An Interactive Model to Teach Motor Skills

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There has been a tremendous increase in our knowledge of human motor performance over the last few decades. Our theoretical understanding of how an individual learns to move is sophisticated and complex. It is difficult however to relate much of this information in practical terms to physical educators, coaches, and therapists concerned with the learning of motor skills (Shumway-Cook & Woolcott, (1995). Much of our knowledge stems from lab testing which often appears to bear little relation to real-life situations. This lack of ecological validity has slowed the flow of information from the theorists and researchers to the practitioners. This paper is concerned with taking some small aspects of motor learning theory, unifying them, and presenting them in a usable fashion. The intention is not to present a recipe for teaching motor skills, but to present a framework from which solutions can be found. If motor performance research has taught us anything, it is that every individual and situation presents unique challenges. By increasing our ability to conceptualize the learning situation we should be able to develop more flexible and adaptive responses to the challenge of teaching motor skills. The model presented here allows a teacher, coach, or therapist to use readily available observations and known characteristics about a motor task and to conceptualize them in a manner which allows them to make appropriate teaching/learning decisions.

When developing a motor skill learning situation the educator is faced with two major constraints (aside from environmental limitations). These are the difficulty of the task, and the skill level of the learner. A knowledge of how these two factors interact is essential if effective and efficient learning is to occur. Both of these factors can be conceptualized through the use of tools such as continuums. A number of continuums will be presented here which can assist in the understanding of both task difficulty and skill level. More importantly, these continuums can be combined to create the framework of a model for decision making. This paper will describe the development and use of an interactive model of task analysis and skill level.

The Intractive Model for Teaching Motor Skills (IMTMS) presented in Figure 1 can be used in motor skill teaching situations to maximize learning efficiency. The IMTMS is situation specific. That is, any task can be analyzed according to its environmental and perceptual demands. The example in Figure 1 shows four steps in the task analysis. An individual's performance on the series of tasks in the analysis can simply be plotted and the optimal level to begin instruction can then be determined. Moderately high performance (50-75% success rate) should allow both a reasonable rate of success and sufficient challenge for optimal learning to occur (see optimal learning zone in Fig 1). The attention demands on the learner at this level will allow the individual to understand and incorporate instructions into their performance, without creating an overload on attention capacity. The following sections will describe the model in greater detail.

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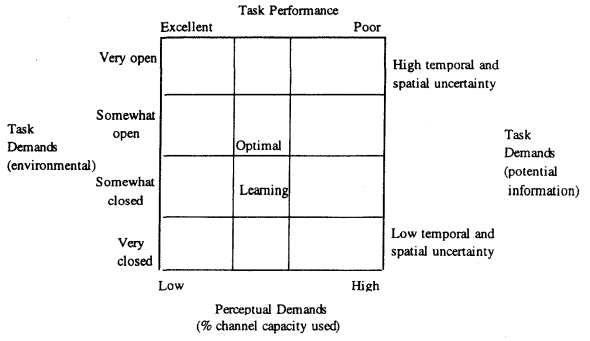

Figure 1. The interactive model of task demands and skill level.

Demands of the Task

The initial step in designing a sound learning situation is to gain an understanding of the demands of the task to be taught. This requires some consistent method of task analysis to determine: 1) the nature of the task, and 2) the perceptual demands of the task.

The Nature of the Task

Poulton (1957) proposed a means of task analysis which classified skills on a continuum in terms of their environmental demands (Fig. 2). For example, some skills are performed in fixed or unchanging environments and Poulton termed these "closed" skills. A face-off in hockey, a foul shot in basketball, and tying one's shoelace typify closed skills. At the other end of the continuum are "open" skills. These occur in constantly changing environments. A quarterback rolling out to pass or a tennis player attempting to return an offensive lob are both performing open skills. Between these two extremes any task can be described as to its relative 'openness' or 'closedness'. A baseball batter for example, stands in essentially the same position every time. However the ball's speed and location, as well as the strategies of the moment, will all differ from time to time and will alter the actual swing itself. The batter then is in a fairly closed situation although responding to a changing environment.

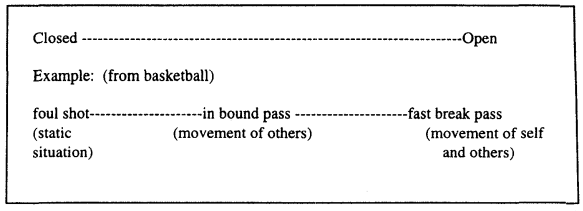

Figure 2. Task demands: Environmental.

This last example demonstrates the importance of understanding the task's demands on the learner. Open tasks obviously place greater attention demands on the learner than do closed tasks. Open skills have an enormous amount of environmental uncertainty or potential information needing to be processed by the individual. They are performed in a constantly changing environment, and the performer must modify the movements involved in the skill in order to meet the demands of the situation. It is doubtful, for example, that a wide receiver in football ever catches two passes in exactly the same manner, even though the same skill (catching) is always involved. The speed and location of the ball, the movements of oneself, opponents, and teammates all must be analyzed, processed, and responded to by the performer. This openness then makes the task more difficult, and the demands on the performer or learner much greater. A key point here is that the openness or closeness of the task, and therefore the learning situation, is within the control of the teacher. Almost any task can be made more closed and thus place fewer demands on the learner. Dribbling a soccer ball alone is more closed than dribbling in a one-on-one situation which is more closed than dribbling in a three-on-three and so on.

Perceptual Demands of the Task

We can place any motor task on a continuum of low to high perceptual or attention demands. Higgins (1977) has suggested that tasks be analyzed in terms of their envi-

ronmental uncertainty or potential information. He suggests that any movement has elements of both spatial (location in space) and temporal (movement speeds) uncertainty (Fig. 3). Greater temporal and spatial uncertainty leads to greater demands on attention placed upon the learner or performer.

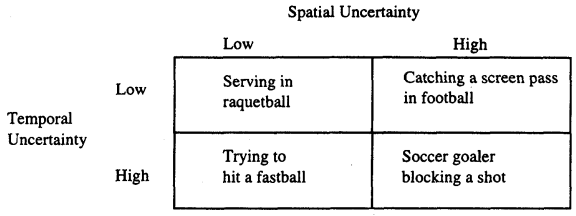

Figure 3. Task demands: Perceptual.

We can analyze the amounts of spatial and temporal uncertainty contained in the task and simply rate them as relatively high or low. Two key points should become apparent about the importance of understanding the perceptual demands of the task. First, as in the closed to open continuum, the perceptual demands of the task can be manipulated and modified by the instructor. Secondly, the perceptual demands of the task must be viewed within the context of the learner's skill level. Combining these two elements allows the creation of learning progressions based on both the demands of the task and the skill levels of the learner. The learning progression must reflect the capacity of the learner to cope with increasing amounts of environmental uncertainty.

For instance, if teaching a very low skilled child how to catch, the following progression might be developed. Using a large ball the teacher might slowly roll the ball to the child with the child sitting with their legs apart. Note that both spatial and temporal uncertainty are reduced to a minimum here. The ball is large and moving slowly, the ball is confined to the plane of the ground alone, the child is not moving, and the legs should guide the ball into the child's hands. As the child progresses the ball could then be rolled faster and its size decreased. Later the child could attempt to catch a bouncing ball while kneeling perhaps, and later yet attempt to catch a ball swung from a pendulum while standing. The progress of the child would determine how much time was spent at each element of the progression and the degree of increase in environmental uncertainty at each step. The same principles hold when developing a learning progression for a high school physical education student or a highly skilled athlete. The key is realizing that any task can be analyzed in terms of its perceptual demands and that those demands will differ depending on the skill level of the learner.

Skill Level of the Learner

Before learning efficiency can be maximized, a second major constraint remains to be analyzed; the skill level of the learner. Skill level and task difficulty always interact to affect learning and task performance. This is apparent in the preceding discussion of perceptual demands. In this model, skill level is described in two ways. First is the very concrete measure of performance - is the performer successful or unsuccessful. It is the actual success or failure at a task which will determine the route that teaching decisions will take. What constitutes success is situation specific. The outcome at hand could range from executing some aspect of a skill correctly, such as the followthrough in a tennis serve to serving an ace in a game situation. Whatever the outcome and criteria for success, the results provide a source of information and knowledge for both the learner and the educator (Peddie, 1995)

Second is the construct of attentional demands and attentional capacity. Attentional demands, simply put, is the notion that we have a structurally limited capacity to process information (Kahneman, 1973). In other words we can only handle so much sensory data (input), make so many decisions about that input (perception), and gen-

erate so many responses (output) at any given time. Abernethy (1993) refers to attention as one of the most important aspects of learning motor skills.

> "It is difficult to imagine that there can be anything more important to the learning and performance of sport skills than paying attention to the task at hand. Whether learning or performing a motor task the demands on attention require assessment. The anecdotal reports of athletes who have performed poorly because they were not quite prepared (e.g. a 100-meter sprinter who "missed" the gun), because they lost concentration (e.g. the young outfielder who is oblivious to a fly ball as they think about their last at bat), because they were distracted (e.g. the basketball player who was disturbed at the free throw line by crowd noise), or because they became confused (e.g. the defensive player in football who was disoriented by the sheer complexity of the opposition's offensive pattern) all bear testimony to the importance of the optimal, selective, and sustained allocation of attention" (p. 127).

When the demands of learning are added to those of performing, the overall demands can become huge. Fig. 4 describes the amount of attention that an individual requires to perform a task at different levels of skill. Note that in the initial stages of learning (unskilled) that 100% of the individual's attention is committed to simply performing the skill. By the time the individual has learned the skill well (highly skilled) very little attention is required to actually perform the skill. At this point substantial attention capacity remains available to consider aspects of performance more typical of open situations - strategies, tactics, etc. At each level of skill the external demands on attention such as verbal feedback, the actions of other classmates, or spectators all add to the total demands on attention.

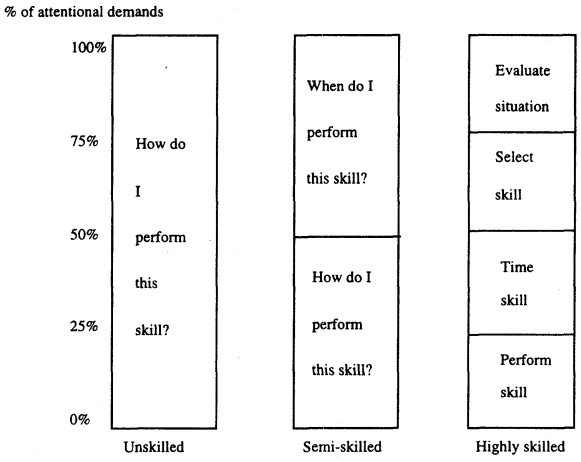

Figure 4. Skill level and attentional demands.

Attention helps us understand the constraints that the perceptual demands of the task place upon the performer or learner. In the model presented in this paper, perceptual demands and attention capacity are interchangeable. Together they provide a good framework for understanding the skill level of the learner. If the performer has too much information to handle, their attention capacity will be overloaded and they will have difficulty in selecting and carrying out an appropriate response. The result will be poor performance and poor learning. If, on the other hand, the task requires relatively little information, the performer will have capacity remaining to select an appropriate response or tactic. Better performance would be expected as a result. When the learner is not overloaded with information, they remain in control and should be able to select and evaluate responses appropriate to the demands of the task (Fig. 4). One can hypothesize an inverse relationship between the percentage of attention capacity required of a performer to execute a motor skill and the success or failure of the resulting performance. Therefore, the lower the proportion of attention capacity that a task demands of the individual, the greater are the possibilities for success (Whiting, 1974) both in performance and in learning.

This is not to say that high attention demands negate the possibility of success. Highly skilled athletes are capable of success in demanding situations. They achieve this success by limiting their attention to those environmental cues which are relevant (Allard & Starkes, 1991). However, when learning a skill, high attention demands relative to capacity will almost certainly interfere with learning. Simple teaching strategies such as limiting feedback to only a single fundamental error needing correction can lower demands on attention (Schmidt, 1995).

In the IMTMS the inverse relationship between attention capacity and performance allows the instructor to make suitable modifications to task difficulty based on the individual's performance. Performance is simple to grade in degrees of success or failure, keeping in mind that the criteria for success need to be established relative to the skill level of the performer. If the learner appears consistently unable to achieve success, and is unable to incorporate instructions into their performance, then the instructor should conceptualize the difficulty in terms of overloaded attention capacity. The instructor can then analyze the task and determine a level of task difficulty which will not over-tax the attention capacity of the learner. The instructor is, then, creating an appropriate step in a learning progression, based on task analysis and an understanding of the demands being placed on the learner's attention capacity. This decision making pathway, within the framework of this model, allows an instructor to develop suitable learning progressions for any individual.

Although the actual attention capacity of an individual may not be changeable, a teacher or instructor can assist a learner by developing tasks that are within the individual's capabilities and by limiting extraneous demands on attention. The demands on attention can be controlled somewhat by the educator. For example, highlighting relevant cues and limiting external distractions, both lessen attentional demands. In order to do this, however, the instructor must be able to analyze a task in light of the demands that the task itself places on attention capacity. Open or perceptually loaded skills require more attention as the learner is faced with the need to make numerous decisions. Closed tasks, by definition, possess little decision making beyond the selection of the response and, therefore, demand relatively little attention beyond that required to perform the task itself. It should be noted however, that even closed tasks can involve a great amount of attention if the task involves numerous or a complex series of movements. For example, a forward twisting one-and-a-half salto vault requires substantial attention if being learned as a whole even though it is a closed skill. Serial skills of this nature however are not often attempted until a fairly high level of skill has been attained. Even then, in order to limit the demands on attention this type of skill might best be learned in a series of parts (McKinney, 1985).

Designing An Effective Learning Progression

Figure 5 provides an example of how the model can be employed in a very practical way, both to develop a learning progression and to accurately place a learner within that progression. The skill being taught is basketball dribbling, and four stations have been developed where pairs of students can test their capabilities. The stations move from a very closed situation (dribbling alone with one hand while standing for 30 seconds without moving the feet or losing control of the ball) to a very open situation (dribbling against a partner the length of the court and back without losing control of the ball or stopping). Between these two extremes lie a somewhat closed and a somewhat open station. These stations have been

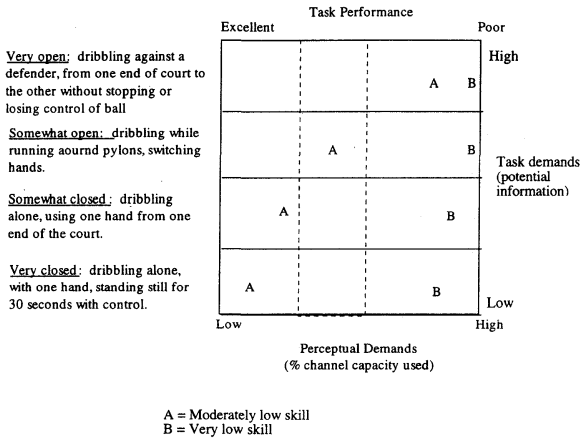

Figure 5. Two learners of different skills evaluated using the interactive model of tasks demands and skill level.

developed through a very rudimentary task analysis. By simply plotting the student's performance against the task, the instructor can quickly estimate the perceptual demands that the task is placing upon the performer. Performer 'A' is relatively high-skilled compared to performer 'B'. In this situation, 'A' should begin practising dribbling tasks that are somewhat open, while 'B' should be working on dribbling in a very closed manner, probably even more closed than the simplest situation in this progression. The instructor should be providing learning information that is appropriate for the individual's skill level, being mindful of the additional loads that instructions will place on the learner's attention capacity. Long lists of instruction alone challenge the capacity of young children (Pangrazi and Dauer, 1995). Lowering the perceptual demands of the task to an appropriate level will enable the learner to make effective use of feedback regarding their performance.

With this information the instructor should be able to estimate the level of skill where the individual requires instruction and practice - based on a knowledge of the demands of the task and the capabilities of the individual. The challenge for the teacher is to find that point where the task is sufficiently demanding, while still providing plenty of opportunity for success. The optimal learning zone is described in the model as between 50-75% success.

It should be apparent that any movement task, and any level of skill, from sports to activities involved in everyday living, can be encompassed by this model. The IMTMS places no constraints on the method or style of teaching or instruction. It simply provides a consistent framework for selecting an appropriate level of task difficulty in relation to an individual's capabilities. The model is limited in that it is designed for individualized instruction, and requires a thoughtful task analysis for each skill being learned. However, any task need only be analyzed once, and once analyzed could be used many times to vary difficulty for differing levels of skill. Once the basic demands of the task are established the relative effect of those demands on learners of varying levels of skill can be considered.

The IMTMS allows for the consistent and thoughtful development of motor skill learning situations. Its use should help maximize learning efficiency and improve teaching skill. It is not a recipe for success however, as the capabilities of the instructor in analyzing tasks, developing suitable progressions, and recognizing and responding to the needs of the learner remain as critical requisites. This model can assist the teacher by providing a framework in which both the learner and the learning situation can be conceptualized and dealt with in a logical and consistent manner.

References

Abernethy, B. (1993). Attention. In R. N. Singer, M. Murphey, & L. Tennant (Eds.), *Handbook of Research on Sport Psychology* (pp. 127-170). New York: MacMillan.

Allard, J. & Starkes, J. (1991). Motor-skill experts in sports, dance, and other domains, In K. A. Ericsson and

J. Smith (Eds.), *Toward a general Theory of Expertise*, (pp. 126-152). New York: Cambridge University Press.

Higgins, J. (1977). *Human movement: An integrated approach.* St Louis: Mosby.

Kahneman, P. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice Hall.

McKinney, S.E. (1985). *Motor learning: An experiential guide for teachers.* New York: Movement Publications.

Pangrazi, R.P., & Dauer, V.P. (1995). *Dynamic physical education for elementary school children.* Boston: Allyn & Bacon.

Peddie, B.K. (1995). What underlies the teaching of motor skills. *The Physical Educator, 52*(3), 119-124.

Poulton, E. (1957). On prediction in skilled movements. *Psychological Bulletin*, 54, 467-478.

Schmidt, R.A. (1991). *Motor learning and performance: From principles to practice.* Champaign IL: Human Kinetics.

Shumway-Cook, A. and Woolacott, M. (1995). *Motor control: Theory and practical applications.* Baltimore: Williams and Wilkens.

Whiting, H.T.A. (1974). Input and perceptual processes in sports skills. *Journal of Motor Behavior*, 6, 217-226.