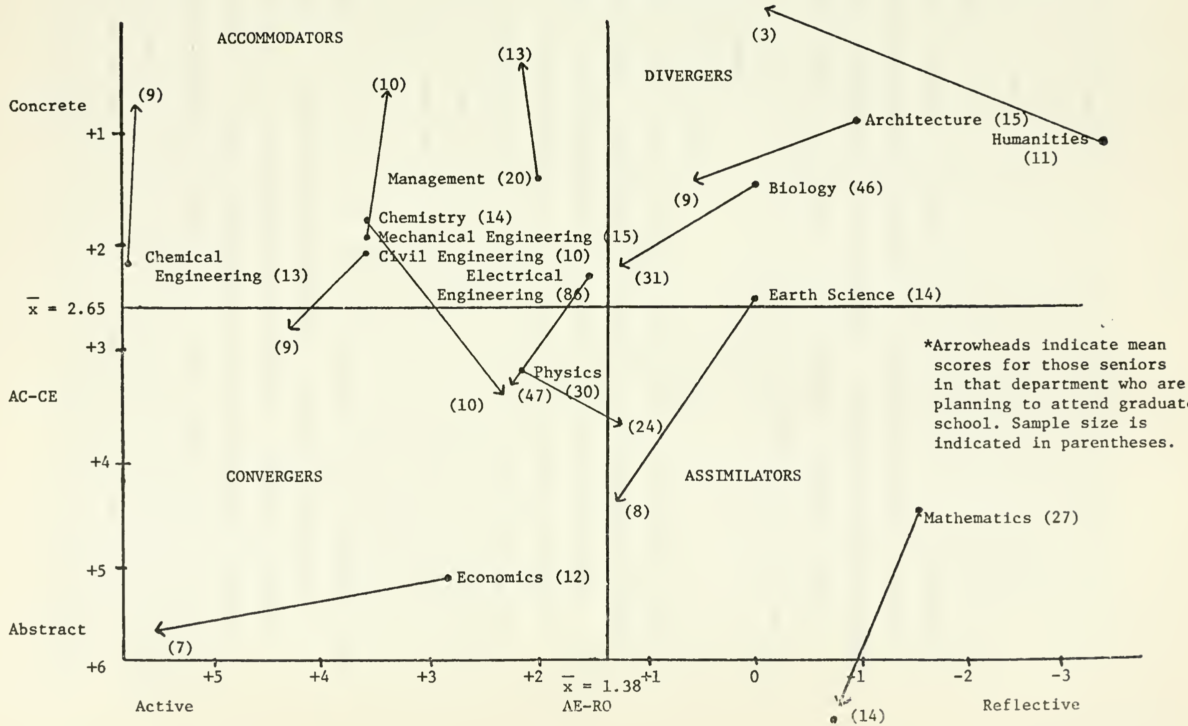
In addition, those students who were seeking a Ph.D. were more abstract than those seeking M.S. or M.D. degrees. These results strongly suggest that level of eudcation is a factor in determining LSI abstractness scores. The results further indicate that the association between amount of education and abstractness may be determined as much by selection into graduate training as by the influence of graduate academic work itself. The students who had chosen graduate school in this sample were more abstract <u>before</u> they actually entered graduate training. We will explore the implications of this fact later in our discussion of the choice/experience cycle in career development.

The expectation that MIT undergraduates would be less active than the management norms was based on the notion that management is one of the most active, pragmatic professions. Yet the active orientation in this sample seems also to be based on educational level. Those students who were planning to attend graduate school were more active (AE-RO=2.0) than those with other plans (AE-RO=0.46 $P \leq 02$, see Figure 2). Our earlier data (Kolb 1971) showed that those with Master's degrees were slightly more active than college graduates; while those individuals with expectations beyond the Master's degree were much more reflective than the college graduates. This same pattern shows in the graduate degree objectives of students although it is not statistically significant (See Figure 2). The pattern seems reasonable in that the Master's Degree program on the whole tend to be oriented toward pragmatic professional training whereas the Ph.D. program more often has a scholarly research orientation. The data in Figure 1 and 2 show that the graduate study plans of MIT seniors are related to their learning styles. Students who are more abstract and active are more likely to go to graduate school. Of the students attending graduate school, those seeking the Ph.D. degree tend to be more abstract and more reflective. These data on graduate plans help explain the fact that MIT undergraduates on the whole are more concrete and reflective than the graduate trained management sample.

Returning to Table 1, let us examine the differences in LSI scores of students with different departmental majors. These differences are shown graphically in Figure 3 for departments with 10 or more students. Analysis of variance for the six learning style dimensions by departmental majors shows that Reflective Observation, Active Experimentation, and the combination score active-reflective all vary significantly by departmental major. Differences on the abstract-concrete dimensions show no significance. This lack of significant differentiation may well be because of more uniform selective and normative pressures toward abstraction that operate across all the MIT departments. MIT's reputation as a "prestige" university is strongly based on scholarship and the advancement of knowledge. Humanities, architecture and management are the most concrete departments in the university and our observations would indicate that these are all quite scholarly in comparison with more concrete programs in other less academic schools such as fine arts, drafting or business administration. Selective and normative forces on the active-reflective dimensions are more diverse representing the tension at MIT between basic science and practical application. With the exception of electrical engineering, the engineering departments are the most active in the university. With the exception of chemistry, the basic sciences and mathematics are more reflective.

If, using Figure 3, we compare our predictions with pattern of LSI score relationships among departments at MIT, there is a general correspondence. Humanities falls in the diverger quadrent while mathematics is assimilative. Management is clearly accommodative. Although the engineering departments all fall on the lower edge of the accommodator quadrent rather than the converger quadrent as predicted; this is most likely a function of the general abstract bias of MIT just noted. Physics and chemistry are not as abstract and reflective

Figure 3. Mean LSI scores on Abstract/Concrete and Active/Reflective by departmental major*



as predicted, although if the LSI scores of only those students planning to attend graduate school are used (as indicated by the arrowheads in Figure 3) the pattern is more consistent with prediction. Economics is somewhat more abstract and active than in our previous sample though, as we will describe later; this is somewhat a function of the unique nature of the MIT department. The architecture department's position in the divergent quadrent is also to some extent a function of the unique nature of the department with its emphasis on creative design and photography as well as the more convergent technical skills of architecture. We did not make predictions about the biology and earth science departments.

Learning Styles and Careers

Figure 3 also contains data about career paths of the students in each of the departments. The arrowheads indicate for each department the average LSI scores for those students who are planning to attend graudate school. Our prediction was that those who choose to pursue a given discipline further through graduate training should show an accentuation of the learning style characteristic of that discipline. That is, the arrows for those departments falling in the accommodative quadrent should point toward the concrete and active extremes of the LSI grid, the arrows for divergent departments toward the concrete and reflective, the arrows for the assimilative departments toward the abstract and reflective and the arrows for the convergent departments toward abstract and active extremes of the LSI grid. The actual results are not so clear-cut. Chemical engineering, mechanical engineering, management, humanities, mathematics and economics all show in varying degrees the predicted accentuation pattern. Potential graduate students in chemistry, civil engineering and electrical engineering score in the convergent quadrent rather than becoming more accommodative. Architecture, biology and earth science potential

graduate students move toward the convergent rather than becoming more divergent. Physics moves into the assimilative quadrent.

The above results should be viewed as only suggestive since several measurement problems prevented a more accurate test of the accentuation hypothesis. The first problem was that it was difficult to determine whether a student was in all cases planning graduate training in the subject he majored in. It was difficult, for example, to determine whether a mathematics student planning graduate work in artificial intelligence would continue studying mathematics or not. While most students clearly planned graduate training in the field of their major, the few borderline cases do contaminate the results. A second measurement problem lies in the fact, already demonstrated, that graduate study in general for MIT students is associated with an abstract and active orientation. Since all six of the departments that did not follow the accentuation prediction showed a tendency toward abstractness and four of the six showed a tendency toward the active orientation; this general tendency for graudate study may well have overshadowed the accentuation process in those departments. The final measurement problem has to do with the prediction of learning demands for those departments like electrical engineering who score close to the middle of the LSI grid.

To deal with these problems in the measurement of the accentuation process we selected four departments for more intensive case study. Several criteria were used to choose four departments whose learning style demands matched the four dominant learning styles. The first criteria used the average learning style scores of the students in a given department as an indicator of the learning style requirements of that department. This criterion assumes that on the average students will over their college career select themselves and be selected into fields that match their learning style. The criterion clearly identified three

MIT departments that matched three of the learning types - Humanities was divergent in its learning demands, mathematics was assimilative and economics was convergent (See Figure 3). The fourth department that was utimately chosen, mechanical engineering was accommodative but was not clearly different from other departments in the accommodative quadrent. To pick the most representative accommodative department, three other criteria were applied. The first was to pick a department whose students going to graduate school showed an accentuation of the departmental learning style. Three departments in the accommodative quadrent showed this accentuation process - chemical engineering, mechanical engineering and management, as did the three departments already chosen to represent the other styles. Of these three accommodative departments, chemical engineering seemed most representative but we had to eliminate it because all of the students in the department but two had accommodative learning styles. This made impossible comparisons between students who matched the departmental norms and those who did not. The other candidate, management, was eliminated because a closer examination of students in that department showed that it was comprised of two seperate and distinct groups - behavioral science and management/computer science majors. Thus students would not be reacting to a single set of departmental learning style demands.

As a final check, the educational objectives and curricula of the four departments selected by the above criteria were examined for indications of their learning style demands. Humanities and mathematics showed strong indications of divergent and assimilative orientations, respectively, as our previous data and theory would predict. For example, course descriptions in humanities often emphasize "different perspectives" of a literary work. In mathematics the

emphasis is on basic theory and research as this quote from the MIT Bulletin's description of the undergraduate mathematics program indicates,

> "The immediate educational aims are to provide an understanding of a substantial part of the existing body of mathematical knowledge and an ability to impart this knowledge to others. But most important, the Department hopes to inspire a deep interest in the discovery or invention of new mathematics or interpretation of mathematics to a new field".

By indication of the learning styles of its students the economics department at MIT is considerably more convergent, i.e. abstract and active than economics majors in our previous research (Kolb 1973). This convergent emphasis is born out however by the objectives and curricula of the department. The department places a very strong emphasis on the quantitative/theoretical and policy formation aspects of economics and considerably less emphasis on the more liberal art approach (e.g. economic history).

While our previous work showed that engineers on the average fall in the converge quadrent of the LSI, we were able to obtain no differentiation among the avrious forms of engineering. One advantage of studying a technical institute like MIT is that we can begin to differentiate between these types. One would expect, for example, that mechanical engineering with its relatively small theory base would be more concrete than electrical engineering where theory plays a larger role. The concrete orientation of mechanical engineering can be illustrated by the following quote excerpted from the MIT Bulletin description of undergraduate study in mechanical engineering,

> ".....the student must experience the ways in which scientific knowledge can be put to use in the development and design of useful devices and processes. To teach this art, largely by project-oriented work of creative nature, is the primary object of subjects in laboratory and design." (1973, p. 65)

Figure 4. Career field and graduate school plans for Mechanical Engineering majors as a function of their Learning Style*

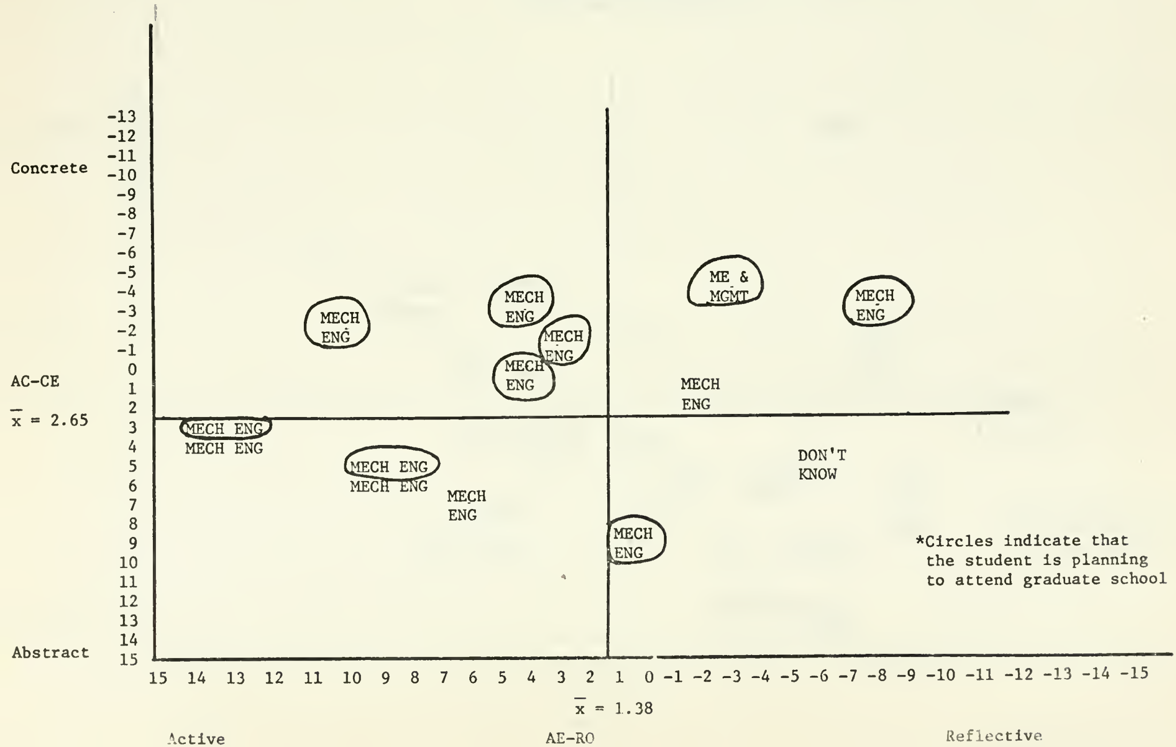
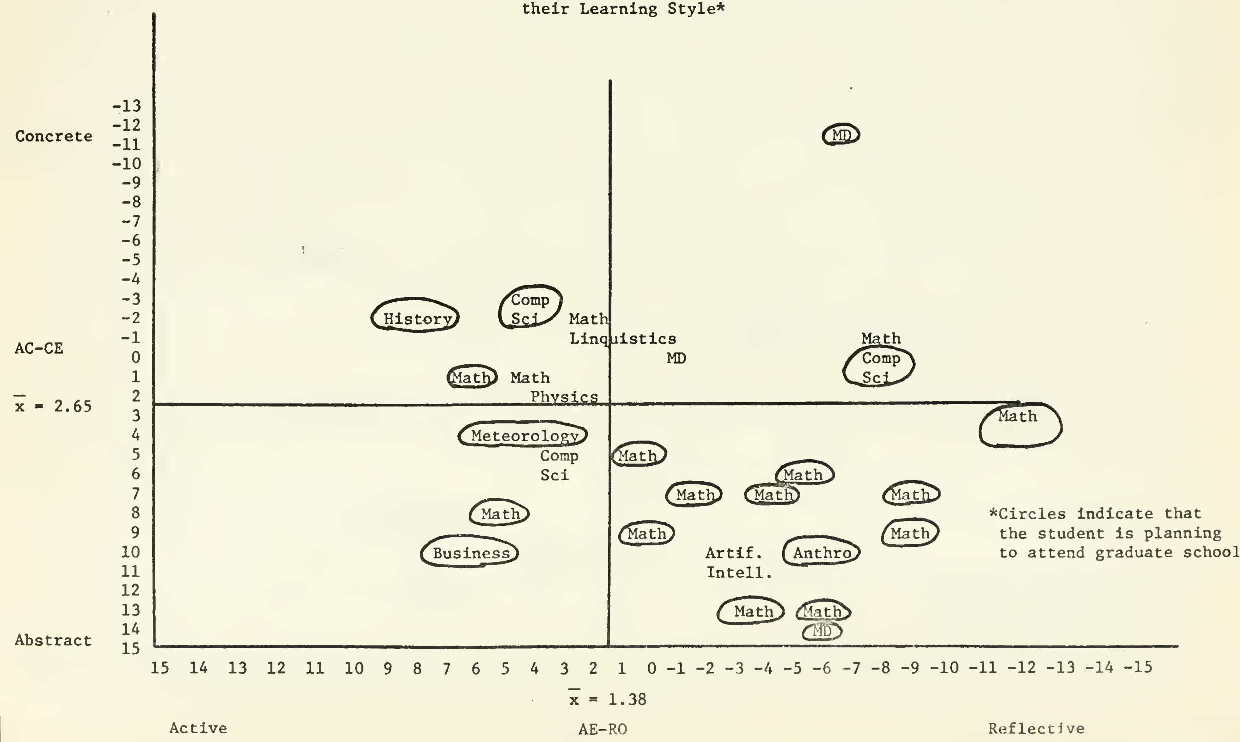
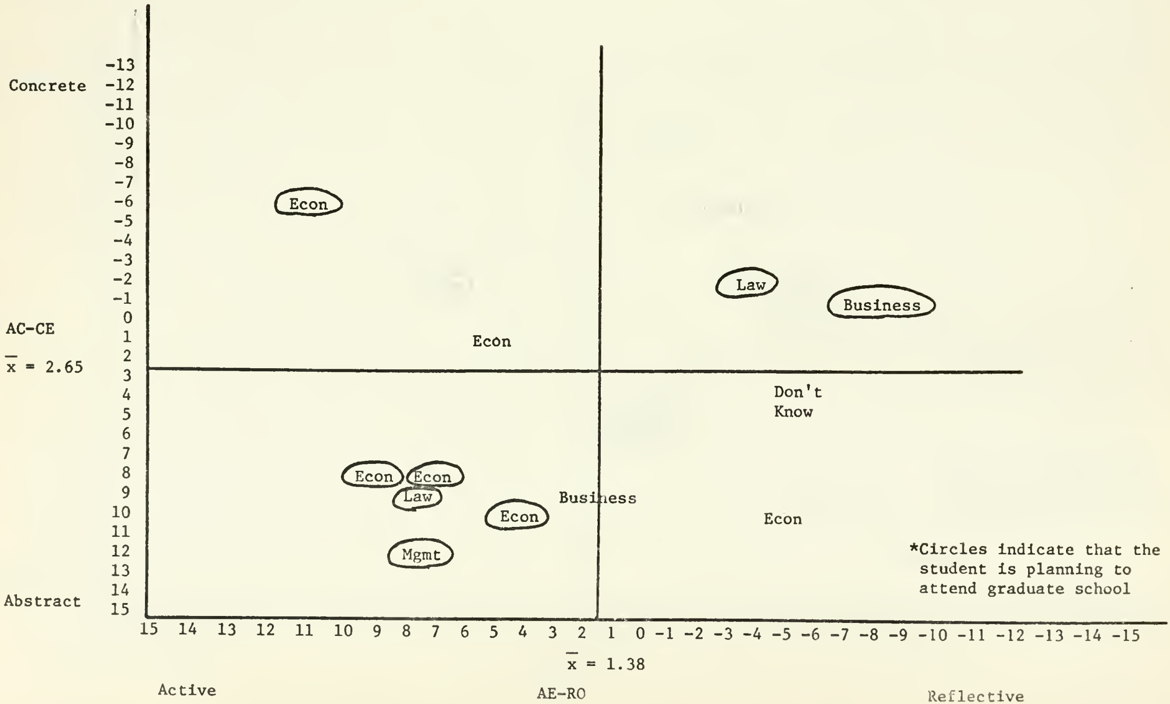


Figure 5. Career field and graduate school plans for Mathematics majors as a function of their Learning Style*



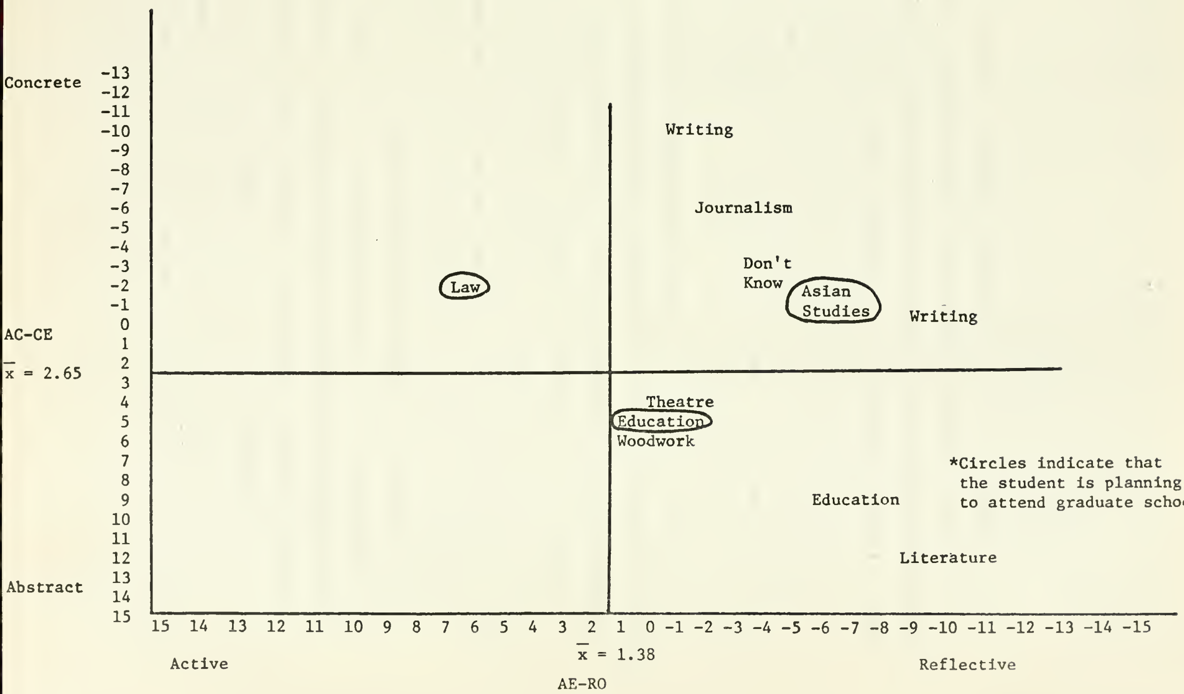
*Circles indicate that the student is planning to attend graduate school

Figure 6. Career field and graduate school plans for Economics majors as a function of their Learning Style*



*Circles indicate that the student is planning to attend graduate school

Figure 7. Career field and graduate school plans for Humanities majors as a function of their Learning Style*



*Circles indicate that the student is planning to attend graduate school

To study the career choices of the students in the four departments each student's LSI scores were used to position him on the LSI grid with a notation of the career field he had chosen to pursue after graduation. If the student was planning to attend graudate school his career field was circled (The results of this analysis are shown in Figures 4-7). If the accentuation process were operating in the career choices of the students we should find that those students who fall in the same quadrent as the norms of their academic major should be more likely to pursue careers and graduate training directly related to that major while students with learning styles that differ from their discipline norms should be more inclined to pursue other careers and not attend graduate school in their discipline. Although the sample size is small and most students plan some form of mechanical engineering career, this career choice pattern can be seen in the mechanical engineering department (Figure 4). All four of the students in the accommodator quadrent (100%) plan careers in mechanical engineering and graduate training as well. Only 4 of the 10 students (40%) whose learning styles do not fit the mechanical engineering are committed both to straight engineering careers and graduate training. The pattern is more clear in the mathematics department where we have a somewhat larger sample (Figure 5). Ten of the 13 mathematics students (80%) whose learning styles are congruent with departmental norms choose careers and graduate training in mathematics. Only two of the 13 students (15%) whose learning styles are not congruent plan both careers and graduate training in math (These differences are significant using the Fisher Exact Test $p < 01$). Figure 6 shows the same trend in the economics department although to lesser degree. Three of the six economics students (50%) with congruent learning styles plan graudate training and careers in economics while only one of the six students (17%) with different learning styles plan graduate training and a career in economics.

The pattern in the humanities department (Figure 7) is somewhat more difficult to interpret. One is immediately struck by the fact that only three of the 11 students (27%) in the humanities department plan to attend graduate school. This is in contrast to the fact that 63% of all MIT seniors plan graduate training. In addition all of the humanities students' career choices are somewhat related to the humanities but are definitely unrelated to the core curricula af MIT. In this sense the humanities department as a whole seems not to fit with the learning demands of the rest of the Institute. The concrete/reflective orientation of humanities seems in conflict with the abstract and active orientation of a technological institute. We will explore this hypothesis further in the next section of results on performance and adjustment to MIT.

To further test the accentuation process in the four departments we examined whether the student's choice/experience career development cycle indeed operated as an accentuating positive feedback loop. If this were so then those students whose learning style dispositions matched and were reinforced by their discipline demands should show a greater commitment to their choice of future career field than those whose learning styles were not reinforced by their experiences in their discipline. As part of the questionnaire students were asked to rate how important it was for them to pursue their chosen career field. They expressed their answers on a 1-5 scale where 5 equaled "great importance". The average ratings for students whose learning styles matched discipline demands and those whose styles did not match the norms of their discipline are shown for the four departments in Figure 8. In all four departments the average importance rating was higher for the students with a match between learning style and discipline norms (The differences being statistically significant in the mechanical engineering and economics departments). Thus it seems that learning experiences that reinforce learning style dispositions tend to produce greater commitment

in career choices than those learning experiences that do not reinforce learning style dispositions.

Taken as a whole the above data present enticing if not definitive evidence that career choices tend to follow a path toward accentuation of one's learning style. Learning experiences congruent with learning styles tend to positively influence the choice of future learning and work experiences that reinforce that particular learning style. On the other hand, those students who find a learning environment incongruent with their learning style tend to move away from that kind of environment in future learning and work choices.

Learning Styles, Academic Performance and Adaptation to the University

The final goal of this research study was to ascertain if a student's learning style was an important determinant of his social adaptation and performance in the university. To do this we compared, on a number of variables, the students whose learning style fit their discipline demands with the students whose learning styles did not fit in the four departments mentioned above. To begin with student cumulative grade averages were examined (see Figure 9).[4] The mechanical engineering and economics departments both showed results consistent with prediction; accommodative students in mechanical engineering had higher grades ($p < .10$) than mechanical engineering students with other learning styles while convergent students in economics had much higher grades ($p < .001$) than economics students with other learning styles. In the mathematics department however, there was no difference between the two groups of students and in humanities, the six students whose learning style was not divergent have somewhat

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[4] A better test of our hypothesis would be to examine only grades for subjects within a student's major, but these were not available at the time of this study.

Figure 8. Student's rating of how important it is for him to Pursue his Career Choice as a function of match between discipline demands and Learning Style in four undergraduate departments

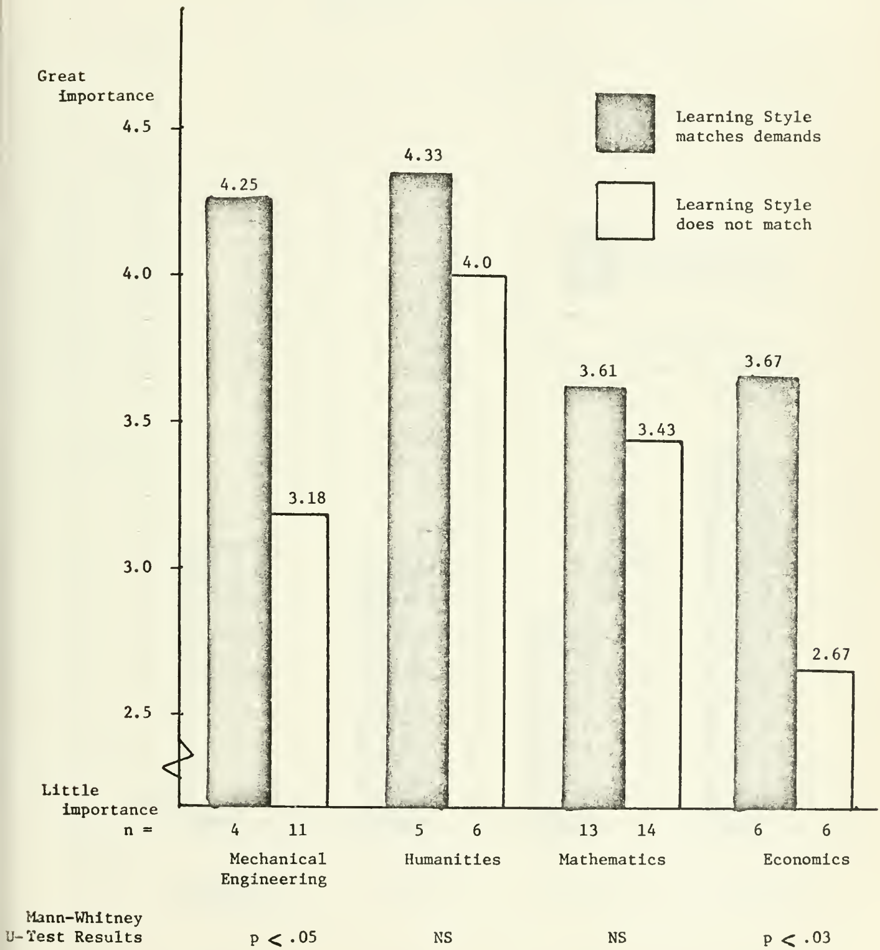
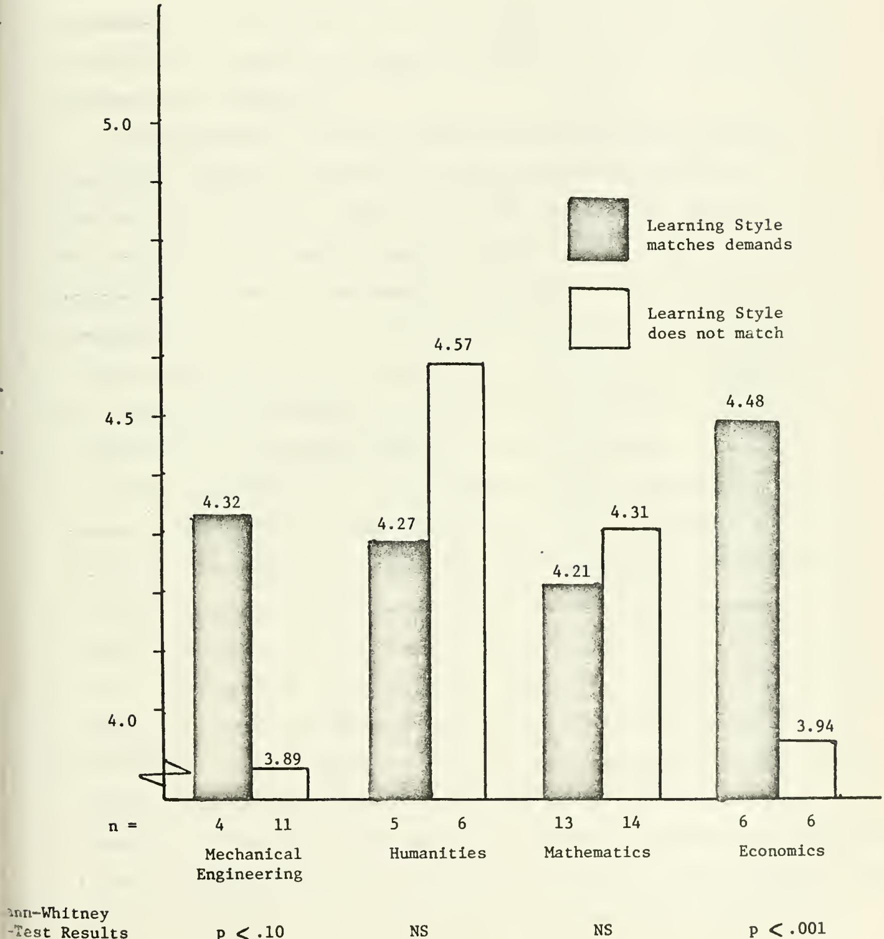


Figure 9. Cumulative grade average as a function of match between discipline demands and learning style in four undergraduate departments

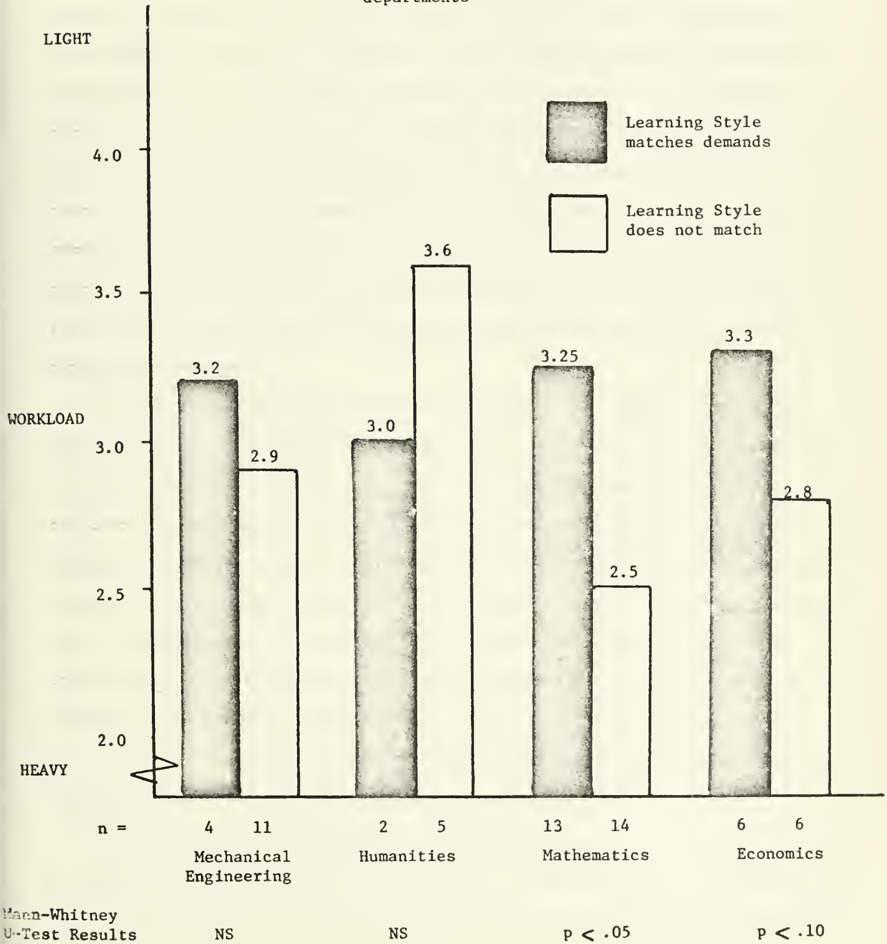


higher grades. While the humanities department results represent a reversal of our original prediction, the results offer further evidence for the hypothesis that humanities and the divergent learning style associated with it are incongruent with the abstract and active norms of MIT as a whole. This latter hypothesis would suggest that humanities students who are not divergers should perform better academically.

The same pattern of results is found when another aspect of academic performance, student perceptions of how heavy the academic workload is, is examined (see Figure 10). Students rated their perception of academic workload on a 1-5 scale where 1 equaled "very great" and 5 equaled "light". In mechanical engineering, mathematics, and economics those students whose learning styles were congruent with their discipline norms felt the workload to be lighter than those students whose learning styles did not "fit". (Statistical significance levels for mathematics and economics are $p < .05$ and $p < .10$ respectively). Again, the humanities department showed a trend in the opposite direction.

We were also interested to see if mismatches between learning style and discipline demands had any effect on the student's social adaptation to the university. An incongruence between a student's learning style and the norms of his major might well undermine his feelings of belonging to the university community and alienate him from the power structure (faculty and administration). To test these hypotheses we used version of Olsen et al.'s political alienation scale (1969) and McCloskey and Schaaer's anomie scale (1963) that were adapted to apply specifically to the MIT environment (see Kolb, Rubin and Schein, 1972 for complete details of these scales). These scales measure two uncorrelated aspects of alienation that influence student adaptation. Political alienation results from the failure of authorities, teachers, administrative officials and the "system" as a whol to meet the student's needs. The politically alienated student feels that the

Figure 10. Students' perception of academic workload as a function of match between discipline demands and Learning Style in four undergraduate departments



authority structure of the university is not legitimate because it is unconcerned about students, because it does not involve them in its decision procedures, because it allows its priorities to be set by vested interests, and because it is incapable of solving the problems it faces. Anomie stems not from dissatisfaction with the formal authority system but from a lack of contact with the norms and values that determine and direct behavior of individuals in the university. These norms and values are communicated most directly through conflict with one's peers. We have found, for example, that feelings of anomie among MIT students are strongly associated with lack of involvement in a personally important group of peers (Kolb, et al. 1972). The anomic student feels lonely, isolated and out of place at MIT. He has difficulty determining what is expected of him and what he himself believes.

Figures 11 and 12 show the political alienation and anomie scores in the four departments for students whose learning styles are congruent and incongruent with their discipline demands. The results are generally consistent with our prediction showing higher anomie and political alienation among those students whose learning style is incongruent with their discipline norms (None of the political alienation differences are significant statistically however. Anomie significance levels for humanities and economics were $p < 10$ and $p < 01$ respectively). One interesting fact in Figure 12 if the very high political alienation scores of all students in the humanities department. Humanities, in fact, scored highest on this variable of all the departments in the Institute. This further develops our pattern of humanities as a deviant learning environment at MIT.

Further insight into the impact of learning styles on social adaptation can be gained by examining student involvement with an important peer group (Figure 13). Students were asked to rate on a 1 to 5 scale (5=very involved) how involved they

Figure 11. Students' feelings of anomie as a function of match between discipline demands and Learning Style in four undergraduate departments

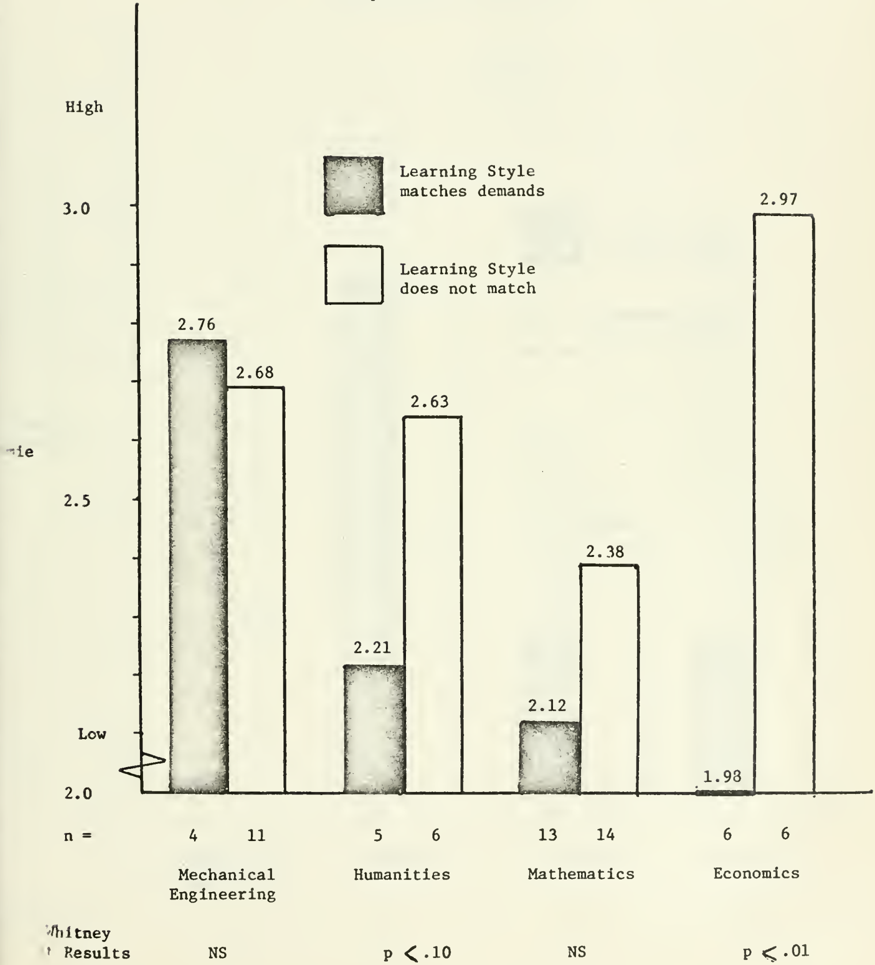


Figure 12. Students' feelings of Political Alienation as a function of match between discipline demands and Learning Style in four undergraduate departments

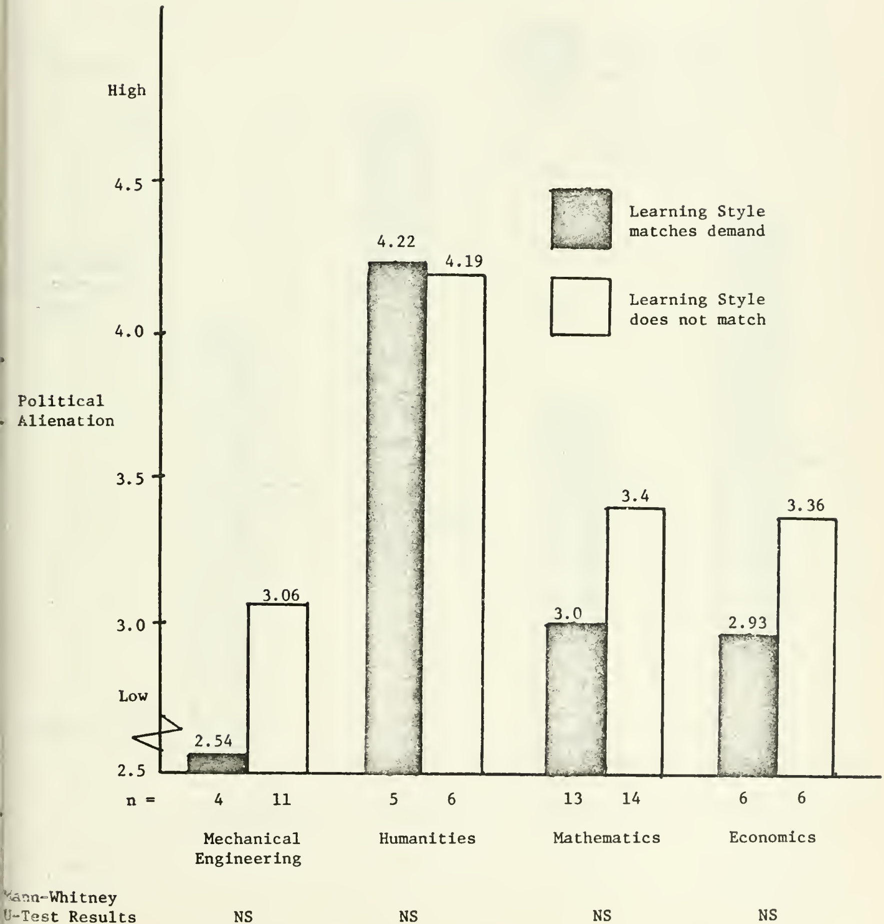
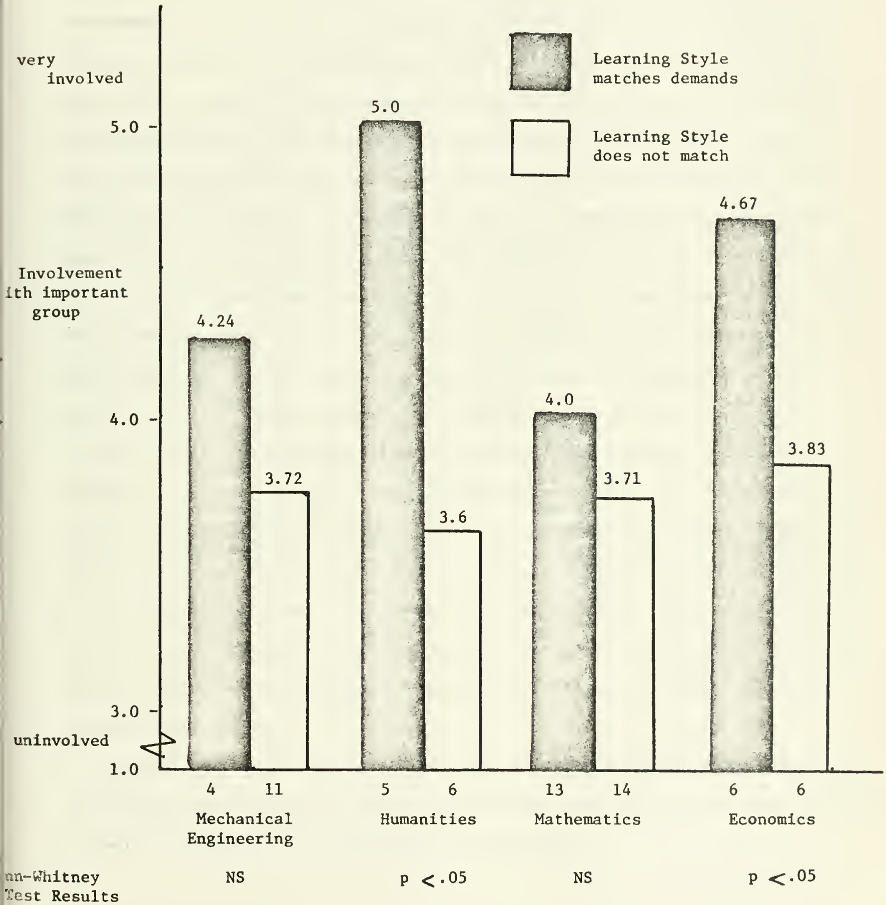


Figure 13. Students involvement with an important peer group as a function of match between discipline demands and Learning Style in four undergraduate departments



were with their most important peer group. As we have already noted our previous research showed high involvement with peers to be associated with low anomie. As Figure 13 shows, in all four departments students with learning styles matching departmental norms tended to he highly involved with their peers. This pattern was most pronounced in the humanities ($p < .05$) and economics ($p < .01$) department. These results suggest that student peer groups may be an important vehicle for the communication of the learning style requirements of a department although, as we already know from many studies of formal and informal organization, peer group norms may sometimes run counter to the formal organizational requirements. Some evidence for this special role of the peer group can be seen in a comparison of the economics and humanities departments. In both of these departments students whose learning style fits with the discipline demands are very involved with their peers; and both groups of students score very low in anomie as we would predict. Yet the convergent economics students score very low in political alienation while the divergent humanities students feel extremely politically alienated from the university. Thus, in humanities, student peer group solidarity among divergers is based on norms of alienation and rebellion from the university while in economics the convergent peer group norms support the goals and procedures of the formal authorities. This may in part account for the fact that the grades of the divergent humanities students are poor relative to other humanities students while the grades of the convergent economics students are far better than other students in economics.

To summarize this final section of results, we have seen that the congruence or incongruence of learning styles with discipline demands is a determinant of both academic performance and alienation in the university.

CONCLUSION AND IMPLICATIONS

This study was undertaken to ascertain the usefulness of the experiential learning model and the typology of learning styles derived from it for describing variations in the ways individuals learn and variations in the learning demands of different academic disciplines. The results of the study show that, at least in this one institution, the learning style typology is useful for describing the learning demand characteristics of different academic departments, for predicting the direction of student career choices; and through examination of the matches and mismatches between student learning styles and departmental learning demands, the typology helps to explain variations in academic performance and adaptation to the university. These results suggest that the experiential learning model may well provide a useful framework for the design and management of learning experiences. Yet before the pragmatic potential of this model can be realized there are a number of questions to be dealt with. As with most research efforts we are left in the end with more questions than when we began. Of prime importance are the questions about the source of a learning environment's learning style demands. In this study we assumed that the accentuation process would operate in the choice of undergraduate majors such that the average learning style of students in a department would characterize the learning demands of the department. For both scientific and practical reasons, a more independent measurement of the learning style demands of a department is desirable. Our case observations of different departments in this study suggest that the learning demand characteristics of a particular learning environment emminate from a number of sources. Among these are:

1. The curriculum content or subject matter to be studied.
2. The teacher's personal characteristics such as his learning and teaching style and his attitude toward students.

3. The teaching methods employed; e.g. lecture, seminar, self instruction, case study, or laboratory exercises.

4. The organization and management of the department including such things as the departmental philosophy about research vs. application, the structure and number of required courses and emphasis on grades.

5. The learning style and norms of student peer groups.

6. The wider university environment including its management and organization, its educational philosophy, the alternative learning environments available, and its selection and evaluation criteria. (These factors, for example, seemed to have a major influence on the students in the humanities department).

If the learning style typology is to be useful in the design and management of learning environments then the specific ways in which these different learning environment characteristics facilitate or inhibit students with different learning styles must be identified. Our current research is focusing on this measurement problem.

Another set of questions are raised by the choice/experience cycle in career development. While the results of this study show that the majority of students seem to be involved in a series of choices and experiences that accentuate their learning style tendencies, many students deviate from this dominant trend. If we are to understand the role of learning styles in the career development process; we need not only to understand dominant trends but also the causes for deviation from these trends. An investigation of the sources of dramatic and abrupt changes in career and life style may well illuminate more fully the nature of adult development.

More specifically, we may gain from this kind of analysis more insight into the relative importance of choices and experiences in human change and development.[5] Until now much emphasis has been placed on the primary importance

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[5] These following ideas were first suggested to me by Dale Lake.

of experience as the cause of change. This orientation has given rise to countless research studies seeking to measure with before-after change measurements the impact of various educational experiences. But suppose than an individual was changed as much through his choices of experiences as by the experiences themselves. Take for example a person interested in mathematics. His interests and appitudes in mathematics may lead him to seek educational experiences that will enhance these dispositions. In addition he may be screened formally and informally for admission to this educational program gaining entry only if he has mathematical appitude. Thus by the time his choice has been realized he will already 1) have gone through a process of consciously recognizing an aspect of himself that he wanted to develop (i.e. his mathematical ability) 2) have done some planning about how to develop this aspect and 3) may even have begun learning mathematics in order to pass selection tests. All of these processes will have occured before the "before" measurement in the typical study designed to assess the impact of an educational experience. Yet they may be as important in determining the directions of adult development. Research that focuses on the dynamics of choices to change career and life style may help answer these questions.

Other questions are raised by findings showing relations between learning style/environment congruencies and their impact on academic performance and adaptation to the university. The dominant trend in research on the "climate" of learning environments has been to focus on the impact on performance and adaptation of social-emotional variables such as motivation, attitudes, participation, liking for the teacher and social isolation. Many of these variables have been shown to be important. However, the results of this study suggest that the climate of learning environments might as productively be examined in terms of its impact on the learning process itself, and in particular in terms of its impact on the learning styles of students. Rather than being a cause

of successful academic performance, motivation to learn may well be a result of learning climates that match learning styles and thereby produce successful learning experiences. Similarily, the sources of student alienation and protest may lie as much in failures to achieve the university's central mission - learning - as they do in its social mileiu.

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