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10 Making Learning Fun: A Taxonomy of Intrinsic Motivations for Learning

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Over the past 2 decades, great strides have been made in analyzing the *cognitive* processes involved in learning and instruction. During the same period, however, attention to *motivational* issues has been minimal. It is now time to redress this imbalance. As Bruner (1966) has put the case:

> The will to learn is an intrinsic motive, one that finds both its source and its reward in its own exercise. The will to learn becomes a 'problem' only under specialized circumstances like those of a school, where a curriculum is set, students confined and a path fixed. The problem exists not so much in learning itself, but in the fact that what the school imposes often fails to enlist the natural energies that sustain spontaneous learning . . . (p. 127)

In fact, it seems a frequent assumption about schools that learning is boring and unpleasant drudgery—something one endures only to avoid punishment or to achieve some external goal, such as a good grade-point average or a high-paying job (Jackson, 1968; Lepper, 1983). This need not be the case. In this chapter, we summarize and extend earlier work by Malone (1981a, 1981b) concerning the design of instructional environments that are *intrinsically motivating,* that is, environments in which people are motivated to learn in the absence of obvious external rewards or punishments.

Our interest in designing intrinsically motivating learning environments—in making learning fun—derives from two related concerns (Lepper, 1985). On the one hand, in any learning environment in which engagement in instructional

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activities is not required, intrinsic motivation is a necessary precondition for student involvement in such activities. On the other hand, even when students are extrinsically coerced to engage in such activities, what they learn and how effectively they learn may be influenced by their level of intrinsic motivation. In the present chapter, we focus on the issue of how to make learning more interesting and enjoyable; in the next chapter, we consider more fully the relationship between intrinsic motivation and instructional effectiveness.

Our primary goal is a more complete taxonomy of intrinsic motivations for learning than that proposed by Malone (1981a, 1981b). In addition to the three classes of "individual" motivations previously discussed by Malone (challenge, fantasy, and curiosity), we have added a fourth class of "individual" motivations (control) and three "interpersonal" motivations (cooperation, competition, and recognition). We believe that the taxonomy now includes all of the most important intrinsic motivations that can be used in designing instructional environments. A secondary goal is to examine the distinction between "endogenous" and "exogenous" versions of the motivations in the different categories. Throughout the chapter, we are particularly concerned with making distinctions and formulating principles that can be used in *designing* intrinsically interesting learning environments, not just in explaining why or predicting that some environments will be more interesting than others.

STUDIES OF INTRINSICALLY MOTIVATING COMPUTER GAMES

Our joint interest in intrinsic motivations for learning derived initially from the study of what makes computer games—even many educationally oriented computer games—so interesting and exciting for children. Hence, to provide both a background and a source of examples before discussing our taxonomy in more detail, we first summarize three studies by Malone (1981a) and Lepper and Malone (in preparation) about what makes computer games fun.

Survey of Computer Game Preferences

The first study reported by Malone (1981a) was a survey of the computer game preferences of 65 elementary-school students who had been playing with computer games in their school for at least 2 months (and some for over 2 years). For the 25 games the teachers of the classes rated as most popular, the children were asked individually to rate how well they liked each game on a scale from 1 to 3. Table 10.1 shows the 25 games included in that survey.

One question we can ask about these results is this: What are the features that the popular games share that the unpopular games do not? As a partial answer to this question, Table 10.2 shows the correlations between several features of the

TABLE 10.1
Computer Games in Order of Preference[a]

Game	Average Rating	Description
Petball	2.8	Simulated pinball with sound
Snake2	2.6	Two players control motion and shooting of snakes
Breakout	2.6	Player controls paddle to hit ball that breaks through a wall piece by piece
Dungeon	2.6	Player explores a cave like "Dungeons and Dragons"
Chase S.	2.6	Two players chase each other across an obstacle course with sound effects
Star Trek	2.5	Navigate through space and shoot Klingon ships
Don't Fall	2.5	Guess words like Hangman but instead of a person being hung, a person or robot advances to a cliff
Panther	2.4	Guess who committed a murder by questioning witnesses who may lie
Mission	2.4	Bomb submarines without getting your ship sunk
Chaser	2.4	Capture a moving square with perpendicular lines
Chase	2.4	Like Chase S. but without sound
Horses	2.4	Bet on horses that race along track
Sink Ship	2.3	Bomb a ship from an airplane
Snake	2.3	Like Snake2 but snakes can't shoot
Lemonade	2.3	Run a lemonade stand: buy supplies, advertise, etc.
Escape	2.2	Escape from moving robots
Star Wars	2.2	Shoot Darth Vader's ship on screen
Maze Craze	2.2	Escape from randomly generated maze
Hangman	2.1	Guess letters of a word before man is hung
Adventure	2.0	Explore cave with dragons, etc.
Draw	2.0	Make any design on the screen
Stars	2.0	Guess a number. Clues given by number of stars
Snoopy	1.9	Shoot Red Baron by subtracting Snoopy's position on number line from Red Baron's position
Eliza	1.8	Converse with simulated psychiatrist
Gold	1.5	Fill in blanks in story about Goldilocks

Note. Average ratings are on the scale: 1 = don't like, 2 = like, 3 = like a lot.
[a]From Malone (1981a)

games and the children's preferences. The feature that was most highly correlated with preference was whether or not the game had an explicit goal. For example, in the popular games like Pet Ball, Snake II, and Breakout, there was an explicit goal in every case: getting a high score, shooting the opponent's snake, or knocking all the bricks out of the wall. In the two least popular games, Eliza and Gold, there were no clear goals: In talking to a simulated psychiatrist or filling in blanks in a story about Goldilocks, there are no predetermined performance goals.

Other features that proved significantly correlated with preference, for this sample of activities, included (a) whether the computer kept a score, (b) whether there were audio (and, marginally, visual) effects involved, (c) whether there were random elements in the activity, and (d) whether speed of response made a difference in the game. These findings show a marked congruence, moreover,

TABLE 10.2
Importance of Game Features in Determining Game Preferences[a]

Feature	Correlation with Average Preference
Goal	.65**
Computer keeps a score	.56**
Audio effects	.51**
Randomness involved in game	.48**
Speed of answers counts	.36*
Visual effects	.34
Competition	.31
Variable difficulty level	.17
Cooperation	.02
Fantasy	.06
Kind of game:	
Graphic game	.38*
Math game	-.20
Word game	-.38*

[a]From Malone (1981a)
*$p < .05$
**$p < .01$

with other analyses concerning the structural features that contribute to a computer game's success (Banet, 1979).

It is, of course, impossible to draw strong causal inferences from a correlational study like this. Hence, Malone's (1981a) further work employed an experimental approach, in which different features in the same game were varied to determine which features contributed most to the appeal of the game.

Experimental Studies

For these initial controlled investigations, a number of variants of the Darts game (Dugdale & Kibbey, 1980), designed to teach children about fractions and number lines, were created. In the original Darts game, three balloons appear at random places on a number line. The student then types in estimates of their locations in mixed-number form. For each guess, an arrow shoots across the screen to the position specified. If the guess is correct, the arrow pops the balloon. If it is wrong, the arrow stays on the screen, and its position is indicated as a mixed number on the screen. The student keeps shooting until all the balloons are popped. Circus music is played at the beginning of the game; and, if the student pops all the balloons in four tries or fewer, a short song is played at the end of the round.

This game seems both educational, as discussed below, and highly motivating for children. The question addressed by Malone's (1981a) next study was: What makes this game fun? To answer this question, eight different versions of the game were constructed starting with the original version of the game and deleting, one at a time, features that were presumably motivational. The features varied included: the music, the scorekeeping, the fantasy of arrows popping balloons, and several forms of feedback, as illustrated in more detail in Fig. 10.1.

Eighty fifth-graders were assigned to one of the eight versions and then allowed to play with either their version of Darts or with a version of Hangman that was the same for all students. The primary measure of motivational appeal of the different versions was how long students played with their version of Darts in comparison to Hangman.

Somewhat surprisingly, there were significant differences between boys and girls in what they liked about the game. The boys seemed to like the fantasy of arrows popping balloons and the girls seemed to dislike this fantasy. The addition of musical rewards, on the other hand, appeared to increase for girls, but to decrease for boys, the intrinsic interest of the activity. The most important general implication of these results is that such motivational embellishments can be important in creating intrinsically motivating environments, but that there may be large individual differences among people in the features they find appealing.

Finally, our most recent study (Lepper & Malone, in preparation) took Malone's paradigm one step further. If one can embed *identical instructional sequences* within different activities that *vary in their motivational appeal,* one may then examine the ways that variations in intrinsic motivation affect learning and study the *educational* consequences of different motivational manipulations (cf. Lepper, 1985; Lepper & Malone, this volume).

In this third study, then, we were interested in comparing children's actual learning from parallel programs that presented identical instructional materials in the form of either a game or a drill. As in the preceding study, we worked with grade-school children playing the Darts program—in either its original *game* form, or in a *drill* format in which the game-like elements (e.g., the audio-visual introduction, the music, the fantasy of popping balloons) were removed from the activity. For two groups of children, we examined intrinsic motivation, as above, by permitting them a choice between the version of Darts they had played and a standard alternative program. Two other groups were given a fixed amount of exposure to either the game or the drill version, and the students' actual learning about fractions was assessed.

The results indicated that the motivational appeal of these two, instructionally identical activities was quite different. Children chose the activity for roughly 50% more time when the material was presented as a game, rather than a drill. In both cases, moreover, comparisons with control subjects showed that significant learning about fractions and number lines had occurred. The enhanced motivational appeal of the game version in this study, however, did not produce enhanced learning—a topic that we consider in greater detail in the following chapter.

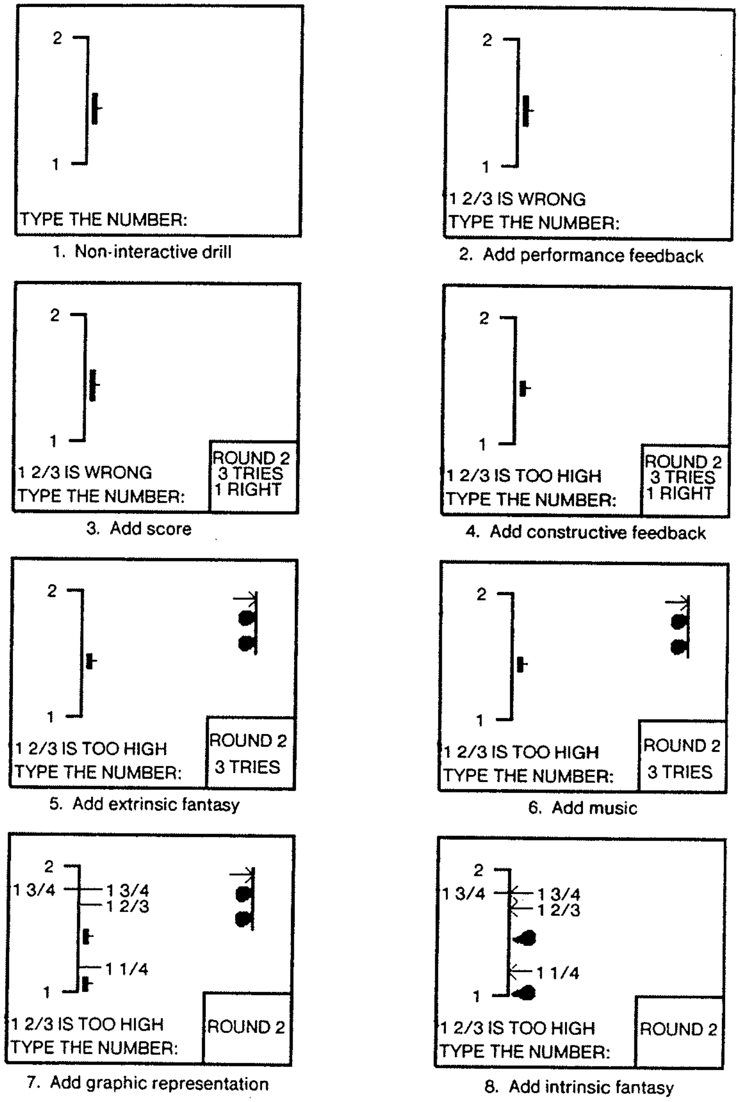

FIG. 10.1. Different versions of the Darts game, from Malone (1981a). Reprinted by permission.

A TAXONOMY OF INTRINSIC MOTIVATIONS FOR LEARNING

We define an activity as being intrinsically motivating if people engage in it *for its own sake,* rather than in order to receive some external reward or avoid some external punishment. We use the words *fun, interesting, captivating, enjoyable,* and *intrinsically motivating* all more or less interchangeably to describe such activities. We consider a particular instance of learning intrinsically motivated if the most narrowly defined activity in which the learning occurs is intrinsically motivated.

For example, suppose the activity of reading a book is intrinsically motivating for one individual, but the subactivity of finding the book in the library is done only in order to achieve the *external* goal of reading it. We would say that the learning that resulted from reading the book was intrinsically motivated, but that the learning that resulted from finding it in the library (e.g., learning where the book was shelved) was extrinsically motivated. Were that same individual to read the book only because it would help to achieve the *external* goal of passing an exam, we would describe the entire activity as extrinsically motivated. In short, we define intrinsically motivated learning as *learning that occurs in a situation in which the most narrowly defined activity from which the learning occurs would be done without any external reward or punishment.*

In a number of the categories below, we also highlight the distinction between endogenous and exogenous versions of the motivation (Kruglanski, 1975, 1978). In the context of explicitly educational activities, this distinction refers to the relationship between the *instructional* content of an activity and those features of the activity that influence its *motivational* appeal. In the former (i.e., endogenous) case, there is some integral relationship between instructional content and motivational embellishments; in the latter (i.e., exogenous) case, the relationship between the two is basically arbitrary.

We believe that both distinctions have important psychological consequences. Although both intrinsic motivations and extrinsic incentives, or endogenous and exogenous motivational embellishments, *may* be equally effective in enhancing motivation in a specific setting, the consequences for subsequent learning and motivation are likely to differ. In general, we hypothesize that the use of intrinsic, rather than extrinsic, incentives, and endogenous, rather than exogenous, motivational embellishments will frequently produce both (a) higher levels of sustained interest in the activity or the instructional content of the activity in future situations (cf. Lepper & Greene, 1978a) and (b) better learning of that instructional content (cf. Brown, 1983; Bruner, 1966; Condry, 1977; Lepper & Malone, this volume). Moreover, even in cases in which the learning activity itself is not intrinsically motivated, we suggest that instructional environments can often be improved by harnessing a wider range of the motivations we describe here.

A Word about Theories and Taxonomies. It is considered a truism in many circles of psychology that if a theory is not empirically falsifiable it is not useful (Popper, 1959). Although empirically falsifiable theories are logically necessary for certain forms of scientific progress, an overly zealous devotion to producing only such theories can hinder the formulation of models that are interesting enough and comprehensive enough to be worth testing empirically at all. Even though we make a number of specific claims in this chapter that are empirically falsifiable, our goal is not to present a single testable theory. Rather, our aim is to synthesize a number of competing theories into a framework that can guide not only further theorizing, but also the design of instructional environments.

Historically, for instance, a number of theorists have explained intrinsic motivation primarily in terms of competence and challenge (e.g., Csikszentmihalyi, 1975; Harter, 1978; White, 1959), others have discussed it in terms of optimal levels of arousal or stimulation (e.g., Berlyne, 1960, 1966; Hunt, 1961, 1965; Piaget, 1952), and still others have focused on concepts such as control and self-determination (e.g., Condry, 1977; deCharms, 1968; Deci, 1975, 1981). Instead of assuming that these theories present contradictory views, we suggest that considering them together in a common framework will help to clarify the conditions of applicability of each (Lepper, 1985; Malone, 1981a, 1981b).

In evaluating a taxonomy such as ours, the criteria to be used are primarily logical, rather than empirical. A good scientific taxonomy (like a good deductive theory) is *complete, consistent, and parsimonious*. In the case of taxonomies, the first two criteria mean that the taxonomy presents a mutually exclusive and exhaustive partitioning of the items to be classified into categories. In our case, the items to be classified are explanations (or theories) of why people learn without any external rewards or punishments, and our taxonomy should be evaluated on whether it does indeed have exactly one *natural* classification for all such explanations. According to the third criteria, parsimony, our taxonomy should also be evaluated on whether the distinctions it makes are *worth the cost*, that is, whether they are indeed useful, and not unnecessarily complex.

INDIVIDUAL MOTIVATIONS

The first four kinds of intrinsic motivations can be present in any learning situation, even those involving only one person. They are *challenge, curiosity, control,* and *fantasy*. These *individual* motivations are those on which most previous theorizing has centered.

Challenge

That we seek and enjoy activities that offer us a challenge is a central tenet of many traditional theories of intrinsic motivation. Although individual theorists have employed a variety of terms—e.g., effectance motivation (Harter, 1978; Kagan, 1972; White, 1959), perceived competence (cf. Deci, 1975; Lepper & Greene, 1978b; Weiner, 1980b), flow states (Csikszentmihalyi, 1975), or self-efficacy (Bandura, 1977; Schank, 1983)—their common conviction seems to be that people prefer an *optimal level of challenge*. Activities that are trivially easy or impossibly difficult will be of little intrinsic interest. Activities that provide some intermediate level of difficulty and challenge will stimulate the greatest intrinsic motivation.

There is some agreement, in addition, on the characteristics of activities that are required for them to provide a challenge to learners. As a number of theorists have noted (e.g., Eifferman, 1974; Kagan, 1972;), in order for an activity to be challenging, it must provide goals such that goal attainment is uncertain. It should also provide performance feedback concerning goal attainment that will engage and enhance the self-esteem of the individual involved with the activity.

Goals. As we saw in the survey described earlier, the presence of an explicit goal seems to be important in the appeal of simple computer games. This appears to be true of other highly structured games and activities as well (Deci, 1975; Eifferman, 1974; Lepper & Greene, 1978b).

In other, more open-ended, learning environments, however, there are sometimes no explicit *fixed goals*, but rather many *emergent goals* (Csikszentmihalyi, 1975, 1978) that people can easily generate for themselves. For example, one of the advantages of the Logo computer progamming environment as a vehicle for instruction is that it is easy for children to generate their own goals: things that they would like to make a moving turtle do on the screen. One of the potential difficulties of such open-ended learning environments may be that it is easy for children to think of things that would be too difficult for them to do at their level of ability.

Finally, Bandura and Schunk (1981) have shown that *proximal* goals are superior to more *distal* or long-term goals for producing sustained intrinsic motivation and enhanced task performance. Hierarchical goal systems—that simultaneously provide both proximal and distal goals across a wide range of performances—may prove especially effective motivational devices.

Uncertain Outcome. Having a goal alone is not enough to make an activity or environment challenging. If one is certain to achieve a goal or certain *not* to achieve the goal, then the environment will not be challenging. In fact, some models of motivation specify that motivation will be maximal when uncertainty is maximal [i.e., when the probability of success is exactly one half (McClelland, Atkinson, Clark, & Lowell, 1953)].

Computer games nicely illustrate a number of techniques that can be used in other instructional environments to make outcomes uncertain for students at a wide range of ability levels or for the same student over time. These techniques include the following:

1. *Variable Difficulty Levels.* The difficulty of an activity for a particular learner, for example, can either be (a) determined automatically in response to the person's prior performance at the activity, (b) chosen by the person himself or herself, or (c) determined by an opponent's skill at the activity.

2. *Multiple Levels of Goals.* Effective learning environments will often present a variety of simultaneously available goals from which the learner may choose. Such multiple levels of goals may involve either (a) goals of the same type that vary in their difficulty or proximity (e.g., success at solving a particular single problem, across a block of similar problems, or over an entire lesson), or (b) goals that vary in kind. In instructional environments, this latter form of multiple levels of goals frequently involves the addition of higher-level performance goals (e.g., solving problems more quickly or efficiently than you or others have done in the past). Scorekeeping systems and response-speed contingencies are often involved here.

3. *Hidden Information.* Uncertainty may also be maintained by incomplete or hidden information. Hangman and other word-guessing games, for instance, use hidden information to create uncertainty.

4. *Randomness.* Finally, uncertainty may be enhanced by the use of random elements. This seems to be an important ingredient in maintaining motivation in many simulations, role-playing programs, and gambling games.

Performance Feedback. A third component that is required for an activity to provide continued challenge is feedback to the learner concerning his or her performance. Both learning from the activity and sustained motivation depend on performance feedback. Because feedback provides the information necessary for the reformulation of goals that govern an activity's challenge, activities will be more intrinsically motivating when the feedback they provide is (a) *frequent*, (b) *clear,* (c) *constructive* (i.e., providing useful information concerning the direction and nature of one's errors), and (d) *encouraging*.

Self-Esteem. Finally, challenge appears to be intrinsically motivating, in large part, because it engages the learner's sense of self-esteem (cf. Harter, 1978; Weiner, 1979). In the instructional domain, as elsewhere, success can make people feel better about themselves, and failure can make people feel worse about themselves. As Weiner and other attribution theorists have noted, however, such affective reactions are largely restricted to situations in which success or failure is viewed as a function of personal ability and/or effort (Graham & Weiner, this volume; Weiner, 1979, 1980b).

One implication of this observation is that performance feedback should be structured so as to promote perceptions of personal competence and effort and to minimize the possibility of diminishing the learner's self-esteem (cf. Dweck & Goetz, 1978; Weiner, 1980a). Note, however, that this concern may occasionally

conflict with the need for clear performance feedback. Similarly, such considerations underscore the potential utility of having a graded sequence of difficulty levels within an activity, so that players at any level of ability can progress with a reasonable rate of success.

Finally, this analysis suggests that to be maximally motivating, performance goals should be *personally meaningful*. Anderson, Shirey, Wilson, and Fielding (this volume), for instance, review evidence concerning the potentially powerful effects of such variations on learning and performance in the domain of reading. Making material that is not already so, personally relevant might be accomplished in a number of ways:

1. *Instrumental Relevance.* The functional utility of learning can be stressed—i.e., the links between proficiency in a subject and other competencies the learner values or desires can be illustrated and emphasized (cf. Bruner, 1962, 1966; Condry, 1977).
2. *Fantasy Relevance.* The material might be embedded in an imaginary context that is familiar to the learner or in a fantasy that the learner finds emotionally appealing.
3. *Social Relevance.* Finally, the material may be presented in a social context that elicits interpersonal motivations, such as cooperation, competiton, or recognition, that make performance goals meaningful to the learner.

A Cognitive Theory of Challenge. Our analysis of challenge is, of course, congruent with recent information-processing models of the problem-solving process. We believe that a further analysis of this source of motivation in such terms may prove useful for further theorizing in this area (Malone, 1980).

One very large and interesting class of intellectual activities can be characterized in terms of a current information *state,* a desired information state or *goal*, a set of *transformations* for changing one state into another, and a body of *search control knowledge* for deciding which transformations to apply in order to change a current state into a more desirable one (Newell, 1980; Newell & Simon, 1972).

A prototypic example of such an activity is the Towers of Hanoi puzzle (see Simon, 1975, for a detailed account). In this game, there are three pegs and a number of disks of different sizes that fit on the pegs. The *state* at any time is the configuration of disks on the pegs. The *initial state* of the puzzle has all the disks arranged on one peg, by size, with the largest on the bottom and the smallest on the top. The *goal* is to get all the disks on another peg, arranged in the same way. The possible *transformations* consist of moving a disk from one peg to another, subject to the *constraints* that only the top disk on a peg can be moved and a disk can never be moved to a peg that has smaller disks on it. The *search control* *knowledge* determines which disk to move when. The *problem space* for this puzzle consists of all the possible states connected by the transformations that change one state into another one.

Now, what makes a problem interesting in terms of this model? Clearly, the importance of having a *goal* in a challenging environment is nicely represented by the fact that a goal is an essential part of the problem-solving model. Two sources of outcome uncertainty also have interesting interpretations in this model. First, it suggests that one think about the determinants of the difficulty of a problem in terms of factors such as the amount of search required to reach the goal, the effort required to apply the transformations, the memory capacity required to carry out the search, etc. Second, it suggests that one think about higher-level goals—those that involve solving problems more quickly or elegantly—in terms of search control knowledge becoming more efficient through experience (e.g., Anzai & Simon, 1979) or the execution of transformations becoming *automatized* (e.g. Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1979). The implication, or at least an interesting hypothesis, here is that well-designed instructional environments, by providing high-level goals, can take advantage of a *natural* cognitive motivation to optimize existing mental procedures.

Note that the problem-solving model itself has little to say about why goals should be more motivating at one level of difficulty than another. To answer this question, we need a theory of why the problem-solving process is invoked in the first place. One way of addressing this issue is to assume that people pick goals at difficulty levels that maximize some function of the probability of success and the value of success. This is the approach taken by most theories of achievement motivation (e.g., Atkinson, 1964). Another way of addressing the issue is to assume that people pick goals that will give them the most information about themselves, thus satisfying their curiosity or social comparison needs (Festinger, 1954). In fact, these two approaches are closer than they seem. Studies of achievement motivation find that people often pick goals for which their probability of success is near 0.5 (see Weiner, 1980a). But these are exactly the goals that are most informative, in the technical sense of information theory, as their outcome is most uncertain.

Toys vs. Tools. The importance of challenge, however, will depend critically on whether one is intrinsically or extrinsically motivated to engage in the activity initially—on whether the activity is seen as a toy or a tool. We define *toys* as objects that are used for their own sake with no external goal (e.g., puzzles and games) and *tools* as objects that are used as a means to achieve some external goal (e.g., computer text editors and programming languages). Because the goals for a tool are already present in the external environment, there is no need for the tool to provide any goal or to make the achievement of the goal uncertain. Instead, tools should be made as efficient and reliable as possible. Unnecessary difficulty or complexity may prove frustrating, rather than rewarding. Toys, on the other hand, are frequently made intentionally difficult to use, in order to enhance their challenge.

Of course, many given activities can, in principle, be approached as either toys or tools, and the manner in which we approach them may significantly affect our enjoyment of them (Carroll, 1982; Lepper & Gilovich, 1982). This may help to explain why some users of complex computer systems seem to take a perverse pleasure in mastering tools that are extremely difficult to use (such as arcane text editors or baroque job control languages). To the extent that they are treating these systems not as tools to achieve external goals, but as toys to use for their own sake, the difficulty enhances the challenge and therefore the pleasure of using them.

In designing intrinsically motivating instructional environments, we sometimes need to create toys (such as the Darts game) that challenge learners to use skills they would not otherwise have wanted to use (such as estimating fractions). At other times, we need to create tools (such as text editors) that reduce the need for effortful, and otherwise unnecessary, instrumental activity (such as laborious recopying of text), thus allowing students to achieve goals they were already motivated to reach (such as communicating their thoughts in writing).

Curiosity

In a sense, curiosity is the most direct intrinsic motivation for learning. Most traditional theories of curiosity have suggested that curiosity is stimulated by an *optimal level of informational complexity* (Berlyne, 1960, 1965) or an *optimal level of discrepancy or incongruity* from present expectations and knowledge (Hunt, 1961, 1965; Kagan, 1972; Piaget, 1951, 1952). Even though curiosity is similar to challenge, in the sense that they both require an optimal level of stimulation, it is useful to treat the two categories separately. For example, the concept of self-esteem seems central to the notion of challenge, but curiosity need not engage self-esteem at all.

Sensory Curiosity. It is also useful to distinguish between *sensory curiosity* and *cognitive curiosity*. Sensory curiosity involves the attention-attracting value of variations and changes in the light, sound, or other sensory stimuli of an environment. The sorts of factors that influence this form of curiosity have been discussed in detail as "collative variables" by Berlyne (1960). Colorfully illustrated textbooks and educational manipulatives, (e.g., Cuisenaire Rods, Diene's Blocks, or Montessori materials) are examples of instructional materials designed to stimulate sensory curiosity.

More recent instructional technologies offer even more powerful opportunities for evoking sensory curiosity. Mander (1978) and Salomon (1979), for example, both discuss the attention-provoking properties of various "technical events": (e.g., zooms, dissolves, changes in camera angle) that have been made possible by the medium of television. Computers not only make possible similar changes in perspective and image, but encourage as well active *interaction* with the medium (e.g., Bork, 1980). One hypothesis would be that sensory curiosity in educational computer programs could be enhanced, independently of educational program content, by an increased use of technical events and/or interactive exchanges.

Cognitive Curiosity. Cognitive curiosity, on the other hand, is evoked by the prospect of modifying higher-level cognitive structures. We hypothesize that people have a cognitive drive to bring "good form" to their cognitive structures and that instructional environments can stimulate curiosity by making people believe that their existing knowledge structures are not well-formed (see Malone, 1980, 1981a, for extended discussions). In particular, we suggest that three of the characteristics of good scientific theories, *completeness, consistency,* and *parsimony,* are also characteristics of well-formed cognitive structures. Curiosity can be stimulated, therefore, by designing environments that make people think their knowledge structures lack one or more of these characteristics. For example, to stimulate curiosity by presenting an apparent inconsistency, one might say that plants require sunlight to live, but that fungi are plants that live in the dark (see Morozova, 1955). Or, to engage someone's drive for parsimony, one could present a number of examples and then indicate that there is a simple rule that parsimoniously explains all those examples.

The "Socratic Method" and related tutorial strategies can be viewed as one traditional means of systematically exposing incompletenesses, inconsistencies, or unparsimoniousness in the learner's knowledge structure (Collins & Stevens, 1981; McGuire, 1960). Again, however, recent computer technology may afford the opportunity for a more widespread use of such potentially powerful techniques for tailoring performance feedback, problem sequencing, and questioning to the capabilities of specific learners through the use of on-line diagnostic modeling and intelligent tutoring systems (e.g., Burton & Brown, 1979; Sleeman & Brown, 1982).

A Cognitive Theory of Curiosity. A number of traditional theorists have speculated about curiosity in cognitive terms (e.g., Berlyne, 1960; Hunt, 1965; Piaget, 1951), but none of these theorists had the benefit of the precise formalisms we have today for representing cognitive structures and processes. We suggest that the time may be ripe now for a modern cognitive theory of curiosity. For example, suppose one had a set of knowledge-structure descriptions in some kind of semantic network or frame-based representation language (e.g., Brachman, 1979; Minsky, 1975). How could one predict from those structural representations which structures would lead their owners to be most curious and what their owners would be curious about?

TABLE 10.3
Curiosity-Arousing Sequences as Predicted by Alternative Theories of Curiosity

1. Structural Anomaly Theories
   a. Inconsistency
      John brought Mary roses.
      Mary was angry.
   b. Incompleteness
      John brought Mary roses.
      Mary was angry.
      Mary said, "Don't you remember I'm allergic to flowers?"
   c. Parsimony
      John brought Mary roses.
      John brought Sally roses.
      John brought Sue roses.
      John brought Debby roses.
2. Spreading Interest Theories
      Dick Snow brought Mary roses.

Table 10.3 shows examples of some sequences of propositions that might be expected to arouse curiosity according to different theories of curiosity. For instance, a *structural anomaly* theory of curiosity would predict that sequence 1a would stimulate curiosity by presenting an apparent inconsistency, a structural anomaly which the reader would be motivated to remove. On the other hand, a *spreading interest* theory of curiosity would predict that people are interested in new information related to topics in which they are already interested—i.e., *interest* spreads along links between nodes as in "spreading activation" theories of memory (Collins & Loftus, 1975). According to a theory of this type, sequence 2 would stimulate curiosity if the reader knew Dick Snow and were interested in things that had to do with him. Again, the research reviewed by Anderson and colleagues (this volume) suggests the potential power of such variables to influence student motivation in the domain of reading.

Control

One of the most frequently cited explanations for why people find computer games so captivating is that these games give their players a powerful sense of control. The concept of control is, moreover, a cornerstone of yet a third set of traditional analyses of intrinsic motivation (cf. Condry, 1977; Lepper & Greene, 1978a). DeCharms, (1968), for example, posits a basic human tendency to seek to control one's environment—to experience oneself as an "Origin" of one's own actions and choices, and not a "Pawn" of external forces. Likewise, Deci (1975, 1981) defines intrinsic motivation as a striving for competence and self-determination (where *self-determination* means *control*).

In fact, within this literature, there are several, slightly different usages of the term *control*. Underlying these varying usages, however, are two general concepts: that the amount of control a person has in a particular environment depends on (a) the range of outcomes that the environment provides, and (b) the extent to which the probability of each outcome is contingent upon (i.e., can be influenced by) responses available to the person in that environment. *Empowering* learning environments, then, are those in which options are rich, and dependent upon the response of the learner. In addition, there seems to be considerable agreement that it is the *perception* of control, rather than the objective level of actual control, that is the important psychological variable of interest (cf. Zimbardo, 1969). Such perceptions, in turn, will be determined not only by the actual contingencies inherent in the situation but also by systematic biases and illusions that color our perceptions of control (Langer, 1975).

Contingency. A first characteristic of an empowering environment is that one's outcomes are, indeed, dependent upon one's responses. In almost any learning environment, there will be differential feedback as a function of the learner's success or failure on particular problems, providing some element of control for those learners who have the ability to succeed at the task. Note, however, that goals that prove, or appear, beyond the learner's capabilities may undermine the student's sense of control as well as his or her sense of competence—with clear adverse effects on intrinsic motivation (cf. Condry & Chambers, 1978; Dweck & Goetz, 1978; Seligman, 1975). In more sophisticated learning environments, of course, other contingencies may be equally significant. The problems to be presented to the learner, the types of corrective feedback provided, and the methods of instruction employed may all vary as a function of the learner's demonstrated strengths and weaknesses on previous problems.

Choice. That an environment is, in fact, responsive may not be sufficient to produce high levels of perceived control. Its responsiveness must be apparent, indeed salient, to the learner. In this respect, one variety of control—the provision of explicit choices among alternatives—deserves special emphasis. Not only has the provision of choice been shown to enhance intrinsic motivation per se (Nuttin, 1973; Zuckerman, Porac, Lathin, Smith, & Deci, 1978), it has also proved a significant variable in a variety of motivational paradigms (cf. Zimbardo, 1969).

Particularly in the domain of computer-based learning (in which much instructional control occurs behind the scenes), students may have trouble recognizing or appreciating differences in actual environmental responsiveness. Fortunately, such environments also afford the opportunity for providing learners with high levels of choice. Some forms of choice may have major instructional

entailments, as when the learner is permitted to choose which task to undertake, which problems to study or solve, or how difficult a goal to set. Other sorts of choices may be introduced, however, without varying the instructional content of a program at all. Students may be explicitly offered choices between a number of different game formats, fantasies, or audio-visual effects, for example, without varying the educational subject matter presented (as illustrated in the Darts studies described earlier). Similarly, instructional materials on the computer can often be *personalized* by allowing the student to construct, select, or name characters (or other features) of a computer-based fantasy, with the computer filling in appropriate slots throughout the program with this information.

In fact, there is evidence that even an *illusion* of control may often produce powerful effects (Langer, 1975). Although we would not recommend it as a design strategy, it seems possible that even response-independent programs that *appear* to have been responsive to user input would produce enhanced levels of intrinsic motivation.

We should note, however, that there is a potential danger in believing that additional choices will always enhance motivation. Instead, we believe, there is probably some optimal, intermediate number of choices that will be maximally motivating. Faced with more choices than we can reasonably discriminate among (perhaps 5–7 alternatives [cf. Miller, 1956]), for instance, we are likely to devalue the importance of choice, and to experience frustration instead of satisfaction.

These considerations should also help us to understand both the potential benefits, and the possible dangers, of more open-ended, exploratory learning environments (e.g., Brown, 1983; Lepper, 1985). On the one hand, the availability of choices at each level of analysis, at every step in the process of selecting and completing a project, can be highly intrinsically motivating (Lepper & Greene, 1978b). On the other, a total lack of structure may leave many learners overwhelmed and unable to make effective choices. We return to these issues in the next chapter.

Power. A final means of taking advantage of the motivational benefits of perceived control is to create environments in which students' actions have "powerful effects"—in which the differences among the alternatives the learner can produce are large and salient. Such a strategy is likely to have particularly potent effects on subsequent motivation, moreover, when such powerful effects have been produced with relatively more minor investments of effort and energy.

This is, once again, a possibility to which computers and other interactive instructional media seem particularly well suited, and for which they have received much attention (e.g., Levin & Kareev, 1980; Papert, 1980). For example, one of the attractive features ascribed to Logo learning environments is that relatively minor alterations in certain sorts of programs or "microworlds" can have very large and spectacular visual effects (Lawler, 1981, 1982; Papert, 1980). Similar opportunities are afforded by increasingly sophisticated computer graphics and music-composition programs (Brown, 1985).

Fantasy

Our final category—fantasy—is often not included in discussions of intrinsic motivation, but it is clearly important in many kinds of intrinsically motivating activities, such as computer games, television, reading, and dramatic play (cf. Singer, 1973). We define a fanasy environment as one that evokes mental images of physical or social situations not actually present (e.g., darts and balloons or being the ruler of a kingdom). We believe such fantasies contribute to intrinsic motivation in several ways.

Endogenous vs. Exogenous Fantasies. In designing instructional environments, it is important to distinguish between endogenous and exogenous fantasies. An *exogenous fantasy* in an instructional environment is one in which the fantasy depends on the skill being learned, but not vice versa. For instance, many exogenous fantasies depend only on whether the answers to a series of problems are right or wrong. An example might be a mathematics game in which a spaceship advances toward the moon every time the player gets a right answer and goes backwards every time the player gets a wrong answer. The Hangman game is another example of an exogenous fantasy, in which every time the player makes an incorrect guess in the spelling of a word, another body part of a man being hung is displayed on the screen.

In contrast to these exogenous fantasies, the Darts game is a good example of an *endogenous fantasy,* in which the skill being learned and the fantasy depend on each other. In Darts, not only does the fantasy of balloons being popped depend on the player's skill at estimation, but the skill also depends on the fantasy since the skill is exercised in the fantasy context. In this latter case, there is an integral and continuing relationship between the fantasy context and the instructional content being presented; whereas, in the preceding case, the relationship is arbitrary and periodic. One frequent advantage of this endogenous connection between fantasy and skill is that the fantasy provides specific constructive feedback (e.g., too high or too low), not just right/wrong feedback. Endogenous fantasies can also provide useful metaphors for learning new skills (e.g. spatial metaphors for mathematical concepts), and they can provide examples of real-world contexts in which the new skills could be used (e.g., a simulation of running a lemonade stand). We hypothesize that, in general, endogenous fantasies are both more interesting and more educational than exogenous fantasies.

Emotional Aspects of Fantasy. Fantasies almost certainly derive much of their appeal from the emotional needs they help to satisfy (e.g., Freud, 1950;

Murray, 1938). In fantasy, each of us can vicariously experience the satifactions of power, success, fame, and/or fortune and can master situations that would baffle or be unavailable to us in real life.

We should note that it may prove difficult, in general, to characterize the different emotional needs people have and to predict precisely which fantasies might be appealing to particular individuals. It does seem clear that there are large differences among people in the fantasies they enjoy (cf. Singer, 1973). For instance, in the survey described earlier, no single game received more than 17% of the first-place rankings. Moreover, fantasies may provide a vicarious fulfillment of motivations from a number of other categories in this taxonomy (e.g., to succeed in the face of challenge or to control the lives of others).

One general mechanism that may underlie, and explain, a number of these salient individual differences is *identification.* That is, fantasies are most likely to fulfill emotional needs when they provide imaginary characters with whom the individual can identify (cf. Anderson & Pichert, 1978; Pichert & Anderson, 1977). The probability of identification with a character, moreover, is likely to increase as a function of three primary factors: (a) *perceived similarity* between the self and the character (in their characteristics or their situations), (b) *admiration* for the character, and (c) salience of that character's *perspective* or point of view in the fantasy. Hence, it should be expected that people's enjoyment of particular fantasies will differ as a function of their own characteristics and values.

Nonetheless, one implication of this variance is clear: If instructional designers can create different kinds of fantasies for different kinds of people, their activities are likely to have a much broader appeal. For example, mathematics games could be designed in such a way that different students see the same problems, but in different fantasy contexts of their own choosing. Alternatively, one might also create fantasy environments into which students can project their own fantasies in a relatively unconstrained way. One might permit students, for instance, to name imaginary participants, locales, or objects to appear in a subsequent computer game, or to actually design characters that will appear on the screen. Once again, the opportunities that computer-based instructional systems offer for such *tailoring* of motivational elements to the needs and backgrounds of different students deserves emphasis.

Cognitive Aspects of Fantasy. In addition to the emotional needs that fantasies may serve, there is also a cognitive component to involvement with fantasies. Endogenous fantasies, in particular, frequently offer analogies or metaphors that may provide the learner with leverage for better understanding new information by relating it to past knowledge. In the Darts game, for instance, children—*if* they make the critical connection between number size and position on the number line—can use their knowledge of physical objects and relationships to help them comprehend the novel domain of fractions and mixed numbers. Conversely, in the case of simulations and modeling systems, the purpose often is to present students with information and experience in an imaginary context that they will later be asked to apply to real-world situations. Finally, the use of fantasies may also have further cognitive advantages, such as improving memory for the material, if it leads the learner to adopt particular roles (e.g., Anderson & Pichert, 1978; Pichert & Anderson, 1977) or evokes from the learner more vivid images related to the material to be learned (Bower, 1972; Paivio, 1971).

INTERPERSONAL MOTIVATIONS

Other forms of intrinsic motivation, (i.e., *competition, cooperation,* and *recognition*) are interpersonal; they depend on other people. Sometimes, what might seem to be interpersonal motivations are decomposable to individual motivations. For instance, competition is often an effective and natural way of providing an appropriate difficulty level for the individual motivation of challenge. At other times these interpersonal motivations are clearly extrinsic. For example, recognition or approval can provide strong extrinsic motivations for learning. But, in many situations, these interpersonal factors provide important intrinsic motivations that would not be present in the absence of other people.

Cooperation and Competition

Cooperation and competition are considered together here because they are, in many ways, parallel. There is an extensive literature about cooperation and competition; for example, the psychological needs they satisfy (e.g., Murray, 1938), the conditions under which one or the other occurs (e.g., Rapoport & Chammah, 1965), the ways they develop as children grow (e.g., Shaffer, 1979), and their effects on tasks such as learning in school (e.g., deVries & Slavin, 1978). Just as the notion of challenge requires a goal (or more precisely, a means of evaluating outcomes), the concepts of cooperation and competition only make sense in situations where utilities can be assigned to the outcomes of the participants' actions. In competitive situations, where one person's gain is another's loss, these utilities sum to zero; in cooperative situations, they do not (Luce & Raiffa, 1957). This is not to say that accomplishing the goal need be more important to the participants than cooperating or competing (in fact, in many cases, it may not be [e.g., Kagan & Madsen, 1972]), merely that there must be some goal in order for the concepts of cooperation and competition to be meaningful.

Often, cooperation has been assumed to be *good* and competition has been assumed to be *bad*. We adopt the position here that both can provide powerful motivations for learning, and that both can be employed in ways that have

detrimental effects and in ways that have beneficial effects. Our primary concern here is with how to harness their motivational power. It should be clear, however, that inappropriate uses of this power may lead to antagonistic social relationships, serious losses of self-esteem, and other detrimental outcomes (cf. Shaffer, 1979).

In order to design instructional environments that encourage cooperation or competition, it is important to distinguish between tasks that are segmented into *independent* units and those that are segmented into *dependent* units. For example, a spelling task could be divided so that the participants take turns spelling whole words at a time (independent units) or take turns providing the next letter in the word being spelled (dependent units). In playing the Darts game, players could take turns on alternate rounds (independent units), or they could let one person make the estimates and another person type them into the computer (dependent units) (see Levin & Cole, 1983). This distinction is roughly equivalent to that between "product" and "functional" divisions in organizational design (March & Simon, 1958).

The techniques for designing instructional environments that encourage cooperation or competition will be different depending on which of these two ways the tasks are segmented. In the independent case, techniques for encouraging cooperation or competition will be *exogenous;* in the dependent case, cooperation or competition may be *endogenous* to the activity. Our hypothesis is that both endogenous cooperation and endogenous competition will have more positive effects on subsequent intrinsic motivation than their respective exogenous counterparts.

Endogenous and Exogenous Cooperation. With independent tasks, the simplest method of encouraging cooperative behavior is to combine the scores of different people (for example, the total words spelled correctly by everyone on the team). We hypothesize that this exogenous form of cooperation will often provide a relatively weak form of motivation.

When a single overall task is broken into dependent parts, however, the people performing different parts are placed in an endogenously cooperative situation. For example, in one computer game we have observed children playing, there were two knobs, one for controlling the vertical motion of an object on the screen and one for the horizontal motion. Even though the game was apparently intended as a one-person game, children often played it cooperatively in pairs, with each player controlling one knob. One of the most elaborate examples of an instructional environment designed to encourage endogenous cooperation is the "jigsaw" procedure developed by Aronson and colleagues (Aronson, Blaney, Stephan, Sikes, & Snapp, 1978), in which each student on a team is given information about a different part of the life of a famous person and the team members are then asked to collaborate in writing a short biography of the person.

Endogenous and Exogenous Competition. With independent tasks, it is easy to encourage competition, simply by providing some salient metric, such as scores, with which people can compare their performances—to determine, for example, who got the most problems right or spelled the word the fastest. The addition of such exogenous competitive pressures *may* stimulate interest during the initial performance, but it appears to have detrimental effects on *subsequent* intrinsic motivation (Deci, Betley, Kahle, Abrams, & Porac, 1981).

When, instead of having independent tasks, the people with conflicting goals are working on dependent tasks, a particularly interesting form of endogenous competition is encouraged. For example, an exogenous means of making the Darts game competitive would be to have players compete with scores on alternate rounds. A much more interesting, endogenous technique (suggested by J. S. Brown [personal communication]) would be to have balloons for both players appear on the number line at the same time (perhaps in different colors), so that when players miss their own balloons, they run the risk of accidentally hitting the other player's balloon and thus unintentionally helping their competitor.

Recognition

The final kind of intrinsic motivation that can be used in designing instructional environments is recognition. Although traditional motivational theorists have again used a variety of terms to describe this motivation (e.g., need for approval, exhibition, or recognition), there is some general agreement that we enjoy having our efforts and accomplishments recognized and appreciated by others.

In order for an environment to engage the motivation for recognition, the results of one's activities must be visible to other people. This can be done in several ways: (1) the *process* of performing the activity may be visible (e.g., artists painting in public), (2) the *product* of the activity may be visible (e.g., paintings in an exhibition), or (3) some other *result* of the activity may be visible (e.g., published names of prize-winners in a contest).

Endogenous and Exogenous Recognition. We hypothesize that the motivation for recognition is likely to be stronger, and learning more effective, when the recognition is endogenous or natural to the activity. For example, class newspapers, art exhibitions, speeches, and musical recitals provide endogenous vehicles by which students' activities can be recognized. Publishing *honor rolls*, on the other hand, provides an exogenous form of recognition.

A nice example of a computer-based learning environment that indorporates recognition motivation is the Hall of Fame facility in the Green Globs game (Dugdale, 1983). In this game, "globs" appear at random places on a Cartesian grid, and players type in equations that are graphed on the grid, as illustrated in Fig. 10.2. The goal in this activity is to type in equations that intersect as many

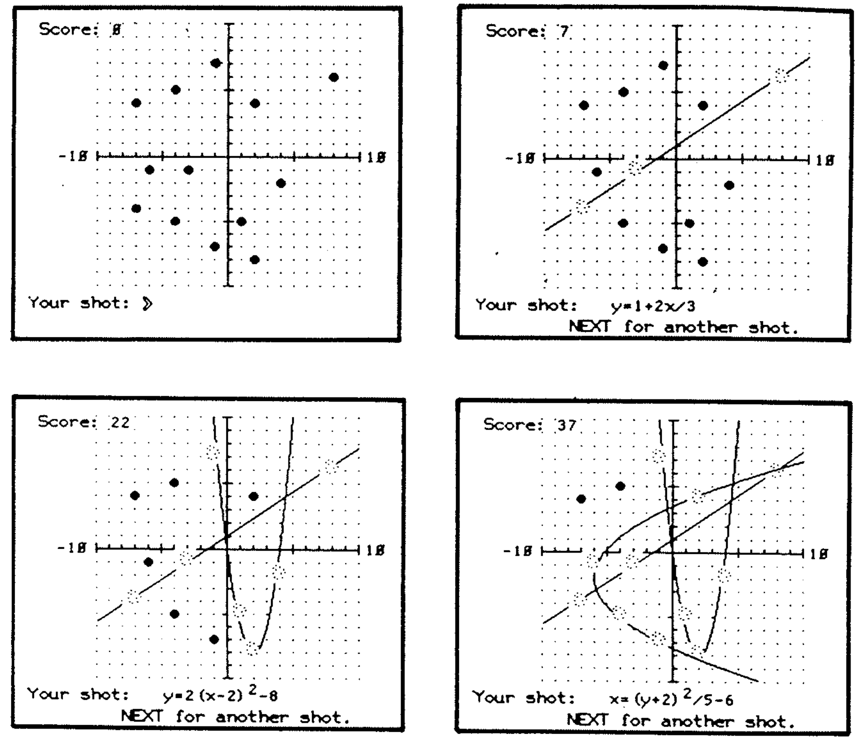

FIG. 10.2. A sequence of displays from a game of *Green Globs,* showing the initial display of 13 globs, followed by the student's first three shots. Green Globs is an activity on the disk *Graphing Equations* by Sharon Dugdale and David Kibbey, Iowa City, IA: CONDUIT, 1983. Copyright 1983 by Sharon Dugdale and David Kibbey. Reprinted by permission.

globs as possible on each try. For example, a straight line might intersect only one or two globs, while a third-degree polynomial might intersect four or five. Scoring is essentially exponential, providing a strong incentive for students to maximize the number of hits per equation.

The Hall of Fame is an on-line record of high scoring games that all students can access. Because the placement of the globs is random for each student, players can almost never copy solutions exactly from the Hall of Fame, but they can learn new forms of equations and other techniques. Thus, successful players can be motivated by the recognition their moves will receive from other players; and the other players can, in turn, learn from these moves.

INDIVIDUAL DIFFERENCES

Throughout the foregoing presentation of our taxonomy of intrinsic motivations for learning, we have indicated areas in which individual differences among learners seemed likely to play a significant part. In this section, we consider the issues raised by potential initial differences among students in more detail.

Student-Treatment Interactions

One potential application of our taxonomy of intrinsic motivations is as a device for discerning and categorizing the dimensions of individual differences that have implications for the design of intrinsically motivating learning environments. There are at least two different ways in which such differences may act to determine the motivational effectiveness of different instructional environments.

Categories. A first type of interaction involves a differential value placed on different categories of intrinsic motivation by different individuals. In this sense, it is possible to use our taxonomy to classify individuals with respect to the importance they attach to different categories of motivational features (e.g., challenge vs. curiosity vs. fantasy) or the importance they attach to different features within a particular category. For some children, for instance, the identification with fantasy characters in role-playing games like Dungeons and Dragons may be a central aspect of the motivational appeal of these activities. For others, however, this fantasy may provide only a largely incidental context in which an opportunity to tackle challenges and establish one's competence is embedded.

Specific Content. A second form of interaction to which the present taxonomy may be relevant involves possible individual differences in the ways in which the content of specific interventions will affect different forms of intrinsic motivation. With respect to challenge, for example, differences in students' levels of ability should be a central determinant of their reaction to manipulations that increase or decrease the difficulty of the task or the speed with which one progresses through different levels of difficulty. One's prior expectations, likewise, will determine the events that one will find surprising and curiosity-provoking. Similarly, individual differences in emotional needs and identifications may determine the motivational effects of embedding mathematics problems in the context of an alien invasion or a football game.

In fact, in the strongest case, there may be situations in which the same intervention or motivational embellishment may have quite opposite effects on different learners (Lepper & Malone, this volume). For example, increasing the difficulty level of an activity or introducing competition may enhance interest for

children with high ability and self-confidence, yet undermine the motivation of children low in ability and self-esteem.

Instigation vs. Maintenance of Interest

Closely related to the foregoing arguments concerning the importance of *chronic* differences among students is the distinction between the power of a learning environment to attract students initially and its power to maintain their interest in the activity over time. In a sense, the point here is that the same pupil may be a *different* student at different points in a sustained interaction with an instructional environment, as learning and habituation occur, as expectations and perceptions of competence change, etc.

Particularly with computer-based learning materials, it seems easy to produce programs in which novel technical gimmicks are employed to attract children's attention and to produce initial task engagement. Many of these programs, however, seem to fail the test of time, losing their appeal rapidly with the repeated use that may be necessary for learning from them to occur. What is needed, obviously, is for the program to be able to diagnose and model changes in the learner and to adjust accordingly. In the realm of challenge, this has long been true of the most sophisticated instructional programs. In our other domains, however, much less attention has been given to these issues.

Most generally, it is instructive to contrast educational research efforts over the past 20 years in the cognitive and the motivational spheres. With respect to cognitive variables, for example, the issues of aptitude-treatment interactions (Cronbach & Snow, 1977), performance-based branching, and diagnostic modeling (Sleeman & Brown, 1982) have received much attention. In the motivational domain, by contrast, there has been minimal attention to such issues, although one might well argue that individual differences in motivation are at least as large and as important as individual differences in cognition. We suggest that greater attention to the individualization of learning environments on motivational, as well as instructional, grounds may ultimately pay large educational benefits.

SUMMARY

The taxonomy we have just described is summarized in Table 10.4 as a set of proposed guidelines for the design of intrinsically motivating instructional environments. One use of this taxonomy, therefore, is as a checklist of heuristics for designing instructional activities. For example, only one fifth of the games in the survey described at the outset had a variable difficulty level and many of the rest of them could presumably have been improved by adding this feature.

There is a danger here, however, in treating this checklist as a prescription or grab bag and assuming that more features are always better. It is easy to produce

TABLE 10.4
Heuristics for Designing Intrinsically Motivating Instructional Environments

I. INDIVIDUAL MOTIVATIONS

A. Challenge:

The activity should provide a continuously optimal (intermediate) level of difficulty for the learner

1. Goals--The activity should either (a) present clear, fixed goals or (b) provide an environment in which it is easy for students to generate goals for themselves at an appropriate level of difficulty

The activity should provide short-term, as well as long-term, goals

2. Uncertain Outcomes--Uncertainty of outcome may be produced using:

(a) Variable difficulty levels
(b) Multiple levels of goals
(c) Hidden information, selectively revealed
(d) Randomness

3. Performance Feedback--Performance feedback should be frequent, clear, constructive, and encouraging

4. Self-Esteem--The activity should employ graded difficulty levels and positive feedback techniques to promote feelings of competence

The activity should employ personally meaningful goals that have instrumental, fantasy, or social relevance for the learner

B. Curiosity:

The activity should provide an optimal (moderate) level of informational complexity or discrepancy from the learner's current state of knowledge and information

1. Sensory Curiosity--Sensory curiosity may be enhanced by variability in audio and visual effects

The activity should promote interactive exchange with the learner

2. Cognitive Curiosity--Curiosity may be promoted by instructional techniques that cause learners to be surprised and intrigued by paradoxes, incompleteness, or potential simplifications

Cognitive curiosity will be enhanced when activities deal with topics in which the learner is already interested

C. Control:

The activity should promote feelings of self-determination and control on the part of the learner

1. Contingency--The activity should provide a responsive learning environment

2. Choice--The activity should provide and emphasize moderately high levels of choice over various aspects of the learning environment

Personalization of the activity may enhance perceptions of choice

3. Power--The activity should permit the learner to produce powerful effects

(Table 10.4 continued)

D. Fantasy:

The activity may promote intrinsic motivation through the use of fantasy involvement

1. Emotional Aspects--Fantasies should be designed to appeal to the emotional needs of learners

Fantasies should encourage identification with imagined characters or contexts

2. Cognitive Aspects--Fantasies should provide appropriate metaphors or analogies for the material presented for learning

3. Endogeneity--Fantasies should have an integral, endogenous, relationship to the material to be learned

II. INTERPERSONAL MOTIVATIONS

A. Cooperation:

The appeal of the activity may be enhanced by enlisting the motivation to cooperate with others

Endogenous cooperative motivation may be produced by segmenting the activity into inherently interpendent parts

B. Competition:

The appeal of the activity may be enhanced by enlisting the motivation to compete with others

Endogenous competitive motivation may be produced by creating an activity in which competitors' actions affect each other

C. Recognition:

The appeal of the activity may be increased if the learner's efforts receive social recognition

Endogenous recognition motivation may be produced by activities that provide natural channels for students' efforts to be appreciated by others

incoherent and unappealing conglomerations of these features if the interactions between the features and the overall aesthetic appeal of the activity are not considered. To the extent that this taxonomy provides a model of how to design intrinsically motivating learning environments (such as games), it is analogous to a model of how to write good novels. No one should expect a simple reductionist approach to novel-writing to enable someone to write good novels, however, unless the writer already has a great deal of other relevant knowledge. In the same spirit, we should expect a taxonomy like the one we have presented here to be a way of guiding and sharpening intuitions and aesthetic sensitivity, not a way of replacing them.

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REFERENCES

Anderson, R. C., & Pichert, J. W. (1978). Recall of previously unrecallable information following a shift in perspective. *Journal of Verbal Learning and Verbal Behavior, 17*, 1–12.

Anzai, Y., & Simon, H.A. (1979). The theory of learning by doing. *Psychological Review, 86*, 124–140.

Aronson, E., Blaney, N., Stephan, C., Sikes, J., & Snapp, M. (1978). *The jigsaw classroom.* Beverly Hills, CA: Sage.

Atkinson, J. W. (1964). *An introduction to motivation.* Princeton, NJ: Van Nostrand.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191–215.

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-instruction. *Journal of Personality and Social Psychology, 41*, 586–598.

Banet, B. (1979). Computers and early learning: A new direction for High/Scope Foundation. *Calculators/Computers, 3*, 17.

Bower, G. H. (1972). Mental imagery and associative learning. In L. W. Gregg (Ed.), *Cognition in learning and memory.* New York: Wiley.

Berlyne, D. E. (1960). *Conflict, arousal, and curiosity.* New York: McGraw-Hill.

Berlyne, D. E. (1965). *Structure and direction in thinking.* New York: McGraw-Hill.

Berlyne, D. E. (1966). Curiosity and exploration. *Science, 153*, 25–33.

Bork, A. (1980). Preparing student-computer dialogs: Advice to teachers. In R. P. Taylor (Ed.), *The computer in the school: Tutor, tool, tutee.* New York: Teachers College Press.

Brachman, R. J. (1979). On the epistemological status of semantic networks. In N. V. Findler (Ed.), *Associative networks: Representation and use of knowledge by computers.* New York: Academic Press.

Brown, J. S. (1983). Learning-by-doing revisited for electronic learning environments. In M. A. White (Ed.), *The future of electronic learning.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, J. S. (1985). Process versus product—A perspective on tools for communal and informal electronic learning. *Journal of Educational Computing Research, 1*, 179–201.

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review, 31*, 21–32.

Bruner, J. S. (1962). *On knowing: Essays for the left hand.* Cambridge, MA: Harvard University Press.

Bruner, J. S. (1966). *Toward a theory of instruction.* Cambridge, MA: Harvard University Press.

Burton, R. R., & Brown, J. S. (1979). An investigation of computer coaching for informal learning activities. *International Journal of Man-Machine Studies, 11*, 5–24.

Carroll, J. M. (1982). The adventure of getting to know a computer. *IEEE: Computer, 15*, 49–58.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review, 82*, 407–428.

Collins, A. M., & Stevens, A. L. (1981). Goals and strategies of inquiry teachers. In R. Glaser (Ed.), *Advances in instructional technology* (Vol. 2). Hillsdale, NJ: Lawrence Erlbaum Associates.

Condry, J. C. (1977). Enemies of exploration: Self-initiated versus other-initiated learning. *Journal of Personality and Social Psychology, 35*, 459–477.

Condry, J., & Chambers, J. (1978). Intrinsic motivation and the process of learning. In M. R. Lepper & D. Greene (Eds.), *The hidden costs of reward.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Cronbach, L. J., & Snow, R. E. (1977). *Aptitudes and instructional methods: Handbook for research on interactions.* New York: Irvington.

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety.* San Francisco: Jossey-Bass.

Csikszentmihalyi, M. (1978). Intrinsic rewards and emergent motivation. In M. R. Lepper & D. Greene (Eds.), *The hidden costs of reward.* Hillsdale, NJ: Lawrence Erlbaum Associates.

deCharms, R. (1968). *Personal causation.* New York: Academic Press.

Deci, E. L. (1975). *Intrinsic motivation.* New York: Plenum.

Deci, E. L. (1981). *The psychology of self-determination.* Lexington, MA: Heath.

Deci, E. L., Betley, G., Kahle, J., Abrams, L., & Porac, J. (1981). When trying to win: Competition and intrinsic motivation. *Personality and Social Psychology Bulletin, 7*, 79–83.

DeVries, D. L., & Slavin, R. E. (1978). Teams-Games-Tournament (TGT): Review of ten classroom experiments. *Journal of Research and Development in Education, 12*, 28–38.

Dugdale, S. (1983). Green Globs. In D. F. Walker & R. D. Hess (Eds.), *Instructional software.* Belmont, CA: Wadsworth.

Dugdale, S., & Kibbey, D. (1980). *Fractions curriculum of the PLATO elementary school mathematics project.* Urbana-Champaign, Illinois: Computer-based Education Research Laboratory.

Dweck, C. S., & Goetz, J. E. (1978). Attributions and learned helplessness. In J. Harvey, W. Ickes, & R. Kidd (Eds.), *New directions in attribution research* (Vol. 2). Hillsdale, NJ: Lawrence Erlbaum Associates.

Eifferman, R. R. (1974). It's child's play. In L. M. Shears & E. M. Bower (Eds.), *Games in education and development.* Springfield, IL: C. C. Thomas.

Festinger, L. (1954). A theory of social comparison processes. *Human Relations, 7*, 117–140.

Freud, S. (1950). *Beyond the pleasure principle.* New York: Liveright. (Originally published 1920)

Harter, S. (1978). Effectance motivation reconsidered: Toward a developmental model. *Human Development, 1*, 34–64.

Hunt, J. Mc.V. (1961). *Intelligence and experience.* New York: Ronald Press.

Hunt, J. Mc.V. (1965). Intrinsic motivation and its role in psychological development. In D. Levine (Ed.), *Nebraska Symposium on Motivation* (Vol. 13). Lincoln: University of Nebraska Press.

Jackson, P. (1968). *Life in classrooms.* New York: Holt, Rinehart, & Winston.

Kagan, J. (1972). Motives and development. *Journal of Personality and Social Psychology, 22*, 51–66.

Kagan, S., & Madsen, M. L. (1972). Experimental analyses of cooperation and competition of Anglo-American and Mexican-American children. *Developmental Psychology, 6*, 49–59.

Kruglanski, A. W. (1975). The endogenous-exogenous partition in attribution theory. *Psychological Review, 82*, 387–406.

Kruglanski, A. W. (1978). Endogenous attribution and intrinsic motivation. In. M. R. Lepper & D. Greene (Eds.) *The hidden costs of reward.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Langer, E. J. (1975). The illusion of control. *Journal of Personality and Social Psychology, 32*, 311–328.

Lawler, R. W. (1981). The progressive construction of mind. *Cognitive Science, 3*, 1–30.

Lawler, R. W. (1982). Designing computer microworlds. *Byte, 7*, 138–160.

Lepper, M. R. (1983). Extrinsic reward and intrinsic motivation: Implications for the classroom. In J. M. Levine & M. C. Wang (Eds.), *Teacher and student perceptions: Implications for learning.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Lepper, M. R. (1985). Microcomputers in education: Motivational and social isues. *American Psychologist, 40,* 1–18.
Lepper, M. R., & Gilovich, T. (1982). Accentuating the positive: Eliciting generalized compliance from children through activity-oriented requests. *Journal of Personal and Social Psychology, 42,* 248–259.
Lepper, M. R., & Greene, D. (Eds.) (1978a). *The hidden costs of reward.* Hillsdale, NJ: Lawrence Erlbaum Associates.
Lepoper, M. R., & Greene, D. (1978b). Overjustification and beyond: Toward a means-end analysis of intrinsic and extrinsic motivation. In M. R. Lepper & D. Greene (Eds.), *The hidden costs of reward.* Hillsdale, NJ: Lawrence Erlbaum Associates.
Lepper, M. R., & Malone, T. W. (in preparation). *Learning and motivation in an educational computer game.* Stanford University.
Levin, J. A., & Cole, M. (1983). Untitled conference session summary. In T. W. Malone & J. A. Levin (Eds.), Microcomputers in education: Cognitive and social design principles. *ACM SIGCUE Bulletin, 17,* 6–20.
Levin, J. A., & Kareev, Y. (1980). *Personal computers and education: The challenge to schools.* (Unpublished technical report). Laboratory of Comparative Human Cognition, University of California, San Diego.
Luce, R. D., & Raiffa, H. (1957). *Games and decisions: Introduction and critical survey.* New York: Wiley.
Malone, T. W. (1980). *What makes things fun to learn? A study of intrinsically motivating computer games.* Unpublished doctoral dissertation, Stanford University.
Malone, T. W. (1981a). Toward a theory of intrinsically motivating instruction. *Cognitive Science, 4,* 333–369.
Malone, T. W. (1981b). What makes computer games fun? *Byte, 6,* 258–277.
Mander, J. (1978). *Four arguments for the elimination of television.* New York: William Morrow & Co.
March, J. A., & Simon, H. A. (1958). *Organizations.* New York: Wiley.
McClelland, D. C., Atkinson, J. W., Clark, R. A., & Lowell, E. L. (1953). *The achievement motive.* New York: Appleton.
McGuire, W. J. (1960). A syllogistic analysis of cognitive relationships. In M. J. Rosenberg, C. I. Hovland, W. J. McGuire, R. P. Abelson, & J. W. Brehm (Eds.), *Attitude organization and change.* New Haven, CT: Yale University Press.
Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63,* 81–97.
Minsky, M. A. (1975). A framework for representing knowledge. In P. H. Winston (Ed.), *The psychology of computer vision.* New York: McGraw-Hill.
Morozova, N. G. (1955). [The psychological conditions for the arousal and modification of interest in children in the process of reading popular scientific literature.] *Izvestiia Akad. Pedag. Nauk, 73,* 100–149. (Cited and summarized by Berlyne, 1965.)
Murray, H.A. (and collaborators). (1938). *Explorations in personality.* New York: Oxford.
Newell, A. (1980). Reasoning, problem solving, and decision processes: The problem space as a fundamental category. In R. Nickerson (Ed.), *Attention and Performance VIII.* Hillsdale, NJ: Lawrence Erlbaum Associates.
Newell, A., & Simon, H. A. (1972). *Human problem solving.* Englewood Cliffs, NJ: Prentice-Hall.
Nuttin, J. R. (1973). Pleasure and reward in human motivation and learning. In D. E. Berlyne & K. B. Madsen (Eds.), *Pleasure, reward, preference.* New York: Academic Press.
Paivio, A. (1971). *Imagery and verbal processes.* New York: Holt, Rinehart and Winston.
Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York: Basic Books.
Piaget, J. (1951). *Play, dreams, and imitation in childhood.* New York: Norton.
Piaget, J. (1952). *The origins of intelligence in children.* New York: International University Press.

Pichert, J. W., & Anderson, R. C. (1977). Taking a different perspective on a story. *Journal of Educational Psychology, 69,* 309–315.
Popper, K. R. (1959). *The logic of scientific discovery.* London: Hutchinson.
Rapoport, A., & Chammah, A. M. (1965). *Prisoner's dilemma.* Ann Arbor: University of Michigan Press.
Salomon, G. (1979). *Interaction of media, cognition, and learning.* San Francisco: Jossey-Bass.
Schneider, W., & Shiffrin, R. R. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 84,* 1–66.
Schunk, D. H. (1983). Reward contingencies and the development of children's skills and self-efficacy. *Journal of Educational Psychology, 75,* 511–518.
Seligman, M. E. P. (1975). *Helplessness.* San Francisco: Freeman.
Shaffer, D. R. (1979). *Social and personality development.* Monterey, CA: Brooks/Cole.
Shiffrin, R. R., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review, 84,* 127–190.
Simon, H. A. (1975). The functional equivalence of problem solving skills. *Cognitive Psychology, 7,* 268–288.
Singer, J. L. (Ed.). (1973). *The child's world of make-believe.* New York: Academic Press.
Sleeman, D., & Brown, J. S. (Eds.) (1982). *Intelligent tutoring systems.* New York: Academic Press.
Weiner, B. (1979). A theory of motivation for some classroom experiences. *Journal of Educational Psychology, 71,* 3–25.
Weiner, B. (1980a). *Human motivation.* New York: Holt, Rinehart and Winston.
Weiner, B. (1980b). The role of affect in rational (attributional) approaches to human motivation. *Educational Researcher, 9,* 4–11.
White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review, 66,* 297–333.
Zimbardo, P. G. (Ed.) (1969). *Cognitive control of motivation.* Glenview, IL: Scott, Foresman.
Zuckerman, M., Porac, J., Lathin, D., Smith, R., & Deci, E. L. (1978). On the importance of self-determination for intrinsically motivated behavior. *Personality and Social Psychology Bulletin, 4,* 443–446.