
Learning styles:

individualizing computer-based learning environments

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In spite of its importance, learning style is a factor that has been largely ignored in the design of educational software. Two issues concerning a specific set of learning styles, described by Honey and Mumford (1986), are considered here. The first relates to measurement and validity. This is discussed in the context of a longitudinal study to test the predictive validity of the questionnaire items against various measures of academic performance, such as course choice and level of attainment in different subjects. The second issue looks at how the learning styles can be used in computer-based learning environments. A re-examination of the four learning styles (Activist, Pragmatist, Reflector and Theorist) suggests that they can usefully be characterized using two orthogonal dimensions. Using a limited number of pedagogical building blocks, this characterization has allowed the development of a teaching strategy suitable for each of the learning styles. Further work is discussed, which will use a multi-strategy basic algebra tutor to assess the effect of matching teaching strategy to learning style.

Introduction

While the need to adapt teaching to the needs of a student is generally acknowledged (see Corno and Snow, 1986, for a wide review of the literature), little is known about the impact of individual learner-differences on the quality of learning attained within computer-based learning environments (CBLEs). What evidence there is appears to support the notion that individual differences have implications for the degree of success or failure experienced by students (Ford and Ford, 1992) and by trainee end-users of software packages (Bostrom *et al*, 1990). The problem is to identify the way in which specific individual characteristics of a student interact with particular features of a CBLE, and how the interaction affects the quality of the resultant learning. Teaching in a CBLE is likely to require a subset of teaching strategies different from that subset appropriate to more traditional environments, and the use of a machine may elicit different behaviours from those normally arising in a classroom context.

Of the candidate-factors influencing learning – like personality, motivation, cognitive style, level of ability, and learning style – it is the last that we consider here. For this work,

learning style is defined as a preference for processing information in a particular way when carrying out a learning activity; it is the observable behaviour that arises from a person's underlying personality, motivation, cognitive style and ability, and which is stable over a variety of situations. There is some disagreement about the stability, and therefore usefulness, of learning style. For example, Entwistle (1988), Pask (1976) and Schmeck (1983) argue that individual students tend to be consistent in their approach to learning, but on the other hand Laurillard (1984) and Ramsden (1979) consider that a student's perception of a particular situation is of overriding importance in influencing what and how a student learns. The position adopted here is that each student's approach to learning is determined both by a relatively stable entity called *learning style*, and by more situation-specific concerns.

Determining learning style

There are two basic approaches to modelling a student's learning style for use within a CBLE. It can be done dynamically during the course of a tutorial session. For the student, this has the advantage of being non-intrusive, but it is expensive in terms of system resources, and it is unlikely that a student would use a small tutoring system for long enough to enable it to infer what learning style is being used. An alternative is to model the student's behaviour by using stereotypes. For a small system this is a potentially useful approach that can substantially simplify the problem of modelling a student. The main disadvantage is that it requires the student to answer questions before starting work, and so runs the risk of alienating its target audience. The aim should be, therefore, to ask as few questions as possible, choosing those with good predictive power. The most radical approach is to ask only one question. This has been explored to some extent by Ford (1985) and by Clarke (1993). In each case, Ford's Study Preference Questionnaire was administered to a group of postgraduate students. One item was identified that differentiated, at an acceptable level of significance, between students on the holist/serialist dimension. The problem is that each attempt identified a different item, a result that Clarke attributed either to the interference arising from the reliability analysis or to sample characteristics. Whatever the reason, it highlights the difficulty of obtaining a reasonable balance between predictive value and user acceptability. Acceptance of a time-consuming procedure might be enhanced if the investment of time and effort on the student's part was made worthwhile. Knowing what one's learning style is can be shown to be beneficial not only within computer-based learning environments, but also in the wider educational context. Knowledge about how one learns has been shown to lead to more effective learning (Pennell, 1985).

The instrument that was chosen to assess learning style is based on Kolb's experiential theory of learning (Kolb, 1984). This theory considers that learning is more than just a cognitive process; it is a series of experiences that involve cognition, and the learner is seen as moving iteratively through four stages. There are, however, problems with Kolb's Learning Styles Inventory (LSI): with the psychometrics (Freedman and Stumpf, 1978) and with the construct and face validity (Wilson, 1986). Although the underlying theory is considered helpful, the shortcomings of the LSI prompted Honey and Mumford (1986) to devise a questionnaire for measuring learning style. Their Learning Styles Questionnaire (LSQ) is based on self-reported behaviour, and their learning styles differ in some respects

from Kolb's. The problem that triggered this investigation was how best to provide adults returning to higher education with the basic skills in algebra to enable them to pursue their studies successfully. Such people are likely to have spent a number of years outside formal education. We can therefore make no assumptions about their knowledge of their own study habits, and a questionnaire that refers directly to behaviour in an academic setting is not likely to be useful. Because the LSQ asks about behaviour and beliefs in the workplace, in particular within a managerial context, it was considered that it would be more meaningful to the target population.

The Learning Styles Questionnaire

The LSQ consists of 80 items which the respondent is required to check either positively or negatively. There is no time limit for completing it and the respondent is assured that there are no 'right' or 'wrong' answers. The questionnaire seeks to identify general trends, and so gives equal weight to all answers; no one answer has more significance than any other. Most of the questions are concerned with a person's normal behaviour in an information-processing and decision-making environment, for example:

I thrive on the challenge of tackling something new and different.

I am careful not to jump to conclusions too quickly.

I like to relate my actions to a general principle.

I am keen to try things out to see if they work in practice.

But a few are concerned with beliefs, for example:

It is more important to enjoy the present moment than to think about the past or future.

I believe that rational, logical thinking should win the day.

On completion, the questionnaire is scored, the respondent is provided with the result and is given the information necessary for its interpretation. Four learning styles are identified. These are Activist, Reflector, Theorist, and Pragmatist. Activists want to learn something new, like immediate involvement in activities, and enjoy the challenge of problem-solving. Reflectors prefer to gather and assimilate as much information as they can from as many sources as possible, and like time to consider; they do not like to commit themselves to a course of action before they are ready. Theorists like to explore complex ideas and concepts, and prefer to use their observations and experiences to build their own models and theories. Pragmatists want to learn techniques, and like to practise and experiment; they prefer to address real-world problems.

The authors have documented the reliability of the questionnaire, and while they admit that its construct validity is difficult to prove, they claim its face validity has rarely been questioned by those who have completed it. Allinson and Hayes (1988), however, failed to find evidence to support the construct validity of the four factors identified by Honey and Mumford. Instead, they distinguished two factors which they called Analysis and Action, and which they considered to be statistically justifiable. Their subject population was drawn mostly from managers in the civil service and public enterprises, and this may have reduced the range of likely behaviours. Doubts have been cast upon the questionnaire's

predictive value by Allinson and Hayes (1988) and by Fung *et al* (1993). In both cases, however, there are problems with the interpretation of the data. In the work of Allinson and Hayes, the correlation between the scores on the questionnaire and the students' results (from both examinations and project work) did not reach significance. They attribute this, at least in part, to inconsistencies in the assessment procedures. In the work of Fung *et al*, the students were asked to rate their preferences for items presented in a list of learning activities; in other words, actual student performance was not assessed. Neither of these studies provides grounds for rejecting the LSQ as a useful indicator of learning style. All that can be inferred is that we must use it with caution until more is known about its effectiveness. Computer-based learning environments have the potential to address the issue of consistency in assessment. Once the assessment process is devised, it is the same for everyone; the effects of variation in assessor behaviour are eliminated. The nature of the assessment process may, of course, favour some learning styles over others. This may or may not be desirable, but the issue highlights another reason for attending to learning style. The relationship between assessment design and learning style can be made explicit, and decisions about assessment procedures are therefore available for scrutiny.

From learning styles to teaching strategies

Empirical work in the classroom has indicated that effective instructional design requires knowledge of how people learn (van der Veer and Beishuizen, 1986; Bernaert, 1978, reported in van der Veer and Beishuizen, 1988). The work of Snow (1989) on Aptitude-Treatment Interaction demonstrated that differences in instructional treatment moderated the learning differences between learners of high and low general ability. Others have made a strong case for adapting teaching to learner needs over a range of cognitive and personality styles (Ash, 1986; Corno and Snow, 1986), and, using a computer-based task, Ambardar (1984) demonstrated significant differences in search behaviour between field-dependent and field-independent types. The converse, that preferred learning style has a decisive influence on what people choose to learn, has been observed. There is a tendency for people to select for study at college level those subjects that fit with their learning style (Witkin *et al*, 1977; Entwistle, 1988).

How can the learning styles identified by the LSQ be used to generate teaching strategies? Of the key aspects of the learning styles described by Honey and Mumford, two can form orthogonal, bi-polar dimensions. One dimension has at one extreme the preference for dealing in the concrete, a need to link the domain material with real-life experiences; and at the other the preference for dealing in the abstract, for symbolic manipulation and making links within the domain. This distinction has been proposed by Gregorc (1979), and as 'visual' versus 'verbal' thinking by Stenning *et al* (in press). On this basis, Activists and Pragmatists prefer the concrete, and Reflectors and Theorists prefer the abstract.

The other dimension is concerned with the challenge/safety dichotomy. Recent work (Newstead, 1989; Stenning and Cox, personal communication to the authors of this paper) has demonstrated marked differences in behaviour, called 'rashness' and 'hesitancy', along what appears to be a similar dimension. Compared to the previous dimension, this one is more difficult to interpret, and possibly also to implement. Honey and Mumford suggest that Activists and Theorists tend to seek challenge, whereas the

other two learning styles prefer safety. Pragmatists prefer to be shown what to do and be given ample opportunity to practise, and Reflectors work best when given sufficient information to assimilate and time to reflect upon it.

The learning styles can be placed on a graph formed by the intersection of the two axes (Figure 1). Consideration of the graph can be used to define appropriate teaching strategies thus:

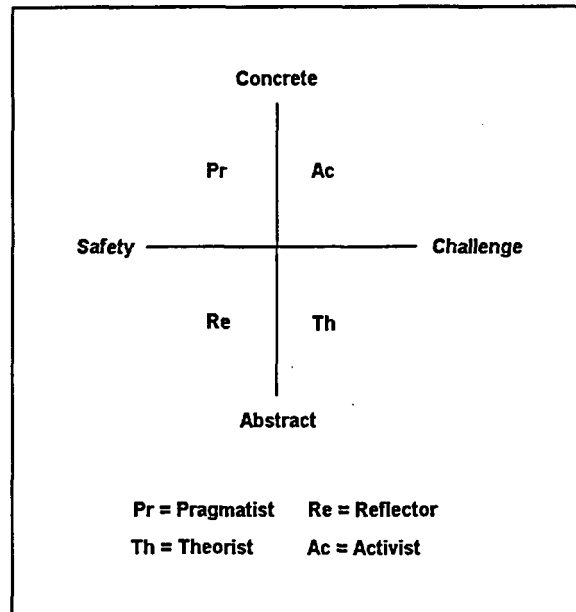


Figure 1: Learning styles

Concrete versus Abstract

The choice of graphical or textual representation of a concept has implications for the way it is processed and communicated. Graphics enforce specificity, or at least restrict the level of abstraction possible, whereas text enables expression of abstract ideas (Stenning and Oberlander, in press). Perceptual and spatial relationships are better depicted by graphics, logical and temporal relationships by text (Larkin and Simon, 1987). The preference of learners for concrete or abstract processing, and for attending to relationships they find meaningful, can be addressed by providing either a graphical or a text-based environment.

Safety versus Challenge

'Safety' can be provided by a highly structured environment, one that teaches the subject-matter in small incremental steps, and which provides ample opportunity either for observing what is to be done (Reflector), or for putting into practice what has been demonstrated (Pragmatist). Meta-information for the learner can consist of what has been done and what still has to be done, but the learner is given no opportunity to alter

the order of events. For 'Challenge', what is required is the opportunity to attempt more demanding tasks as soon as the learner wants to tackle them, whether or not a teacher (or CBLE) would agree. Essentially, what is happening is that the learner is free to try out a course of action, or to test a hypothesis; in other words, to experiment in whatever way suits. The learning environment should, of course, allow back-tracking when the step taken proves to be too large. This implies that the learner should have complete control over the learning environment.

Designing the system

Once the teaching strategies have been derived from the learning styles, they have to be translated into teaching methods that are possible in a CBLE, at a level of granularity suitable for the design and implementation of a system. Chen (1993, pp. 299–300) has developed a methodology for classifying pedagogical methods, most of which are applicable to a small system. Such methods can provide the basis for designing the learning environment, and for analysing user actions. Her basic pedagogical methods, with some minor adaptations, are:

1. setting goals: the knowledge or skills the learner is expected to acquire during the lesson;
2. providing instructions: uninterrupted presentations of any type of knowledge through text;
3. providing demonstrations: illustration of a particular task, a worked example;
4. providing explanations: the rationale behind a particular action;
5. presenting tasks: activities presented through text or graphical representations;
6. asking questions: questions requiring specific answers are presented;
7. providing working spaces: opportunities to interact with the program, the learner being able perform a task only when a corresponding working space is provided;
8. providing examples: the designer relates a learner's daily experience to the present learning;
9. providing reminders: the designer presents key words, such as commands, or key concepts, that a learner needs during the performance of a task;
10. providing hints: implicit cues are embedded in the task to be performed;
11. providing evaluation and feedback: the learner's performance is evaluated and feedback is provided accordingly.

Implementation of all of the pedagogical methods is possible within the proposed system, and each is relevant to one or more of the learning styles. All teaching strategies will have relevant goals set and stated, and appropriate evaluation and feedback provided; tasks will be presented and workspace will be provided. Thus each learning style will be targeted with a teaching strategy consisting of the core pedagogical methods (those concerned with goals and feedback possibly implemented differently to match learning style), with different combinations of the others.

For the 'concrete' strategies (Pragmatist and Activist learning styles), graphics will provide the medium of instruction (where the use of graphics will explicitly link the material to be learned with examples from the everyday world of experience), and for the 'abstract' strategies (Theorist and Reflector) text directly relating to symbolic manipulation will be used. For 'safety' strategies (Pragmatist and Reflector), a tightly structured environment will be provided, and for the 'challenge' strategies (Activist and Theorist), no structure will be imposed. Instead information about the contents of the system, and recommendations about what might be an appropriate activity, will be available.

Each teaching strategy will require its own particular subset of the pedagogical methods. The teaching strategies for each of the learning styles are as follows:

Concrete-safety learners will have graphical examples and demonstrations provided, to tie in with the need to learn how to do things. Only after students have been shown how to do a task will they be given the opportunity to perform similar tasks for themselves.

Concrete-challenge learners will also have the material presented in graphical form, to allow opportunities for direct hands-on experimentation. These students will be given no explicit instructions; instead, tasks will be so presented that hints about what to do will be embedded in the material. Information about the content and organization of the system will be provided graphically.

Abstract-safety learners will be text-based, and instructions, demonstrations, and reminders will be given before students are required to carry out a task.

Abstract-challenge learners will also be text-based and, within an unstructured environment, students will have access to explanations and instructions. They will be provided with textual information on the content and organization of the system.

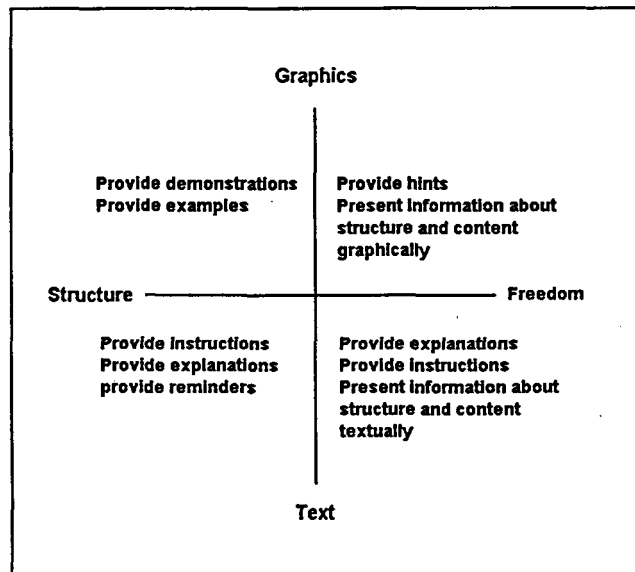


Figure 2: Teaching strategies

The pedagogical methods can be placed on a graph of teaching strategies analogous to the one above of learning styles (Figure 2).

Multi-strategy CBLEs?

Further work will address two issues:

- whether it is worthwhile to develop a CBLE with relatively independent teaching strategies, that is, whether the extra effort involved in developing a multi-strategy CBLE is justified by improvement in student learning; and
- to what extent the LSQ is a useful tool for measuring learning style, particularly with reference to its predictive validity.

The two issues are linked. The question is not so much whether learning style exists; most teachers believe so, and behave as if it were so, by adapting their teaching to the needs of their students, most noticeably in one-to-one situations. The problem is how to *assess* learning style. The identification and measurement of useful learning styles are critical to the development of the teaching strategies in a CBLE. Honey and Mumford's LSQ is a candidate, despite the doubts about its predictive validity and concern about its length. Factor analysis of the individual items rather than of the sub-scales has been suggested by Allinson and Hayes (1990); this can address questions about both predictive validity and length.

While the algebra tutor is being developed, a pilot study is planned. The LSQ will be administered to first-year students so that the correlation between the questionnaire items and the students' progress (in terms of course choice and measures of success, for example courses passed and qualifications – if any – obtained) can be considered. The relationship between learning style and teaching strategies will be examined in a more controlled manner using the algebra tutor which will present the same subject matter differently according to the four teaching strategies. Using a four-by-four within-groups experimental paradigm, the effect of the teaching strategies on each learning style will be assessed. It is hoped that analysis of both field and experimental data will provide some insight into the difficulties and benefits of developing a multi-strategy CBLE, and also help to determine whether refinement of the LSQ should be pursued.

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