AN ABSTRACT OF THE DISSERTATION OF

Ben Young for the degree of Doctor of Philosophy in Human Performance presented on July 23, 1998. Title: An Analysis of the Diagnostic and Prescriptive Expertise of Level II and Examiner Downhill Ski Instructors.

Abstract approved: ___________________________

Debra J. Rose

For coaches to qualitatively analyze the performance of sport skills as executed by their students, they must possess an internal image of the desired skill against which to make comparisons (Hoffman, 1983; Pinheiro & Simon, 1992). Leas and Chi (1993) have indicated that there are differences between novice and expert swimming coaches in the internal image of the freestyle stroke. They further reported group differences in their ability to diagnose errors in movement form. Study 1 extended that investigation to include a beginning and advanced skill in downhill snow skiing. Two groups of downhill ski instructors (n=8) certified at Level II (n=4) and Examiner status (n=4) were compared on their knowledge of the prototypical versions of the wedge and open parallel turns. They were subsequently tested on their ability to diagnose errors in incorrectly performed videotape versions of those turns. Two Level II instructors internalized the skill similarly to the level of the Examiners on their knowledge of the prototypical skills, while the other two instructors did not appear to have constructed the same type of prototypical model. On the wedge turn diagnostic task, Level II instructors misdiagnosed 50% of the primary errors in student performance compared to a perfect performance by Examiners. On the open parallel diagnostic task, performance across groups was similar for the primary error. It was suggested that the open parallel level of skiing is similar to the skiing ability of Level II instructors, which may have enhanced their ability to better diagnose the errors associated with that skill compared to the wedge turn. In Study 2, participants prescribed exercises for the errors identified in Study 1. Results indicated that exercises primarily addressed errors in the same order as they were prioritized. The lesson plans of Level II participants, however, attempted to address 35% more errors than Examiners. The use of part-task teaching methods, used by seven of eight participants, was subsequently addressed and theoretical implications were discussed. A possible theory of expertise explaining group differences was described.

An Analysis of the Diagnostic and Prescriptive Expertise of Level II and Examiner Downhill Ski Instructors

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Chair of Department of Exercise and Sport Science

Dean of Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

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Ben Young, Author

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INTRODUCTION

The process of qualitative analysis requires instructors to observe the performance of their students and compare it to an internalized, ideal version of performance for detection of errors (Hoffman, 1983; Pinheiro & Simon, 1992). Subsequently, instructors provide prescriptions to remedy those errors. When students execute new movements, instructors again observe performance, detect errors, and prescribe solutions (Knudson & Morrison, 1997). The circularity of this pattern characterizes the process of qualitative analysis and both professionals and recreational athletes alike seek out those instructors with the expertise to perform this task.

Prior Studies

Knowledge of the ideal, or prototypical, versions of performance is prerequisite to the diagnosis of error (Hoffman, 1983). Studies investigating expertise differences between novice and expert instructors have typically sampled this knowledge base (Leas & Chi, 1993; Pinheiro & Simon, 1989). Similarly, the knowledge-based approach has been successfully used to investigate novice-expert differences in the domain of cognitive skills such as chess (Chi, 1978; Chi, Feltovich & Glaser, 1981) and, more recently in the sporting domain (French & Thomas, 1987; McPherson & Thomas, 1989). French and Thomas (1987) found that the domain-specific knowledge base of children increased measurably over the course of a season playing competitive basketball, resulting in better decision-making during competitive game play. McPherson and Thomas (1989) demonstrated that expert children tennis players possess a larger knowledge base of tennis rules, strategies, and decision-making skills than novice players.

Several different models of qualitative analysis have been used to explain how instructors observe, diagnose, and remedy errors in the movement patterns of learners. The Hoffman model (1983) indicates that instructors must possess an internalized, ideal template of the desired skill against which comparisons can be made to actual movement. The Hudson model (1985) is a biomechanical approach that requires the purpose of movement to be identified, and provides definitive kinesiology measures that can be used as feedback to the learner. The Arend and Higgins model (1976) divides observation of movement into pre-observation, observation, and post-observation phases. Hay and Reid (1982, 1988), similar to Knudson and Morrison (1997), posit a four-step model that includes the intervention with the learner.

Expertise studies conducted with sport instructors have found expert instructors, compared to novices, to have a larger knowledge base of prototypical skills and superior diagnostic skills (Leas & Chi, 1993; Pinheiro & Simon, 1989). The current investigation seeks to similarly identify diagnostic differences in expertise in downhill ski instructors, but extend this work to identifying expertise differences in their prescription of solutions to errors. In Study 1, a knowledge-based approach was used that required downhill ski instructors of two different certification levels to each identify their ideal versions of two separate ski skills. They subsequently identified errors in incorrectly performed videotaped versions of the same skills. This methodology is supported by models of qualitative analysis that indicate that the mechanism which instructors use to identify errors is to compare internalized versions of ideal movement to the actual movements of the performer (Hoffman, 1983; Pinheiro & Simon, 1992).

In a second study the participants provided prescriptive solutions to error. The link between the diagnosis of errors and prescriptions has not been empirically investigated. In order to establish that link it was crucial to this study that all instructors were capable of offering prescriptions to the errors identified and prioritized in Study 1. Leas and Chi (1993) reported that the novice group of swimming coaches they had defined was incapable of providing solutions to errors they had identified. It was not clear whether this was because of a deficient knowledge base or the fact that they were assessing the skill of interest from an underwater window, a view with which they were unfamiliar. The current study recruited instructors for the less experienced group who had been certified by a governing agency to provide prescriptions for the skills of interest.

Since the diagnostic/prescriptive link has been largely unexamined it was important to first provide fundamental data on this relationship. For example, downhill ski instructors primarily provide training exercises to the learner as solutions to error. While it seemed likely that these exercises address errors, this relationship has not been investigated. Pilot data, in fact, indicated that this is not always the case. Furthermore, it seemed likely that errors would be addressed in the order they had been prioritized, but again, this relationship has not been investigated. Study 2 addressed this fundamental question.

Additionally, preliminary research indicated that lower and upper level ski instructors differ on what has been identified as lesson scope. Lesson scope is the amount of student error that an instructor attempts to resolve in a single encounter. Lower level instructors purportedly attempt to resolve more errors than upper level instructors, thus providing fewer opportunities for practice. Learning, as defined by relatively permanent changes in the ability for skilled action (Rose, 1997), has been found to be highly related to the amount of original learning (Christina & Bjork, 1991). Lesson scopes that address multiple errors would necessarily provide less opportunity for practice than lesson scopes that address fewer errors. Therefore , data were collected on the lesson scope provided by each participant.

By reputation, expert downhill ski instructors have at their command unique solutions for resolving movement error. Instruction manuals devote much of their content to solutions for error (Alpine Manual, 1996; Alpine Level II, 1996) and the popular press publishes numerous articles on this subject. It is unknown whether expert instructors are, in fact, unique in this regard. Therefore, a comparison was made on the uniqueness of solutions offered by instructors for identified errors.

A further examination was made of the different types of teaching techniques that instructors use when working with students. New ski skills have been traditionally taught using progressive-part techniques in which whole movements are broken down into parts for practice. Eventually the parts are reassembled and practiced as whole movements, thereby simplifying learning for the student. Theoretical questions have been raised regarding the transfer of cognitive processes underlying part practice to those underlying whole practice, and the effect this has on learning (e.g., Bransford, Franks, Morris, & Stein, 1979; Schmidt, 1991). Transfer-appropriate-processing (Bransford, Franks, Morris, & Stein, 1979) indicates that learning occurs when the cognitive processes underlying practice are similar to those underlying the goals of the skill. There is some concern that the cognitions underlying the practice of ski turns in parts are not the same cognitions that underlie the performance of the entire turn. The use of whole-task teaching and possible alternatives was subsequently examined as instructional techniques.

Theories of Expertise

While it was the primary goal of this research to identify expertise differences in diagnostic and prescriptive areas, it was also of interest to identify possible explanations for the source of those differences. Experience is probably the most popular explanation used to account for teaching expertise. In the case of downhill ski instructors, experience can be operationally defined as the number of seasons spent teaching. One might argue, however, that the amount of personal skiing experience should also be included. DiCicco (1990) investigated the role of both participation and teaching experience on tennis diagnostic ability. Four groups of tennis instructors (high playing/high teaching, high playing/low teaching, low playing/high teaching, low playing/low teaching) were asked to identify errors observed in beginning and advanced tennis serves. It was concluded that high playing/low teaching experience was superior to low playing/high teaching experience, but the combination of high playing/high teaching experience resulted in better diagnostic performance. Gould, Giannini, Krane, & Hodge, (1990) in a survey of 130 elite instructors from 30 different Olympic sports, provided further support for the results of this study. The authors concluded that a majority of the coaches had participated at the competitive level in the sport they were coaching.

Although personal participation may be a predictor of teaching expertise, some researchers have indicated that teaching experience is not. Berliner (1987) acknowledged that many instructors are not experts despite years of teaching experience. Ericsson (1998) argued that when individuals learn new tasks, performance improves only until it reaches either a self-imposed level of acceptability, or a standard imposed by an external source. Thereafter, it often remains fixed for decades and experience alone leads to no further improvement. Walkley and Kelly (1989) indicated that if instructors do not receive formal training in the analysis of movement, it is unlikely to be learned through teaching. Imwold and Hoffman (1983) found that with experience, the ability of coaches to qualitatively analyze skills may actually decrease. Teaching experience alone, is therefore met with skepticism as an explanation for expertise.

Innate ability has been offered as another theory to explain expertise. The talents of instructors and athletes alike are often explained as being special gifts, or genetic endowments. This position minimizes the effort or work that has been put forth to achieving expert status. Among the first to investigate this theory was Sir Francis Galton (1892). It was his contention that expertise is inherited and passed through bloodlines to children. Although he recognized that mental and physiological prowess could be improved through education and exercise, heredity necessarily limited expertise. Gardener (1993) has been a contemporary advocate of this position, theorizing that individuals are predisposed to exhibit any one of several “intelligences” in such diverse areas as athletics, art, scholastic achievement, or musicianship.

The theory of deliberate practice (Ericsson, Krampe, & Tesch-Romer, 1993) is yet another explanation accounting for expertise. This explanation specifically rules out experience or innate ability as predictors of any significance. A consistent pattern of expertise as a result of deliberate practice has been demonstrated across several professions including writers, musicians, artists, and athletes (Bloom, 1985), suggesting that this phenomenon is universal and can be extended to instructors.

Deliberate practice is distinct from experience, or just general practice, in several ways (Ericsson et al., 1993). First, it is a highly structured activity that is not necessarily pleasurable or motivating. Second, it is generally effortful and must be sustained for prolonged periods. Third, the overriding goal is improved performance, and a number of sacrifices are usually made toward that end. Ericsson et al. (1993) originally investigated deliberate practice with populations of pianists and violinists, and found no role for innate ability in the development of expertise.

Hodges and Starkes (1996) recently questioned certain premises of deliberate practice (deliberate practice is unpleasurable, for example) but have found general support for this theory in the sport domain. When extended to instructors, expertise in movement analysis would not be considered a side effect of experience in the profession, but rather, a result of deliberate training efforts made toward the refinement of diagnostic and prescriptive skills.

Experience, innate ability, and deliberate practice all offer possible explanations for expertise in instructors. It was the primary interest of this study to first determine where expertise differences in qualitative analysis lie between two different levels of downhill ski instructors. However, an underlying theory of expertise is of interest because it would indicate how the gap could, or could not, be closed between lower and upper level instructors more quickly. Experience, as an explanation, suggests that instructors become experts based on their ability to make a long-term commitment to field experience. Innate ability, as an explanation, suggests that instructors become experts based on inherent traits they already possess. Finally, deliberate practice, as an explanation, suggests that instructors would become experts based on their willingness and motivation to commit to on-going study and training.

Chapter 2

A Knowledge-Based Approach to the Investigation of Diagnostic Expertise of Level II and Examiner Downhill Ski Instructors

Ben Young

Introduction

Contemporary models of qualitative analysis indicate that the ability to expertly interact with the learner be included as a measure of instructor expertise (Hay & Reid, 1988; Knudson & Morrison, 1997; McPherson, 1990). A necessary skill that is prerequisite to this interaction is the correct diagnosis of movement error. Hoffman (1983) hypothesized that diagnosis of error requires an internalized mental image of the prototypical skill against which to make comparisons to actual execution. The discrepancies between the prototypical skill and the performance of the student become the subject matter of the interaction with the student.

Pinheiro and Simon (1992) similarly proposed the existence of an internal model, or schema, against which comparisons can be made. Schemas are rules governing the parameters of movement. Multiple schemas for the performance of movement would be contained in a single action. Using the tennis serve as an example, an instructor would have a schema for how the preparatory position should look. There would be successive schemas for action as the serve develops (e.g., ball toss, wind-up, follow-through, etc.)

Pinheiro and Simon (1992) further elaborated on how the diagnostic process actually develops. Starting with cue acquisition, they argue that instructors look for elements in performance that fall in or out of response acceptability for the schema. An alternative model proposed by Knudson and Morrison (1997) referred to this stage as the observation phase. The key for the instructor at this point is to know where in the movement pattern to look. This requires that observation is done from the appropriate vantage point and there is enough observation time to obtain the necessary information.

As a second step in the Pinheiro and Simon model, cues are evaluated against the schema for interpretation. Inferences are made based on values that have been assigned to them through prior experience, and then stored in long term memory. Diagnostic decision-making is the third step in this model, the culmination of the first two steps.

The knowledge of what cues to look for in the acquisition phase is critical, but evaluation of the acquired cues depends on the internal model to which it is being compared. It is hoped that instructors diagnosing the same skill use the same model for comparison. A logical first step in the evaluation of instructors' ability to diagnose error is to first investigate the similarity, or dissimilarity, of the internal models that are being associated with the skills being diagnosed.

Leas and Chi (1993) pursued this line of inquiry using a knowledge-based approach to examine the internal prototypical models that novice and expert swimming coaches use for the freestyle stroke. Using an interview technique, two novices and two experts verbalized their ideal version of the freestyle stroke. This skill consists of four major stroke components; body position, armstroke, kick, and breathing. Experts correctly identified all four while novices identified only two component denoting a very basic difference between groups on the internal model used for comparison.

A unique feature of that study was the inclusion of a diagnostic task in which participants viewed videotape of freestyle swimming performances, and subsequently diagnosed errors in form. Results indicated that novice coaches were less proficient than expert coaches when discriminating errors.

The primary objective of the present study was to extend the findings of Leas and Chi (1993) by exploring expertise in a population of downhill ski instructors. Similar to their study, participants were interviewed in-depth to examine whether expertise differences existed. The line of inquiry was broadened to include beginner and advanced skills, the wedge and open parallel ski turns respectively. Furthermore, expertise studies have typically compared novice and expert instructors in order to maximize differences between groups. Of practical interest to the ski profession is the use of a higher level of instructors than a true novice group, since novices without training are not allowed to instruct students, and would therefore be a meaningless comparison.

Method

The agency responsible for the certification of all downhill ski instructors in the United States is the Professional Ski Instructors of America (PSIA). Examiner-certified instructors, the highest level attainable as certified by PSIA, conduct the certification exams for all instructors. In order to qualify as an Examiner, an individual must first pass through levels of certification that include a minimum of one year at Level I, one year at Level II, two years at Level III, and two years as a Divisional Clinic Leader (DCL). A minimum of six years as an instructor is required prior to Examiner status being awarded. More typically, it requires much more time. On average, instructors that participated in this study achieved Examiner status after teaching 10 years.

Examiners comprise approximately 2% of all instructors and are rarely available to the general public for lessons. Level I, II, and III certified instructors are more likely to be encountered at most ski schools. Level II instructors are certified to instruct the wedge (a beginner turn) through open parallel (an advanced turn) and are the first level of instructor that interacts with advanced students. Although it is not expected that Level II instructors have the full range of expertise as Examiners, it is of interest to determine where differences in expertise may lie, since they have been certified to teach all but the most advanced skiing skills.

The present study was comprised of two tasks. The first was a knowledge-based task in which the ideal model for two different ski skills was probed for accuracy. Four specific movements common to the wedge and open parallel turns have been determined by the ski certification agency, PSIA, to be necessary in the prototypical performance of those skills. The rationales for the performance of those movements have also been specified. Two additional specific movements relative to the use of the ski pole and the subsequent rationales for that usage are common to the open parallel turn. This taxonomy of specific movements and rationales comprised the knowledge base that was probed to ascertain the composition of the internal model being used for comparison to student performance.

The second task was a diagnostic task in which incorrect videotaped performances of both the wedge and open parallel turn were shown to all participants. They were first asked to identify all errors in those performances, and then prioritize them in order of importance.

A comparison was made between Level II instructors and Examiners on both the knowledge-based and diagnostic task. A multiple case study approach was used in order to conduct an in-depth analysis of participants across these two broad fields of inquiry.

Participants

Four Level II certified ski instructors and four Examiner certified instructors were recruited as participants for this study. Initial contact with the Level II instructors was arranged through the ski school directors at their respective schools of employment. The PSIA office, Northwest Division, furnished a list of Examiners. Initial contact with these individuals was made directly. The objectives of the project were described, and arrangements were made for one-to-one interviews. Demographic statistics for background areas of interest are presented in Table 2.1:

Table 2.1. Background Demographics

Category	Level II		Examiner	
	M	SD	M	SD
Age	45	13	43	5.4
Ski experience (seasons)	21	5.5	33	8.5
Teaching experience (seasons)	7	5.4	23	4.2
Certifications	2	.5	6	2.4

Additionally, competitive experience was minimal. Two instructors from each group had no competitive experience. Competitive experience among the remaining four varied from one to three seasons, with the exception of one Examiner who reported 41 seasons of competitive experience. The employment history of each Level II instructor was limited to the ski school in which they were currently employed. Conversely, Examiners had worked at an average of four different ski schools.

Skills

The skills of interest in this study were the wedge and open parallel turns in downhill snow skiing. The wedge is a beginner turn characterized by an inverted "V" relationship between the skis, in which the tips of the skis are kept close together and the tails are held wide apart. The skier's center of mass is located between the skis during the entire execution of the turn. The open parallel turn is characterized by a parallel relationship between the skis at all times. The skier's center of mass moves from one side of the skis to the other during the course of each turn.

Although to the untrained observer it would appear that these two skills are vastly different, they are actually quite related in that both require four specific movements for effective performance. The underlying rationales for those movements are likewise similar. Those specific movements and rationales are as follows:

1. Extension – a lateral extension of the uphill leg to initiate the turn

   Rationale:

   - to flatten the ski
   - facilitation of steering
   - facilitation of weight transfer to the new turning ski
   - aid in moving the center of mass into the turn

2. Steering - rotary motion of both legs

   Rationale:

   - turn shape
   - speed control
   - facilitate counter positioning of upper/lower body in finish phase

3. Flexion - lower body flexion in the control and finish phases of the turn

Rationale:

- regulation of ski edge angle
- regulation of ski pressure
- aid in steering (flexion of ankle, knee, and hip allows more rotary power to be applied to the ski)
- aids in dynamic balance through lowering the center of mass

4. Counter - a counter positioning of the upper body compared to lower body

Rationale:

- upper and lower body seeks to re-align, facilitating turning
- facilitates movement of center of mass into turn
- supports balance toward outside ski

In addition to the four movements and rationales just described, the open parallel turn is characterized by the use of the ski pole. Those uses are as follows:

5. Pole swing – outside ski pole is swung forward and toward the center of the next turn in the finish phase of the previous turn

Rationale:

- facilitates movement of upper body into turn
- stabilization of upper body
- timing

6. Pole Touch – signals edge change, weight transfer, and movement of upper body into turn

   Rationale:

   - Timing

The previous movements and rationales form a taxonomy by which the knowledge base of the prototypical wedge and parallel turns were assessed. Knowledge of the first four specific movements for the wedge turn, and all six of the specific movements for the open parallel turn are basic to the model used for comparison when diagnosing errors. Knowledge of the underlying rationales for the performance of those movements is an indication of the instructor's understanding of those movements. Therefore, specific movements and rationales were used as dependent measures.

Procedures

Interviews were conducted with seven of the participants at the site of their employment. One interview was conducted at the residence of the participant. Each participant was required to complete a background questionnaire (Appendix A) in which they described their training, teaching, and participation backgrounds. All participants also completed an informed consent (Appendix B). The Institutional Review Board at Oregon State University had previously approved the contents of the informed consent and the overall study design. All interviews were audiotaped using a Sony CFS-209 portable recorder. A portable Panasonic VCR and a Panasonic 9" portable monitor were used to show the skills of interest.

The interviews were prefaced with the following statement from the investigator: " I want to get as much information as possible. In doing so, I'll often say 'Is that all?' or 'Is there anything else?' That does not mean I think there is more information to add. I just want to be sure you have said everything you want to say." Pilot work had indicated that the absence of this prefatory statement led instructors to believe they should add more information.

Incorrect performances of the two skills of interest were videotaped for the diagnostic task. Skill models were required to sign an informed consent form (Appendix C) explaining the research and the benefits to them for participating.

Knowledge-based task. The knowledge-based task was designed to sample the knowledge of the participants' internal model, or mental image, of the ski skills used for comparison when diagnosing errors in performance. Knowledge of the specific movements across participants is an indication that the comparative model used for instruction was standardized, and those instructors were not working from individualized interpretations. Moreover, those movements have purposes, or rationales for being performed. Knowledge of the purposes of those movements is an indication of the instructor's depth of understanding. These movements and rationales are described in the manuals of PSIA, and have been further verified through videotape observation and on-the-hill testing.

Pilot work with four Level II instructors and two Examiners yielded the following question: "Going through all the phases of a turn starting with the initiation, describe the specific movements of an exam quality wedge turn." A similar question was asked relative to the open parallel turn, substituting "open parallel turn" for "wedge turn."

Participants were allowed to comment as long as necessary. If there was a pause in the answer, a summarized version was provided to them from notes taken by the investigator, and a reminder was given as to where in the turn they had ended their last comments. When instructors indicated that they had no further information to add, follow-up questions ensued in which they were asked to identify the rationale for the specific movements they had identified. For example, if it had been indicated that leg extension was a specific movement in the initiation phase of the turn, a follow-up question asked the purpose of that movement. Similar follow-up questions were posed for any other specific movements identified.

In addition to the two dependent measures, specific movements and rationales, one other measure was obtained. The amount of time taken by each participant to identify the specific movements was calculated. The recording of specific movement time began with their spoken response to the initial question, and ended when they indicated that they had nothing further to add.

Diagnostic task. The diagnostic task was conducted immediately following the knowledge-based task. It was introduced with the following statement: "You are going to see a videotape of a skier performing wedge turns. It will be shown twice. Identify all errors." A 30-second videotape of a skier performing eight wedge turns incorrectly was then shown twice to the participant. The skier passed from uphill to downhill relative to the camera position, facilitating frontal, sagittal, and rear viewing. The investigator made a list of the errors as each was identified by the instructor. That list was then read back to the instructor and he/she was asked to prioritize those errors in order of importance. For example, "You identified stance, upper body rotary, inward lean, and turn shape as errors. What was the most important? The second most important?"

A second videotape depicting an incorrect execution of the open parallel turn was also shown twice to participants. It was 25 seconds in duration during the course of which the skill model made 12 turns. Similar to the wedge model, the skier proceeded past the camera from an uphill to a downhill position. As was done in the wedge example, a list of identified errors was made, from which the instructor was asked to prioritize them in order of importance. Dependent measures for this task were the total number of errors identified and errors identified as primary and secondary. Primary errors were those errors that instructors identified as most responsible for all other errors. A secondary error was recorded in those cases where instructors wished to distinguish another error from lower level errors.

Results/Coding and Reliability

Naturally Speaking Preferred Version 2.02 voice recognition software was used for the transcription of verbatim interviews. The primary investigator and a trained assistant with prior teaching experience independently coded specific movements, rationales, and errors identified by each of the instructors. The ability of separate individuals to consistently identify the same data in a given data set ensures that measures are reliable, and facilitates replication. Reliability coefficients were calculated by dividing agreements by the sum of agreements and disagreements. These coefficients are presented in Table 2.2.

Table 2.2. Reliability Coefficients

	Wedge	Open Parallel
Knowledge-based Task		
Specific Movements	.93	.96
Rationales	.88	.89
Diagnostic Task		
Errors	.94	.89
Error Prioritization	.92	1.0

Reliability for the dependent measures ranged from .88 to 1.0. The average of all scores was .93, indicating a high level of reliability.

Results/Knowledge-based Task

Knowledge-based Task / Wedge Turn

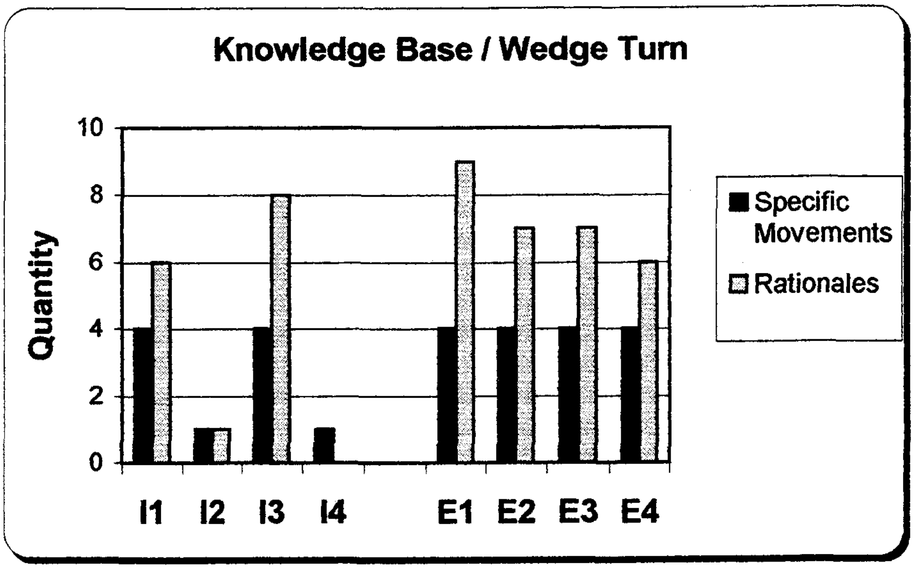
The objective of the knowledge-based task was to probe the instructor's knowledge of the specific movements and rationales for both the wedge and open parallel turn. The results for each instructor for the wedge turn are presented in Table 2.3. The specific movements associated with the wedge turn appear in bold type. Rationales follow each specific movement. Y indicates those specific movements that were identified. Blank spaces indicate those that were not. X indicates those rationales that were specified for the specific movements.

Table 2.3. Results/Knowledge-based task/Wedge turn

		Level II					Examiner		
Knowledge-based Task / Wedge Turn	I1	I2	I3	I4		E1	E2	E3	E4
Extension	**Y**		**Y**			**Y**	**Y**	**Y**	**Y**
Flattening of skis	X		X				X		X
Weight transfer			X			X			
Move COM into turn	X		X			X		X	X
Facilitates steering							X	X	
Steering	**Y**	**Y**	**Y**	**Y**		**Y**	**Y**	**Y**	**Y**
Turn shape	X	X	X			X		X	
Speed control						X	X		
Facilitates counter in finish phase									X
Flexion	**Y**		**Y**			**Y**	**Y**	**Y**	**Y**
Aids in dynamic balance							X	X	
Regulation of pressure			X			X	X	X	X
Regulation of edging	X					X		X	X
Aids in steering			X			X			
Counter	**Y**		**Y**			**Y**	**Y**	**Y**	**Y**
Re-alignment of upper body w/lower body	X		X			X	X		
Facilitates movement of COM into turn	X		X			X	X		X
Maintain balance over outside ski								X	
Total Specific Movements	4	1	4	1		4	4	4	4
Total Rationales	6	1	8	0		9	7	7	6

Figure 2.1 summarizes the specific movement and rationale scores for each instructor.

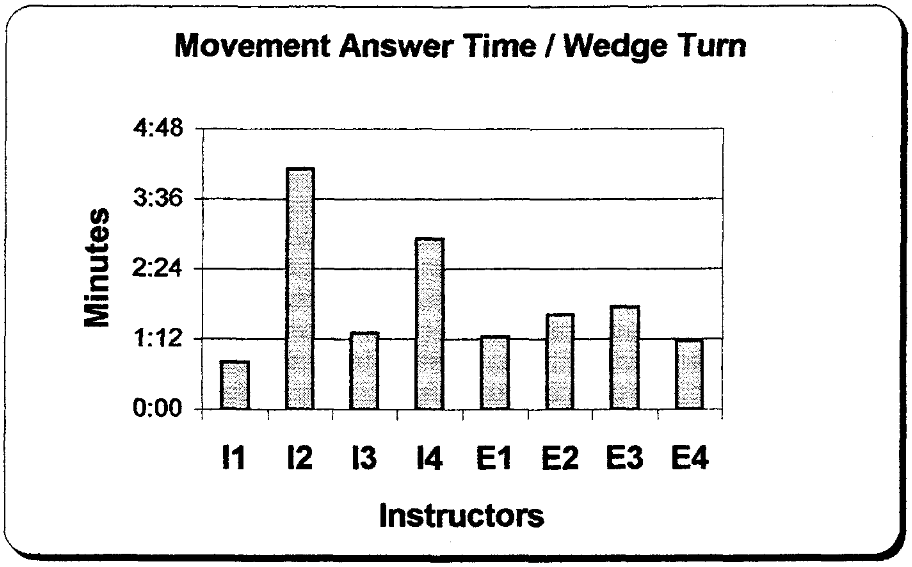
Figure 2.1. Specific movements and rationales/Wedge turn



The total possible score for specific movements for each participant was four. All Examiners had perfect scores on that variable, as did I1 and I3. The average number of rationales provided by Examiners was 7.3, while the average rationale scores for the Level II instructor was 3.75. I1 and I3 had rationale scores of 6 and 8 respectively, approximating the same level as that of the Examiners. I2 and I4 each identified only one specific movement and had rationale scores of 1 and 0 respectively.

The amount of time each individual required to identify the specific movements was also recorded. Those results are presented in Figure 2.2.

Figure 2.2. Movement answer time/Wedge turn



An answer typical of the more rapid times follows (E4):

"At the initiation, there is a slight rising (extension) and a flattening of the ski, especially the old downhill, new inside ski. In the control phase, there is some good steering (steering) of both legs, especially the inside leg. The inside ski tip will take a slight lead throughout the control phase. In the finishing phase, there is a slight flexing (flexion) to compensate for a buildup of pressure from external forces. A slight countering (counter) position is also achieved through a steering of the legs, more than the rotary movement of the upper body."

The slower times of I2 and I4 were characterized by an inability to verbalize a prototypical image of an exam quality wedge turn. Multiple attempts were made by each individual to answer the question in terms of how they teach the wedge turn, rather than identifying the specific movements of their mental image of a prototypical model. I4 concluded that he/she did not know what an exam quality wedge turn would look like. In follow-up questions, this instructor specifically indicated that extension, flexion, and counter were not specific movements in the prototypical wedge turn.

I2 similarly focused on the interaction with the student. Despite the use of follow-up questions, steering and weight transfer were the only movements that were identified. Weight transfer, as a movement, was not coded as a specific movement since it is actually a rationale, or consequence, of leg extension.

Knowledge-based Task / Open Parallel Turn

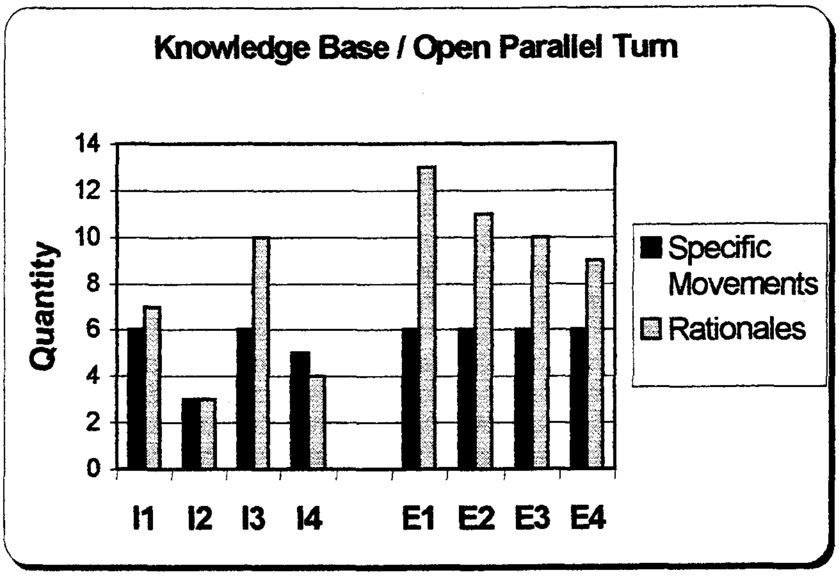
Table 2.4 shows the results of each instructor for the open parallel turn. Similar to Table 2.3 in which the results for the wedge turn were presented, specific movements appear in bold type. Rationales follow each specific movement. Y indicates that the specific movement was identified. A blank space indicates it was not. X indicates rationales that were specified for the movement.

Table 2.4. Results/Knowledge-based task/Open parallel turn

	Level II					Examiner			
Knowledge-based Task / Open Parallel	I1	I2	I3	I4		E1	E2	E3	E4
Extension	Y		Y	Y		Y	Y	Y	Y
Flattening of skis	X		X	X		X	X	X	X
Weight transfer			X			X	X		
Move COM into turn						X		X	X
Facilitates steering				X		X		X	
Steering	Y	Y	Y	Y		Y	Y	Y	Y
Turn shape	X	X	X			X	X	X	
Speed control			X				X		
Facilitates counter in finish phase									X
Flexion	Y		Y	Y		Y	Y	Y	Y
Aids in dynamic balance			X				X	X	
Regulation of pressure	X		X	X		X	X	X	X
Regulation of edging	X					X	X	X	X
Aids in steering						X	X		
Counter	Y	Y	Y	Y		Y	Y	Y	Y
Re-alignment of upper body with lower body						X	X		
Facilitates movement of COM into turn	X	X	X						X
Maintain balance over outside ski				X		X		X	
Pole Swing	Y		Y			Y	Y	Y	Y
Timing and Rhythm	X		X			X	X	X	X
Aids in moving COM into turn						X			X
Stabilization of upper body			X						
Pole Touch	Y	Y	Y	Y		Y	Y	Y	Y
Timing	X	X	X			X	X	X	X
Total Specific Movements	6	3	6	5		6	6	6	6
Total Rationales	7	3	10	4		13	11	10	9

Figure 2.3 summarizes the specific movement and rationale scores for each instructor.

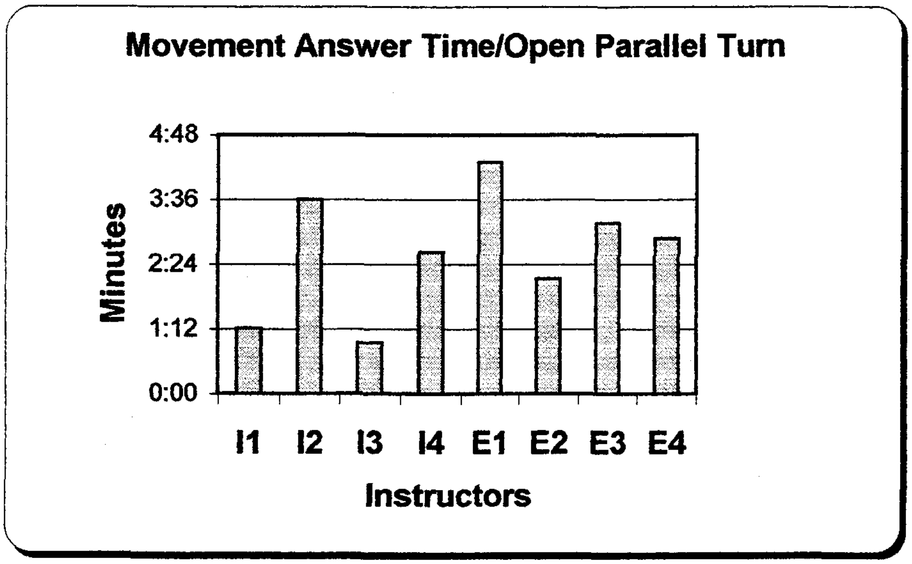
Figure 2.3. Specific movements and rationales/Open parallel turn



The total possible score for specific movements in the open parallel turn was six. All Examiners had perfect scores in that category, as did I1 and I3. The average number of rationales provided by Examiners was 11. This contrasted to a much lower rationale average of 6.0 for the Level II instructor group. Only I1 and I3 had rationale scores that were above the average for the Level II group. I2 and I4 had specific movement scores of 3 and 4, with rationale scores of 3 and 4, respectively. The Level II group average for specific movements was 4.75.

The amount of time each individual used to identify the specific movements was also recorded. Those findings are presented in Figure 2.4.

Figure 2.4. Movement answer time/Open parallel turn



Despite the two additional movements of the open parallel turn compared to the wedge turn, Level II instructors decreased their average response time by 8% while Examiners increased their average response time by 117% as they elaborated on the complexity of the skill and the additional movements. E1, E2, E4, and I3 prefaced their comments with a statement indicating that the open parallel turn is merely an extension of the wedge turn and therefore, the specific movements described in the wedge turn would carry over to their descriptions of the open parallel turn

I2, who identified steering as the only specific movement in the wedge turn, added counter as a specific movement in the open parallel, but still did not include extension and flexion. I4, who also identified steering as the only specific movement in the wedge turn, included flexion, extension, and counter in the open parallel turn assessment. Both I2 and I4 also included the pole touch but not the pole swing.

Before presenting the results of the diagnostic task, a brief interpretation of the knowledge task findings is warranted.

Discussion/Knowledge-based Task

Knowledge-based Task / Wedge Turn

The knowledge-based task was designed to probe instructor knowledge of the specific movements and rationales for the two ski skills of interest. Extension, steering, flexion, and counter are basic movements common to the prototypical performances of the wedge and open parallel ski turns. These four specific movements have been identified in the PSIA ski instruction manuals as basic not only to the wedge and parallel turns, but also to the other two turns in the learning process, the wedge christy and the dynamic parallel turn. A thorough understanding of this relationship necessarily links all ski turns and appears so basic to effective ski instruction that it was thought that there would be no differences between groups on this variable. The failure to identify extension, flexion, and counter in the wedge turn by two Level II instructors raises the question of whether this link has been adequately established during the training process. The knowledge-based task revealed that a prototypical model of the wedge turn has not been developed by all of the instructors probed in the present study.

Knowledge-based Task / Open Parallel Turn

In this task the results of Level II instructors improved over their results for the wedge turn. Additionally, movement answer time diminished for all Level II instructors, indicating a clearer understanding of the open parallel turn versus the wedge turn. Personal familiarity with the execution of the skill could offer some explanation since Level II instructors are more often engaged in the deliberate practice of this skill rather than the wedge.

This does not answer, however, why Examiners averaged over twice the answer time for the parallel task versus the wedge task. Whereas Level II instructors provided succinct answers to the knowledge task question, Examiners demonstrated a complex understanding of the skill by explaining relationships and adding detail to their descriptions.

It should be noted that two Level II instructors performed at the Examiner level on the knowledge-based task. I1 and I3 had perfect scores on the specific movements measure on both ski skills. Additionally, their scores on the rationale measures, which is an indication of their understanding of the specific movements, was only slightly lower than that of the Examiners. The fact that their movement answer time for the open parallel task was less than half of that of the examiners would suggest that their answers were not as detailed, however.

Results/Diagnostic Task

Diagnostic Task / Wedge Turn

In the diagnostic task the participants viewed videotape presentations of incorrect performances of both the wedge and parallel turns. They were asked to identify all errors and to then prioritize the importance of those errors. Table 2.5 is a record of those errors for the wedge turn. Each participant identified a primary major error (P1). They also were asked to identify a secondary major error if appropriate (S2). All other errors were effects of the primary and/or secondary errors and are identified with an X.

Table 2.5. Diagnostic task/Wedge turn

Diagnostic Task / Wedge Turn									
		Level II				Examiner			
		I1	I2	I3	I4	E1	E2	E3	E4
1	Stance is back	**P1**	**P1**		**S2**	**P1**	**P1**	**P1**	**P1**
2	Upper body turning	X	X	**S2**		**S2**	**S2**	**S2**	**S2**
3	Excessive hip flexion				X	X	X	X	X
4	Lack of ankle flexion					X	X	X	X
5	Excessive knee flexion					X	X	X	X
6	Lack of initiation extension	X		X			X	X	
7	Inactive inside ski				X		X		X
8	Bracing against outside ski		**S2**	**P1**				X	
9	Lack of finish phase flexion	X		X			X		
10	Whole body inward tipping					X		X	
11	Hands were back	X				X			
12	No outside edge, finish phase			X		X			
13	Irregular turn shape		X	X					X
14	Inconsistent speed		X						X
15	Excessive edge, outside ski	X						X	
16	Hips behind feet		X						X
17	Ski is aimed, rather than guided						X		
18	Doing a braking wedge	X					X		
19	Excessive weight on inside ski								X
20	Outside leg is pushed around								X
21	Wedge is too large				**P1**				
22	Tails of ski used for turning				X				
23	Looking down at feet		X						
24	No counter	X							
25	Turn forced thru muscle power	X							
26	Flexion & Ext. from knee & hip					X			
	TOTAL ERRORS	9	7	6	5	9	10	9	11

The eight participants identified a total of 26 separate errors. Level II instructors averaged 6.75 errors each. Examiners averaged 9.75 errors each. Examiners were unanimous in their choice of error # 1 (stance) as being the primary error and error # 2 (upper body turning) being secondary. I1 and I2 selected stance as being the primary error, while I3 and I4 selected error # 8 (bracing outside leg) and error # 21 (wedge width) as the primary errors. I2, I3, and I4 indicated error # 8 (bracing outside leg), error # 2 (upper body turning), and error # 1 (stance) as secondary major errors respectively. A discussion of stance and its importance in the performance of ski skills is contained in Appendix D.

The cluster of errors in the upper right hand corner on the Examiner side of the table provides insight into how Examiners detect inappropriate stance. Errors 3, 4, and 5 (hip, ankle, and knee flexion) identify angles at those specific joints that the Examiners used to determine if the stance of the model was rearward. A lack of ankle flexion as detected in the sagittal plane puts the lower leg at an angle perpendicular to the ski. It is practically impossible to bring the center of mass back over the boots at the center of the skis without ankle flexion. Excessive hip flexion is an indication of an attempt to bring the stance back over the skis. The net result is rearward stance, which puts the center of mass behind the boots.

The Examiners took their analysis a step further however, establishing the relationship of stance to their second major error, upper body turning. After viewing the wedge videotape E3 noted that "the muscles at the hips that would allow him to turn his legs are burdened with holding his body upright. They are tense, so he needs to find another movement to initiate that rotary movement to get the turn started. So what he is doing is using his whole upper body, hips, shoulders, everything he can, to get the turn started." The observation that rearward stance actually <u>requires</u> upper body turning (error # 1 requires error # 2) was independently stated in the diagnostic task by all four Examiners.

I1 and I2 instructors, similar to Examiners, denoted stance as being the primary error. Unlike Examiners however, the concept of stance <u>requiring</u> upper body turning as the only option for turning was not identified. I1, in fact, indicated that the upper body played a minor role in turning in the demonstration but was probably a factor. I2 indicated that bracing against the outside ski (error # 7) was a more critical error in this case than the upper body error.

I3 identified bracing the outside leg (error # 8) as the primary error, which resulted in using the upper body as the turning force. Stance was not identified as an error.

I4 identified a wide stance (error # 21) as the primary error, causing the secondary error of stance.

<u>Diagnostic Task / Open Parallel Turn</u>

The results for the diagnostic task in which the open parallel turn was assessed are presented in Table 2.6.

Table 2.6. Diagnostic task/Open parallel turn

Diagnostics Task / Open Parallel Turn										
		Level II					Examiner			
		I1	I2	I3	I4		E1	E2	E3	E4
1	Stance is back	**P1**	**P1**	**P1**	**P1**		**P1**	**P1**	**P1**	**S2**
2	Upper body turning	X	**S2**	X	X		**S2**	**S2**	**S2**	**P1**
3	Excessive hip flexion				X		X	X		
4	Lack of ankle flexion						X	X		
5	Excessive knee flexion						X	X		
6	Hands were back	X	X				X	X		
7	Pole swing off-timed			X	X			X	X	
8	Bracing outside leg		X	X						X
9	Whole arm pole swing						X		X	X
10	Hips behind feet		X							X
11	Hip and/or shoulder initiation		X				X			
12	Two-footed weight transfer							X	X	
13	Improper guidance of skis						X	X		
14	Whole body inward tipping	X						X		X
15	No counter		X						X	
16	Lack of initiation extension			X						
17	Weight on inside ski									X
18	Lack of finish phase flexion			X						
19	No outside edge, finish phase			X						
20	Irregular turn shape			X						X
21	Inconsistent speed							X		
22	No hip movement, inside of turn							X		
23	COM is back & inside at finish		X						X	
24	No corresponding pole swing								X	
25	Wide stance	X								
26	No pole use				X					
27	Using back of skis for turning				X					
28	Excessive head movement				X					
	TOTAL ERRORS	5	8	8	7		9	12	8	8

The eight participants identified a total of 28 separate errors. Level II instructors averaged 6.75 errors each. Examiners averaged 9.25 errors each. All instructors except E4 selected the stance error as being the primary error.

Examiners E1, E2, and E3 took the same position as they did with the wedge turn, citing error # 2 (upper body rotary) as a secondary error required by the stance error. Because of the severity of upper body turning, E4 identified that problem as the primary error, citing error # 17 (weight on the inside ski), error # 14 (whole body inward tipping), and error # 8 (bracing outside leg) as evidence. Error # 10 (hips behind feet) was supplied as evidence of the stance being back.

I1 prioritized error # 1 (stance) as being the primary error, resulting in all other errors. I2 also identified stance as the primary error. Error # 10 (hips behind feet), error # 23 (center of mass is back and inside at finish), and error # 8 (bracing outside leg) was cited as evidence of the stance error. Error # 2 (upper body turning) was identified as a secondary major error, separate and apart from the stance error. Evidence in support of this was provided by error # 6 (hands were back) and error # 11 (hip and/or shoulder rotation).

I3 identified stance as the primary error, with all other errors originating from this factor. Similar to this individual's wedge analysis, error # 2 (upper body turning) resulted from error # 8 (bracing outside leg). This is counter to the position taken by Examiners that error # 2 results from error # 1.

I4 indicated that the open parallel skier was just an extension of the wedge skier previously viewed. "He is the skier that was performing the wedge turns and learning to ski on the tails of his skis. He is still skiing that way. He has taken it into a new level of parallel. He is still leaning back." Identified errors for I4 were similar to the wedge analysis. In this case however, stance was labeled as the primary error rather than wedge width, which is not a feature of the open parallel turn.

Discussion/Diagnostic Task

Diagnostic Task / Wedge Turn

Only two of eight instructors did not identify stance as being the primary error in the wedge demonstration. The importance of stance is addressed in the appendix, but its importance cannot be overrated in skiing. Stance is not static. The center of mass must constantly be moving forward and back as the pitch of the hill changes in order for the skier to remain balanced over the center of the ski, thus using the whole ski length for control.

The wedge diagnostic task was distinguished by the results of the Examiners. They unanimously identified the primary error of stance by referring to the identical body landmarks of ankle, knee, and hip flexion. They also determined that the secondary major error, upper body turning, resulted from the stance error. Assuming there is further agreement beyond these four Examiners, the acceptance of this scanning technique as a universal approach should be considered.

Of further interest though, is the total number of errors identified. Two instructors or less identified 16 of the 26 errors. This lack of consensus would indicate that instructors extract different cues to make their diagnoses. The errors are, however, highly related. A sample scenario for inclusion of these errors follows:

The psychological variable of fear could force the stance rearward (error # 1). This directly leads directly to errors 3, 4, and 5 (less than optimal hip, ankle, and knee angles). This pushes the hips behind the feet (error # 16), the hands back (error # 11), and forces the skier's weight back to the tails of the skis (error # 22). Since incorrect stance requires upper body turning (error # 2), the turn requires greater muscle power (error # 25). As a result of rearward stance and upper body turning there was no leg extension in the initiation phase (error # 6), and an inward lean of the whole body (error # 10), resulting in too much weight on the inside ski (error # 19). This creates an inactive inside ski (error # 7), a subsequent bracing against the outside ski (error # 8) and excessive edge angle on the outside ski (error #15). This combination of errors results in an irregular turn shape (error # 13), inconsistent speed (error # 14) and a downward projection of the eyes to the feet (error # 23).

This litany of secondary errors all originated from the primary error. It gave rise to 18 of the 26 errors. The importance of identifying the primary one or two errors is obviously critical if so many other problems result. Faults must be corrected at their source. The elimination of seminal errors has more impact on lower level errors than the reverse (Hay & Reid, 1988).

Diagnostic Task / Open Parallel Turn

All instructors identified stance as the primary error except E4, who identified upper body turning as the primary error. E4's first comment was "I didn't feel good about his stance." However, instead of focusing on the ankle, knee, and hip angles (errors 3, 4, & 5) as was done in the wedge turn, E4 identified upper body turning (error # 2) as the primary error.

Additionally, the diagnoses of E1, E2, and E3 were consistent with their wedge diagnostics, stating that rearward stance requires upper body turning. I2 was the only Level II instructor who identified this relationship. This was discovered for the first time during the course of the interview.

Similar to the diagnoses of the wedge turn, 20 of the 28 errors were identified by two instructors or less. This may indicate that the instructors used different information to draw similar conclusions.

Conclusion

The results of this study indicate that differences exist both within levels of instructor and between levels. Beyond differences in the knowledge bases, other differences between the two groups were evident in the prioritization of observed error. Error prioritization is seen as particularly critical since it forms the basis of the interaction between the instructor and student. It is important that instruction addresses the primary errors, and not the secondary problems that are caused by primary errors.

It is also evident that Examiners, unlike the Level II instructors, see a causative relationship between stance and upper body turning. Examiners are also using the observation of particular lower-body joint angles to determine the primary error, and subsequently add upper body turning as a secondary error.

There appears to be a direct link between the knowledge base that governs the internal model and error detection abilities. Specific qualities that were not identified as crucial to the performance of the prototypical skill by I2 and I4 were also not detected as performance errors in either the wedge or parallel turns viewed.

Also, Level II instructors were more proficient at diagnosing the open parallel turn than the wedge turn. While it can be argued that the wedge is a simpler skill to diagnose, an individual who trains instructors at a major U.S. resort reviewed these results and explained that the open parallel level of skiing is closer to the level at which Level II instructors ski. This provides them with a better understanding of the skill. In his opinion, since Level II instructors are often still working on improving stance in their own skiing, they could better identify that error in the skill model.

Having established that differences exist between these groups of Level II instructors and Examiners, it is important to examine why they exist. Theories that have been used to explain expertise in other domains include experience and deliberate practice (self-improvement training). Follow-up discussions with participants in the present study indicated that deliberate practice, and not teaching experience, should be considered as a theoretical explanation for expertise in the coaching domain. Those discussions yielded the following insights:

Level II instructors are in demand to teach, leaving them little time to engage in activities that will improve their personal skiing, teaching, and technical skills. A Level II subject interviewed for this study indicated that he left his prior school of employment in order to work where he could get more training. Although instructors are required to attend a minimum number of teaching clinics per season (usually two), the demands on their time is such that they often do not attend more than that. The results of I1 and I3 were superior to the results of the other two Level II instructors in this study. I1 indicated that he typically attends 18 clinics per year, and sets aside time during every teaching day for improving personal skiing. Similarly, I3 attended a weeklong teaching clinic at a

Colorado resort this season, and was currently training for a Level III exam. The other Level II participants indicated far less time had been committed to these activities. This finding is consistent with Walkley and Kelly (1989) who have stated that skills in qualitative analysis must be learned through formal training, as they will not be otherwise learned through field experience.

Chapter 3

An Analysis of Prescriptive Expertise as Determined by the Lesson Plans Developed by Level II and Examiner Downhill Ski Instructors

Ben Young

Introduction

Several diagnostic models have been proposed to explain the analysis of movement error (Hay & Reid, 1982, 1988; Hoffman, 1983; Pinheiro & Simon, 1992). However, comprehensive models not only include the analysis of movement error but also intervention with the learner (Knudson & Morrison, 1997; McPherson, 1990). The inclusion of an intervention completes a circle in which new performances by the learner give rise to new observations, diagnoses, and prescriptions by the instructor. To focus on an instructor's diagnostic abilities only addresses part of the equation that comprises instructor expertise in movement analysis. A comprehensive examination of instructor expertise necessarily requires an investigation of both areas, diagnosis and prescription. The current study investigated the interventions that instructors designed to remedy errors diagnosed in Study 1.

Intervention with the learner can include many techniques and/or strategies including modeling, physical guidance, and the prescription of corrective exercises. Modeling can efficiently convey task-relevant information that lengthy verbalizations often cannot (Rose, 1997). Physical guidance can provide exact information to the learner, but risks overreliance on the instructor. While each of these techniques is important, the prescription of exercises is the primary mechanism by which downhill ski instructors effect changes in the performance of learners.

In the second study, the same eight instructors provided their separate lesson plans for the errors that had been diagnosed in study 1 relative to both skiing skills. This took the form of providing a list of exercises they would use to guide their interventions with the student. This made it possible to make comparisons across instructors relative to the different solutions offered to eliminate the identified errors.

Before making those comparisons however, the first task of interest was to identify the relationship between diagnosed errors and the exercises prescribed for those errors. While it would seem logical that the correct prioritization of the most pivotal errors would be prerequisite to the correct intervention with the student, it is governed by the assumption that identified errors are the subject matter of the interaction. While this has intuitive appeal as being the most likely possibility, this relationship has not been empirically tested. In fact, this question was raised by pilot subjects who prescribed generic exercises in lessons, regardless of the type of error made by the learner.

A second area of interest was the ordering of exercises that were designed to remedy the diagnosed errors. Again, it would seem logical that the order of exercises would address the primary errors first, followed by the secondary errors. Knudson and Morrison (1997) have indicated however, that this may constitute only one of several possible strategies used to prioritize the exercises used in an intervention. The strategy of addressing the primary errors first would be to maximize skill improvement in the learner (Hay & Reid; 1982, 1988). Instructors can just as easily utilize other strategies in which they correct the least difficult problems first, or correct problems in the order they are observed.

This investigation also addressed the area of lesson scope, or the number of errors instructors attempted to remedy in any given lesson. Pilot research suggested that Level II instructors attempt to teach more subject matter and address more problems in their lessons than Examiners. As a result the learner would be provided fewer opportunities to practice corrective exercises for each error. Rose (1997) has argued that one of the most difficult tasks that instructors face is setting the criterion for mastery of the intended skill. With fewer opportunities to practice corrective exercises, the criterion for mastery of each error would necessarily be set lower for Level II instructors. This is critical since the amount of original learning is one of the best indicators of whether movement patterns will be retained (Christina & Bjork, 1991). Data were collected to investigate whether the scope of lessons differed between the two groups of downhill ski instructors.

An additional interest of the second study was a comparison of different solutions to error that instructors provided in their lesson plans. Ski instruction manuals present multiple exercises as solutions to movement error (Alpine Manual, 1996; Alpine Level II, 1996). Whereas correct error prioritization is critical in movement analysis, the solutions that are offered are equally important. It is not known whether these solutions are a measure of expertise. This area was therefore investigated.

The type of practice strategy used (i.e., part or whole task practice) was also addressed. With rare exception, instructors traditionally teach ski skills in parts. Ski instruction manuals, in fact, devote much of their content to part exercises. The available options to instructors when teaching in parts are to simplify, segment, or fractionate the desired skill (Wightman & Lintern, 1985). To rectify incorrect stance for example, the first exercises in the lesson plan are often practiced statically, thus simplifying the task. In the next phase of the progression the exercises are performed in the context of partial, and eventually whole turns. This partitioning of skills into temporal elements would be an example of segmentation, a second method of part teaching. The third method of part-task teaching, fractionization, would be exemplified by practicing in isolation those components of a skill that would normally be practiced together. This technique is the least effective of the three different methods. In ski instruction, this is commonly done through exercises that emphasize lower body movements irrespective of the accompanying upper body movements. Flexion and extension exercises without the use of the ski pole would be an example. While all three of these methods would have short-term performance advantages in the lesson setting, there is some question as to whether the temporal and spatial elements that link the whole task are preserved (Rose, 1997). The use of part-task teaching methods was therefore examined.

Finally, two pilot subjects and one instructor in the current study indicated as part of their lesson plan that they first assess the learning preferences of their students in order to determine the best method of communicating to the student. Students are categorized as thinkers, watchers, feelers, doers, or some combination thereof. The PSIA instructor manual (Alpine Manual, 1996) recommends this as a policy. Implicit in this categorization is the assumption that thinkers learn through analytical description, watchers by observing, feelers by sensing, and doers by practicing. This system of classification was discussed in terms of the practical and scientific evidence of support.

Method

Participants

The eight Level II and Examiner certified instructors from Study 1 were participants in this research.

Procedures

After the diagnostic task each instructor was asked the following question: "Suppose you could have this individual as a student. Where would you start and how would you correct the problems you just diagnosed? Be as specific as possible. Describe all possible exercises." This question was asked for both the wedge and open parallel turn. Participants were allowed to comment as long as necessary. The investigator developed a list of exercises based on each instructor's responses. If there was a pause in responding, the list was read back to each instructor and they were asked if there was anything further that they would like to add. If it was unclear as to what error was being addressed by an exercise, a follow-up question was posed requesting that information. All answers were audiotaped to ensure the accuracy of the interpretation.

Results

Coding and Reliability

Naturally Speaking Preferred Version 2.02 voice recognition software was used for the transcription of verbatim interviews. The primary investigator and a trained assistant independently coded each transcription. The coding method required the identification of exercises, and the error that was being addressed with each exercise. Reliability coefficients were calculated by dividing agreements by the sum of agreements and disagreements. These coefficients are presented in Table 3.1.

Table 3.1. Reliability Coefficients

	Wedge	Open Parallel
Exercises	.94	.98
Lesson Scope	1.0	1.0

<u>Diagnostic-Prescriptive Link/Lesson Scope</u>

The following results address the relationship between prioritization of error and the exercises used as interventions with the student. Tables 3.2 and 3.3 are for the wedge and open parallel turns respectively. The contents of these tables address three areas of inquiry:

1. How appropriately do the exercises prescribed address the errors identified?
2. Does the order in which the errors prioritized relate to the order in which exercises are to be performed during the lesson?
3. Does the scope of the lesson plan vary between groups of instructors?

Column two in Tables 3.2 and 3.3 show the errors identified in study 1. Column three denotes the prioritization (P) level. Cases in which there were multiple second level or third level errors indicate no distinction was made between prioritization level. Column four lists the order of errors as they were addressed in the lesson plan. Totals in column five represent the total number of errors addressed by the exercises represented in the lesson plan, and are an indication of the scope of the lesson plan.

Table 3.2. Diagnostic/prescriptive link – Wedge turn

Wedge Turn				
Level II	Errors Identified	P Level	Lesson Plan Errors	Lesson Scope
			(in order)	(errors per instructor)
I1	Stance	1	Stance	
	Upper body turning	2	Upper body turning	
	Counter	2	Counter	Total = 3
I2	Stance	1	Stance	
	Bracing outside leg	2	Bracing outside leg	
	Upper body turning	3	Upper body turning	
	Turn shape	3	Turn shape	Total = 4
I3	Bracing outside leg	1	Bracing outside leg	
	Upper body turning	2	Upper body turning	Total = 2
I4	Wedge is too large	1	Wedge is too large	
	Stance	2	Stance	
	* Not Identified		High speed turns	Total = 3
Examiner				
E1	Stance	1	Stance	
	Upper body turning	2	Upper body turning	Total = 2
E2	Stance	1	Stance	
	Upper body turning	2	Upper body turning	
	Inactive inside ski	3	Inactive inside ski	Total = 3
E3	Stance	1	Stance	
	Upper body turning	2	Upper body turning	
			Stance	Total = 2
E4	Stance	1	Stance	
	Upper body turning	2	Upper body turning	Total = 2

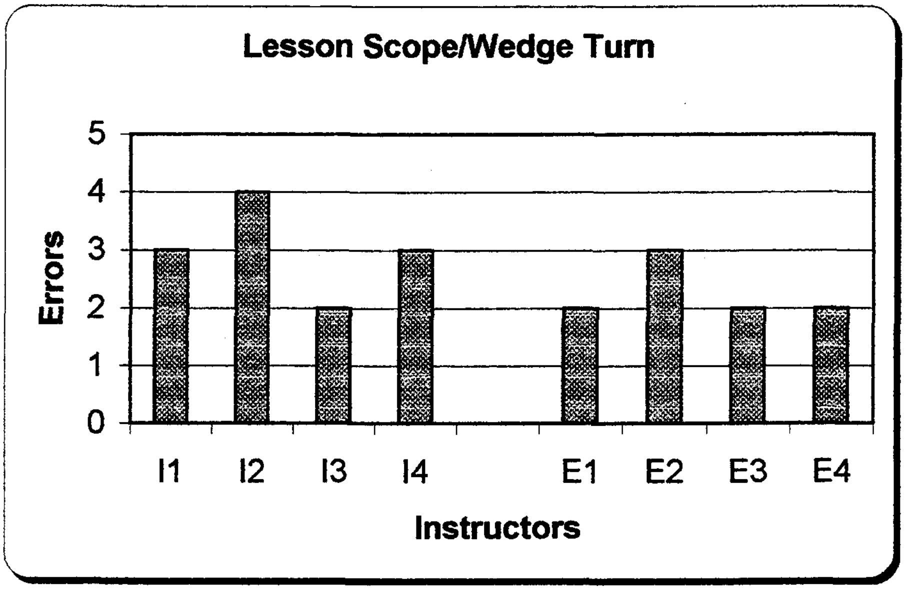
With one exception, all instructors addressed only those errors that had been previously diagnosed. I4 identified high-speed turns as an exercise that would be used, and no corresponding error had been identified. This is interpreted as a generic exercise that this instructor deemed important to do with this student, regardless of the errors he exhibited in performance.

All instructors ordered their sequence of exercises as they prioritized their errors. One exception to this appears in the lesson plan of E3, whose lesson started with exercises addressing the stance error, moved to upper body turning, and then returned to stance. The explanation that was provided for returning to exercises addressing stance was the change of terrain to a higher pitch late in the lesson. This change in terrain resulted in the re-emergence of the stance error.

Other information that can be derived from this table is the scope of the lesson. Pilot research had indicated that lower level instructors attempted to cover more errors in their lessons than upper level instructors. For the wedge lesson, the average number of errors for which the four Level II instructors specified exercises was 3.0. In contrast the Examiners specified exercises for an average of 2.25 errors. When converted to lesson length, Level II instructors would correct in approximately 45 minutes the same number of errors that Examiners would correct in 60 minutes.

Figure 3.1 presents the number of errors in the lesson plan addressed by each instructor in the wedge turn.

Figure 3.1. Lesson Scope/Wedge Turn



The link between diagnosis and prescription for the open parallel turn is presented in Table 3.3.

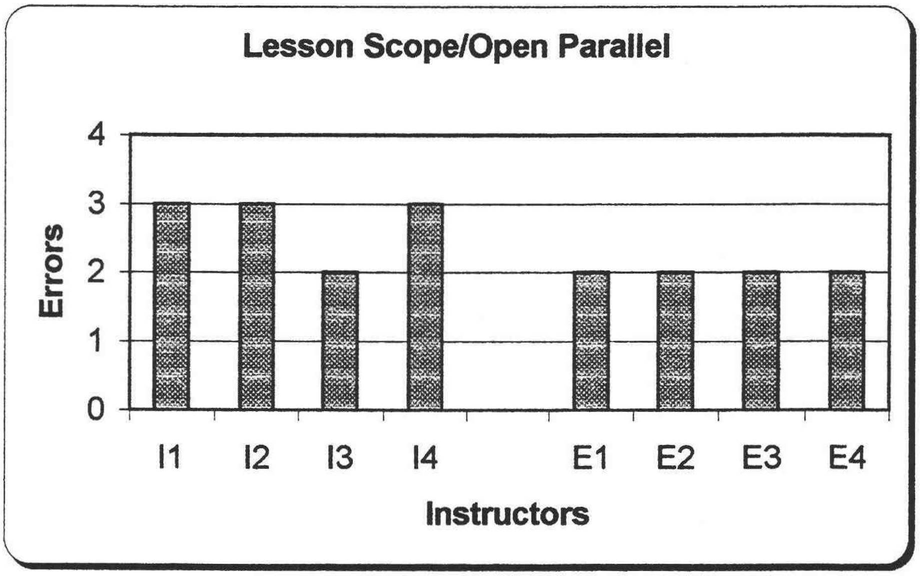
Table 3.3. Diagnostic/prescriptive link – Open parallel turn

Open Parallel Turn				
Level II	Error Identified	P Level	Lesson Plan Errors	Lesson Scope
			(in order)	(errors per instructor)
I1	Stance	1	Stance	
	Upper body turning	2	Upper body turning	
	Hands were back	2	Hands were back	Total = 3
I2	Stance	1	Stance	
	Upper body turning	2	Upper body turning	
	COM-back & inside	3	COM-back & inside	Total = 3
I3	Stance	1	Stance	
	Edge control	2	Edge control	Total = 2
I4	Stance	1	Upper body turning	
	Upper body turning	2	Stance	
	* Not Identified		Counter	Total = 3
Examiner				
E1	Stance	1	Stance	
	Upper body turning	2	Upper body turning	Total = 2
E2	Stance	1	Stance	
	Upper body turning	2	Upper body turning	Total = 2
E3	Stance	1	Stance	
	Upper body turning	2	Upper body turning	Total = 2
E4	Upper body turning	1	Upper body turning	
	Stance	2	Pole swing	
	Pole swing	3		Total = 2

Again, with exception of one instructor, all remaining instructors addressed only those errors that had been previously diagnosed. I4 indicated that counter exercises would be part of the lesson plan and no corresponding error had been identified. Similar to the wedge turn, most instructors ordered their exercises in the same order as they were prioritized. The one exception was I4 who chose to first provide exercises for an error that had been prioritized as secondary, upper body turning. I4 also developed exercises for an error that had not been specified.

In the lesson scope for the open parallel turn, Level II instructors averaged 2.75 and Examiners averaged 2.0 errors addressed. Figure 3.2 presents the number of errors in the lesson plan addressed by each instructor in the open parallel turn.

Figure 3.2. Lesson Scope/Open Parallel Turn



The Level II instructors in this study attempted to teach more material in their lessons than Examiners as evidenced by the lesson scope statistics. The following lesson plans of

E3 and E4 indicate they further limited the scope of their lessons. Despite identifying two errors on which to provide exercises, they focused almost entirely on one error. It is of further interest that the E3 lesson plan is balanced toward correcting the upper body turning error and the E4 lesson plan is balanced toward correcting the stance error. Their respective lesson plans for the wedge turn are presented below.

E3/Wedge Turn

Errors	Exercises
1. Stance	check boots for tightness
2. Upper body turning	static steering exercises
3. Upper body turning	whole turn steering exercises
4. Upper body turning	whole turn weight transfer exercises
5. Stance	stance adjustment at turn initiation

Synopsis: It was reasoned that moving to more shallow ski terrain and adjusting the boots would minimize the stance error for most of the lesson. Upper body turning was addressed with steering and weight transfer exercises, primarily in the context of whole turns, which occupied most of the lesson. As the pitch of the terrain and the speed of the turn subsequently increased, stance was again addressed.

E4/Wedge Turn

Error	Exercises
1. Stance	general movement exercises
2. Stance	static exercises
3. Stance	straight run exercises

4. Stance exercises	turning exercises
5. Upper body turning	extension and flexion exercises

Synopsis: Student is moved to more shallow terrain to enhance performance. Almost the entire lesson focused on stance. Only when correct stance was achieved in a variety of exercises, progressing from static to dynamic, was the secondary error of upper body turning addressed.

Despite the identification of two errors, the prior lesson plans of E3 and E4 demonstrate that in their lesson plans they primarily focused on only one error. This is a further indication of the extent to which Examiners limit the scope of their lessons.

<u>Uniqueness of Solutions to Error</u>

Of further interest is the uniqueness of the solutions that were designed to effect change in the performance of the learner.

<u>Wedge turn.</u> Of the eight instructors interviewed in this study, six prioritized stance as being the primary error in the wedge turn. All but one of the instructors (E3) addressed the stance error with a part-task teaching progression in which a) the student practiced correct stance statically, attending to sensory cues, and then b) practiced the stance position while moving, eventually performing whole turns. E3 argued that simply moving the student to more shallow terrain (which all instructors did) and making a boot adjustment will solve the immediate stance error, allowing the focus of the lesson to move to the second major error, upper body turning. To quote, "I would just about bet any amount of money his boots were too loose. As a result, he was trying to maintain

contact with some part of the cuff at all times so that he had control over his turns, and for a defensive or lower level skier, that tends to be the back of the boot." This Examiner went on to describe how he has worked with students for hours on their stance only to find out at the end of the lesson that they only needed to adjust their boots. He has since adopted this approach when teaching at all ability levels, including instructors, and indicated that he had just returned from a teaching clinic in which he required instructors to adjust their boots. The position taken by this Examiner for this lesson is distinct from the other instructors, who designed multiple static and movement exercises to accomplish the same goals of correcting the stance position. It can only be assumed that if the equipment adjustment did not fully address the stance error that it would be necessary to perform exercises with the student.

Open parallel turn. Although only one instructor (E3) recommended an adjustment to the student's boot as part of the lesson plan when teaching the wedge turn, three instructors (E1, E2, and E3) recommended an adjustment to the student's boot as part of the open parallel turn lesson plan. No Level II instructors made this recommendation.

Part-Whole Task Teaching Progressions

Seven of eight instructors interviewed used a part-task practice approach when introducing skills. Stance skills were typically practiced statically, then progressed to partial and whole turns. Exercises for the upper body turning error typically addressed the finish phase of the turn first, followed by exercises addressing the initiation of the turn. Often, these phases were further divided into smaller parts, or even static exercises.

Eventually, the parts were put back together into the whole turn. An example from each group is provided below in which the upper body turning error is addressed.

I1/Open Parallel Turn

Error	Exercises
1. Upper body turning	static flexion and extension exercises
2. Upper body turning	flexion and extension exercises while traversing
3. Upper body turning	flexion exercises at finish phase
4. Upper body turning	extension exercises at initiation phase

Synopsis: Upper body turning is addressed with lower body extension and flexion exercises, first performed statically. The same exercises are then performed while traversing the hill. Flexion exercises are then performed at the finish phase of the turn, followed by extension exercises at the initiation phase of the turn.

E4/Open Parallel Turn

Errors	Exercises
1. Upper body turning	flexion and extension exercises while traversing
2. Upper body turning	flexion exercises at finish phase
3. Upper body turning	extension exercises at initiation phase
4. Upper body turning	whole turns, combining 2 & 3

Synopsis: Upper body turning error is addressed with flexion and extension exercises, first with traverses, then in the finish phase of turn. Extension exercises are then performed in the initiation phase of turn. Finish phase and initiation phase are put together as whole turns.

Whereas the prior two examples (I1 and E4) demonstrate the part-task teaching approach that the instructors used in this study to introduce skills, E3 did not use this approach. He explained "This is what I typically do when I teach a lesson. I identify the movement, display it statically and make sure they have a good understanding of it. I give them a good demonstration in the context of the whole, and then have them perform it in the whole. That way, if they get it, great, and we just move on. If they don't then I have a whole picture to look at, and I can see if some of it is working, or some areas have been misinterpreted. I have had a lot better success doing that, rather than using a straight progression and building piece by piece, and building back up. That way, I can pace the lesson based on their success rather than based on the progression." The lesson plan for E3 is as follows, in which he demonstrates how he corrects the upper body turning error.

E3/Open Parallel Turn

<u>Errors</u>	<u>Exercises</u>
1. Upper body turning	whole turning exercises, focusing on current errors
2. Upper body turning	whole turning exercises, cueing uphill leg extension

3. Upper body turning — whole turning exercises, cueing flexion at bottom of turn

Synopsis: Exercises for upper body turning error are performed in the context of whole turns rather than parts. Lesson is paced according to success at whole movements rather than building progressions.

Learning Preferences

The PSIA recommends that instructors identify the learning style of the student. Learners are characterized as "thinkers", "doers", "see-ers", and "feelers." Thinkers would learn best through verbal explanation of the desired task, doers through practice, see-ers through visual modeling, and feelers through identification of the correct kinesthetic feedback. E3 indicated in his lesson plans that he uses this classification system. Similarly, two of the six pilot subjects also indicated that they attempt to identify the learning preferences of the student. No other instructors referred to this categorization of learning styles in their lesson plans.

Discussion

The current study addressed several issues in instructor lesson plans that will be discussed in the same order they were presented in the results.

Diagnostic/Prescriptive Link

It is possible for instructors to provide lesson plans that do not immediately address identified errors. For example, if instructors knew they were to have extended contact with a student, such as weeks or months, they may choose to provide fundamental exercises that would be unrelated to current errors. Classroom instruction is required at many European ski schools at the beginner level. The American system is more focused on the immediate skill improvement of the student. The lesson plans of downhill ski instructors interviewed in this study were limited to errors that had been identified in the performance of the student. Very few exercises were ever included that did not directly address observed errors. These findings would indicate that lessons are driven by error diagnostics and not by preconceived lesson plans that operate irrespective of immediate skill enhancement.

Additionally the order of the exercises in the lesson plan was the same as the order of prioritization of the identified errors. This also meant that if the wrong primary or secondary error was identified, the first exercises of the lesson plan would not address the appropriate errors. Correcting the most important errors eliminates more faults than correcting lower level errors (Hay & Reid, 1982, 1988). The failure to identify that error results in the development of a set of exercises that would necessarily have less influence on overall improvement. With this link firmly established between error prioritization and lesson plans, it is imperative that errors be correctly diagnosed in order to maximize improvement.

Lesson Scope

Combining the results of both the wedge and open parallel turn Level II instructors provided exercises for 35% more errors than Examiners. Examiners limited their lesson plans to fewer errors and provided more exercises to the learner for each error. Level II instructors addressed more errors and provided fewer exercises to the learner for each error. In terms of lesson length, Level II instructors would attempt to correct in approximately 45 minutes the same number of errors that Examiners would attempt to correct in 60 minutes.

These results raise the much larger question of learning, and what students actually learn from ski lessons. The fact that instructors can quite rapidly change the performance of students in the lesson setting is not questioned. The permanence of that change, however, is disputable. Most ski instructors are in the unfortunate position of not being able to observe the effects of their efforts several days, or weeks, after their lessons. Most are aware, however, that the performance achieved in lessons is not always permanent.

The ability of a student to produce skills at a later date seems to be influenced by the amount of original learning (Christina & Bjork, 1991). The criterion that an instructor sets for mastery, and thus the amount of original learning, would apparently vary between Level II and Examiner level instructors.

The goal of most skiers, especially at the beginning level, is to ski steeper slopes. This goal can run counter to the mastery of fundamental skills since skiing beyond one's ability usually reinforces incorrect stance and the upper body turning error. A mechanism for setting the criterion for mastery at a higher level would be to move the lesson setting to steeper slopes, thus varying the conditions under which the same skill is practiced. Schmidt (1975) argues that practice variability requires different movement parameters be applied to a given skill, thus widening the range of application. Moving students to more difficult terrain to practice the same skills would satisfy the student's goal of mastering more difficult slopes and meet the theoretical precepts of learning as first described by Schmidt (1975). Though possibly an error of omission, only one instructor (E3) mentioned that he would move the student to more difficult terrain during the course of the lesson. It appears that instructors prefer to cover more skills on easy terrain, rather than move their students to more difficult terrain to widen the criterion of mastery for one skill.

Uniqueness of Solutions to Error

The stance error has, by now, become evident as a prominent error in skiing. The solution to that error is typified by the instructor increasing the awareness of the student to sensory feedback associated with correct performance. Most instructors do this with static exercises, progressing to general movement exercises, followed by complete turns. The issue of equipment (boots) playing a role in incorrect stance was raised by E3 at the wedge level, and further supported by two other Examiners at the open parallel level. E3 further asserted that this policy is applicable, even when working with instructors in teaching clinics.

The role of boot adjustment in the stance error is not new and it is unlikely that the Level II instructors in this study were unaware of that fact. The PSIA certification manual details its importance. It is apparently more meaningful to Examiners though, since three of them listed it in the lesson plan for the open parallel turn and one listed it in the wedge turn.

Aside from the boot adjustment very little else can be added that was unique to the solutions provided by any instructors in this study. Multiple exercises are delineated in the ski certification manuals and none of the exercises prescribed as solutions for these errors were uniquely different from what has been published. This would indicate that the exercises themselves are not a discriminating factor in instructor expertise.

Part-Whole Task Teaching Progressions

The breakdown of ski skills into component parts for instruction is advocated by the certification agency and has been universally adopted. The learning of complex skills in parts for certain skills simplifies the task and makes it easier to perform in the lesson setting (Wightman & Lintern, 1985). However, the goals of learning whole skills by part methods are not always evident to the learner. While the logic of how parts fit together is obvious to the instructor, the learner is not necessarily privy to this logic.

There is also some concern that the use of fractionization as a part-task teaching method is over-utilized as a teaching technique. This is exemplified by isolating the practice of those upper and lower body movements that would normally be performed at the same time. Rose (1997) has indicated that part-practice may prevent the student from umderstanding how the temporal and spatial components of the entire task can be integrated into a fluid execution of the whole skill. It is suggested here that the independent practice of skills that would ordinarily be performed simultaneously would contribute to this problem.

While part-task practice can facilitate immediate improvements in performance in the lesson setting, it is not the objective of ski lessons. The objective of ski lessons is a more permanent acquisition of learning that can be transferred beyond the lesson setting. The theoretical framework known as transfer-appropriate-processing (Bransford, Franks, Morris, & Stein, 1979) has been used to explain how this transfer of learning is achieved. Proponents of this theoretical framework argue that the underlying cognitions in practice should be similar to those required in the transferred state. Coaches that adhere to this principle attempt to simulate game conditions. While it seems practical to teach initial movements using part-practice techniques within the practice setting, it is questionable whether the cognitive processes associated with the parts are the same as those when performing the whole skill. Similarly, Schmidt (1991) argued that isolating movement into parts results in a motor program being developed for executing each part. This would not facilitate the performance of the whole movement however, which would be based on a different motor program.

The presentation of one or two attentional cues during the performance of the whole skill would seem to be more appropriate given the culminating goal in skiing, that of fluid, sequential turning skills. This whole practice technique with attentional cuing was only adopted by E3. The learner would apparently be using the underlying cognitions associated with the whole performance, and the temporal and spatial qualities of movement would therefore be preserved.

It is not argued here that whole task practice, even with moderate attentional cuing, should be adopted as the only technique used to introduce ski skills. If a student cannot perform a skill in the context of whole turns, a part task approach would be appropriate. The student should be advanced as rapidly as possible however, to whole task practice once the parts of the skill are accomplished.

Learning Preferences

A component of the lesson plan mentioned by E3 and two pilot subjects for this investigation was the identification of the student's learning style. The PSIA certification manual identifies students as learning through thinking, watching, feeling, or doing. Implicit in this classification system is the notion that students categorized as "thinkers" learn best by having movements explained to them. Similarly, "watchers" learn best by having movements demonstrated for them, "feelers" learn through sensory feedback, and "doers" learn through practice. E3 also indicated that he sees this classification system as too simplistic, even though he attempts to identify some type of learning preference in students. The two pilot subjects (an Examiner and a Level II instructor) who mentioned this classification system took it quite literally and used it as a mechanism for determining the method of communicating to the student. From a practical standpoint, instructors typically use multiple communication methods when conveying any motor skill information. When introducing a skill, they very often provide an explicit verbal explanation, a multi-angled visual model of the skill, an explanation of the kinesthetic sensations the student should be feeling, and the opportunity for physical practice. In so doing, they recognize the many ways in which students assimilate motor information. The classification of students into these learning preference categories, or any combination of these categories, remains empirically untested however. It is interesting to note that on the many occasions that this investigator has asked teaching professionals outside of the ski industry to classify themselves as to their personal preference for learning motor skills, none have questioned the validity of such a classification system. They have instead responded with the category under which they thought they might fit. As a future area of investigation, the validity of this classification system merits consideration.

SUMMARY

Having established that there are expertise differences between the Level II instructors and Examiners interviewed in this study, a discussion of the theory of expertise that might explain those differences is warranted. Originally, it was intended that Level II instructors with more than five seasons of teaching experience at that level would be excluded from this study. This was based on the premise that experience, one theoretical explanation advanced to explain differences in expertise, possibly qualified them to be at a higher level of certification. However, two of the Level II instructors used as pilot subjects had over 20 seasons of teaching experience and did not have results markedly different from less experienced Level II instructors. Walkley and Kelly (1989) have indicated that coaches do not develop movement analysis abilities as a result of extended field experience. The findings of the two present studies support this contention. Imwold and Hoffman (1983) have further suggested that as the amount of teaching experience increases, movement analysis skills may actually decrease. The five-year restriction was therefore eliminated. It would appear that other factors besides experience were accounting for the differences in expertise observed.

Innate ability has been advanced as another explanation for differences in expertise. Sir Francis Galton (1892) posited genetic endowment as a limitation of expertise. The work of Gardiner (1993) further argued that humans have a natural predisposition for certain “intelligences” (e.g. athletic, interpersonal, scholastic, musical, and artistic). Especially in sports, expertise has been thought to be the result of inherited talent. This position has been challenged in recent years, however, by research that has found the body not to be limited by a fixed capacity (Ericsson, 1998). Ericsson et al. (1993) have further argued that innate ability plays no role in the expertise of accomplished violinists and pianists. Instead they have indicated that the expertise of these groups is the result of deliberate practice, the goal of which is self-improvement. Retrospective studies that have been conducted in wrestling (Hodges & Starkes, 1996), soccer, and field hockey (Helsen, Starkes, & Hodges, 1998) further indicate that with modification to the definition, a theory of deliberate practice can generalize to the sport domain.

Ericsson et al. (1993) indicated that expertise is the result of deliberate practice, and specifically rule out innate ability and experience as factors. It is suggested here that this definition should be further expanded to include the deliberate practice in which instructors engage to improve their qualitative analysis skills. While the current study did not specifically test a theory of instructor expertise, evidence indicates that a theory of deliberate practice best explains instructor expertise. This was suggested in several ways. First, the lack of differences found between high and low experienced Level II pilot subjects would minimize the role of experience. Second, follow-up discussions conducted with Level II instructors and Examiners indicated a relationship between the diagnostic and prescriptive expertise and the amount of time outside of teaching spent improving their own skiing, attending teaching clinics, and engaging in technical study. The third area of support came in the form of the number of certifications achieved by each group. Examiners in the present study had many more certifications than Level II instructors, averaging six certifications versus two. The certification process in downhill ski instruction requires deliberate practice. Certification exams require that instructors rigorously prepare themselves for testing of their skiing, teaching, and technical skills. Higher level exams successively require more expertise. The preparation in which instructors engage to pass exams fits the classic definition of deliberate practice in that a) it is often a highly structured activity that is not necessarily pleasurable or motivating (the practicing of ski exercises required in lessons, for example), b) it is generally effortful and c) the overriding goal is improved performance (Ericsson et al., 1993). In contrast, teaching does not usually improve the skiing skills of the instructor. Most instructors indicate that it actually degrades their skiing skills. And although most would argue that teaching is effortful, the overriding goal is not the improved performance of the instructor.

Furthermore, no instructor would attempt to pass his/her exams, supposedly a measure of expertise, by only teaching lessons. If exams measure the level of expertise they are intended to, this explains why instructors with numerous seasons of teaching experience and a low certification level are not experts. Deliberate practice would could constitute at least one mechanism by which the necessary expertise is achieved.

Practical Implications

Innate ability as a theory of expertise indicates that limitations are imposed by genetic endowment, about which little could be done. A theory of experience indicates that field experience is the primary requirement for achieving expert status, again posing a limitation. If it can be argued that expertise in downhill ski instruction is the result of deliberate practice, a mechanism for creating experts is thus provided. A theory of deliberate practice places the responsibility for expertise in the hands of the individual, or the ski school directors who would require their instructors to pursue certifications.

A direct approach to the expertise differences demonstrated in this study is to provide training addressing those differences. There is some concern though, that there are too few resources that currently provide training in qualitative analysis. Physical education teachers have similarly been found to be lacking in qualitative analysis education, due in large part to the unavailability of instructors to provide such training (Walkley & Kelly, 1989). There are only eight Examiner level instructors in Oregon to provide training to an estimated 600 instructors. The use of Divisional Clinic Leaders, the next level below that of Examiner, adds another five individuals to that list. However, the number of qualified trainers still remains far below what could be considered adequate.

Future Directions

If adequate education in this form cannot be provided, an alternative solution would be to use interactive CD-ROM's and/or videodiscs. Lower level instructors could diagnose multiple student performances on computer screens and results could be compared to those of Examiners. Similarly, the lesson plans provided for those diagnoses could be compared. The advantages of this approach are a) training can be self-paced, b) standardized, and c) accessible to an unlimited number of individuals. Wilkinson (1991) has demonstrated that significant improvements can be effected in the ability of novices to diagnose errors in volleyball skills through a videotape training program. The use of interactive computer technology could similarly utilize visual portrayals but would offer the advantage of providing feedback without the need for that rare expert to be present.

This study used a necessarily small sample size in order to learn as much as possible from each individual. This made it possible to present two skiing skills, the wedge and open parallel turn, and examine expertise in the areas of diagnosis and prescription. A larger sample size, examining only one of these diagnostic or prescriptive areas would indicate how pervasive these differences are. For example, Level II instructors demonstrated better diagnostic abilities for the open parallel turn than the wedge. While it can be argued that the wedge is a simpler skill, the results from the diagnostic study would suggest that instructors have a better understanding of the skill level which most resembles their own. The interaction between skill level and teaching expertise would be of interest in a future investigation.

The need to study expertise in the applied setting to determine how these results actually affect student performance is also needed. It should be determined if the additional lesson scope described by of Level II instructors would depress original learning and impact long-term retention. Likewise, a determination of the impact of part versus whole learning on the production of a fluid turning movement is of interest.

Further testing of the deliberate practice theory of expertise is also warranted. Studies in other domains have been conducted retrospectively in which participants identify factors that influence expertise. A similar investigation in the coaching domain would be of interest. A study that controlled for teaching experience between groups would provide an interesting examination of variables that may be contributing to expertise.

It has been suggested here that a theory of deliberate practice is the most viable explanation of expertise. Innate ability is currently being discouraged by this investigator as an explanation for expertise in qualitative analysis. It is interesting that Examiners seem to rapidly achieve their certifications. Two of the Examiners in this study attained their certification status in 6 and 8 years, respectively. No Level II instructors known to this researcher are on such a remarkable time line. Motivation may be a factor to engage in such rapid achievement, and it is certainly a factor when engaging in deliberate practice itself. Innate ability may eventually be found to have a role in expertise if the motivation to engage in deliberate practice is found to be a heritable trait.

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APPENDICES

APPENDIX A

BACKGROUND QUESTIONNAIRE

Background Questionnaire

Name______________________________________Age_____ M / F (circle)

Address____

City, State, and Zip Code____

Phone Number____

# of Years Skiing_________ # of years teaching___________

Amount of competitive experience, if any (include frequency, duration, levels, and locations of competitive experience)

____

____

____

Amount and level of ski lessons I have taken (include frequency, duration, levels, and locations of lessons)

____

____

____

Teaching Training (include frequency, duration, levels, and locations of training)

____

____

____

Certification(s) (please include the name of certification agency, level, location, and date of certification)

____

____

Populations Instructed (children, adult, gender, etc; include number of years instructing each group)

____

____

Levels Instructed: Examples: wedge, wedge christy, parallel, bumps, powder (include number of years you have instructed at each level)

____

____

Geographic locations in which I have instructed, including number of season(s) at each location

____

____

APPENDIX B

INFORMED CONSENT/SKI INSTRUCTORS

CONSENT FORM / SKIING INSTRUCTORS

You are invited to participate in a study being conducted by Ben Young who is currently a doctoral candidate with the College of Health and Human Performance at Oregon State University. You were selected as a participant in this study because of your expertise in ski instruction. The purpose of this investigation is to examine differences among instructors in diagnostic and prescriptive expertise in skiing skills.

As part of your participation, you will be asked to discuss your background relative to teaching skiing, and identify common skill problems that will be presented to you on videotape. Your interview will take approximately 60 minutes and will be audiotaped.

Your comments will be confidential and only Ben Young will know your identity.

Possible benefits to you include the clarification of your own ideas regarding the diagnosis and remedy for movement error. Additionally, the results of this study will be made available to you.

I understand that any questions I have about the research study and/or specific procedures should be directed to either of the following individuals:

Ben Young
Oregon State University
College of Health and Human Performance
Corvallis, Oregon 97331
(541) 737-6267

Dr. Debra Rose
Ruby Gerontology Center 8B
California State University Fullerton
Fullerton, Ca. 92834-7057 (714) 278-5846

Any other questions that I have should be directed to:

Mary Nunn
Sponsored Programs Officer
OSU Research Office
(541) 737-0670

(over)

My signature below indicates that I have read and that I understand the procedures described above and give my informed and voluntary consent to participate in this study. I understand that I will receive a signed copy of this consent form.

____ ______________________

Name of Participant (Print) Date

____

Signature of Participant

____

Street Address

____

City, State, Zip Code Area Code and Phone Number

APPENDIX C

INFORMED CONSENT/SKILL MODELS

CONSENT FORM / SKILL MODELS

You are invited to participate in a study being conducted by Ben Young who is currently a doctoral candidate with the College of Health and Human Performance at Oregon State University. You were selected as a participant in this study because of your participation in skiing. As part of your participation, you will be asked to model a skiing skill which you are currently trying to learn. Your performance of the selected skill will be videotaped. The purpose of this investigation is to examine differences among instructors in diagnostic and prescriptive expertise of skiing skills.

Your identity will be confidential and known only to me. As a benefit to you for your participation you may request feedback on your performance.

I understand that any questions I have about the research study and/or specific procedures should be directed to either of the following individuals:

Ben Young
Oregon State University
College of Health and Human Performance
Corvallis, Oregon 97331
(541) 737-6267

Dr. Debra Rose
Ruby Gerontology Center 8B
California State University Fullerton
Fullerton, Ca. 92834-7057 (714) 278-5846

Any other questions that I have should be directed to:

Mary Nunn
Sponsored Programs Officer
OSU Research Office
(541) 737-0670

My signature below indicates that I have read and that I understand the procedures described above and give my informed and voluntary consent to participate in this study. I understand that I will receive a signed copy of this consent form.

________________________________ ____________________
Name of Participant (Print) Date

____
Signature of Participant

____
Street Address

____
City, State, Zip Code Area Code and Phone Number

APPENDIX D

STANCE

STANCE

Due to the critical nature of stance in the sport of skiing, a discussion of stance is appropriate. Skis are designed to be controlled with the skier's weight over the center of the ski. While it is true that in certain phases of the turn the stance should move to the inside of the turn to counterbalance centripetal force, weight should still be evenly balanced from tip to tail. This insures that the entire ski length is used for control. Rearward stance places weight toward the back half of the skis, making them more difficult to control.

If skis were always level during the course of a turn, remaining evenly balanced would be a simple task. During the course of each turn however, skis go from a fairly level angle when they are pointed across the hill, to a downward angle when they are pointed down the hill. This requires a constant stance adjustment within each turn. Probably the biggest factor at all levels of skier ability is the willingness, or lack thereof, of the skier to commit to the forward stance adjustment that must be made when the skis turn downhill. And yet, this adjustment must be performed in order for skiers to maintain control over their skis. From a psychological viewpoint, moments of fear or uncertainty often result in an uphill movement of the skier's center of mass. While normally a good strategy for self-preservation, this intuition is not a good strategy for control in skiing.

APPENDIX E

PILOT STUDIES

PILOT STUDIES

The original pilot work for this research was conducted with windsurfing instructors in Hood River, Oregon. Unlike the current work, the scope of that research was limited to an investigation of the diagnosis of error and not prescriptions. In the first of two tasks, eight professional windsurfing instructors of varying professional experience verbalized their ideal versions of three prototypical windsurfing skills. The purpose of that exercise was to identify the extent to which prototypes had been standardized among instructors. In a second task, instructors identified and prioritized errors in videotaped presentations of incorrectly performed windsurfing skills.

No differences were evident among instructors, either in the prototypical model formed or the diagnosis of errors. Subsequently, the current study sought to extend those findings to a population of downhill ski instructors. The taxonomy for a task in which instructors verbalized their ideal version of two prototypical skiing skills was developed. The wedge and open parallel turn were selected as the skills of interest because they represent a wide range of skiing and teaching ability. Originally, the dynamic parallel turn was selected instead of the open parallel turn, but was rejected because the skiing public rarely takes lessons at that level and the Level II instructors were not certified to perform or instruct that skill. It was determined that the use of the dynamic parallel turn would reduce the practical meaningfulness of this investigation.

It was the intention at the proposal phase of this research that taxonomy for knowledge of the wedge and open parallel turn be used similar to that used by Leas and Chi (1993). The authors had indicated, however, that their measures did not detect the correctness or incorrectness of the responses given by the participants. Furthermore, no reliability estimates were provided for the dependent variables. Consequently, taxonomy was developed for the current work that could be validated and reliably reported.

Pilot interviews were conducted with six downhill ski instructors (4 Level II instructors, 2 Examiners) in which several questions were tested. This resulted in the addition of the error prioritization and lesson scope measures. The interview technique itself was also refined to minimize any intrusive role of the investigator in the collection of the data.

Also, inclusion criterion for Level II ski instructors was adjusted as a result of the pilot work. The teaching criterion for inclusion as a Level II instructor had originally been set at five years of certification. This was to prevent instructors that were possibly qualified at a higher level, yet had not taken the Level III exam, from being included as participants. This restriction was eliminated however, when no relationship between experience and expertise was indicated in pilot research.

When all protocols were stabilized, four Level II and four Examiner level instructors were interviewed and included as participants.

APPENDIX F

LITERATURE REVIEW

REVIEW OF LITERATURE

Research Paradigms Used to Study Expertise

The pattern-recognition and knowledge-based paradigms have been the primary approaches used to investigate the qualitative expertise of instructors. These paradigms are explained and evaluated in the following section.

Pattern-Recognition Paradigm

Numerous studies have been conducted researching the expertise of instructors in the diagnostic area by comparing novices with experts (Imwold & Hoffman, 1983; Pinheiro, 1989; DiCicco, 1990; Leas & Chi, 1993). The pattern-recognition paradigm, first developed in the area of cognitive psychology (de Groot, 1966; Chase & Simon, 1973), has been a common method for researching diagnostic expertise in sport (Imwold and Hoffman, 1983; Starkes, 1987; Carter, Cushing, Sabers, Stein & Berliner, 1988). This paradigm has been used to study expertise in chess, in which novice and expert chess players view slides of chess boards with player positions in either random, or standard game positions. Recall of these positions (thus the name pattern-recognition) has shown that experts are superior to novices in recalling standard game positions, and indicating that encoding strategies, rather than memory capacity, is related to expertise (Abernethy, Thomas, & Thomas, 1993).

Using this paradigm, Imwold and Hoffman (1983) examined the ability of experienced and inexperienced gymnastic instructors to recognize elements of gymnastics performance. Recognition accuracy was compared between gymnastic coaches (specialists), physical education teachers (generalists), and pre-service physical education teachers (novices). Each participant viewed a film of the running front handspring (sagittal view). Subsequently they attempted to recognize critical body positions depicted in the film by examining a selection of static contour drawings created from the film. Results demonstrated specialists to be significantly more accurate than either the generalist or novice instructor groups. Surprisingly, there was no statistically significant difference between generalist and novice instructors.

Abernethy et. al. (1993) have indicated that there are two significant shortcomings to the use of the pattern-recognition research paradigm to study expertise in the motor domain. The first is the use of static displays (slides) in situations that are really dynamic. That is, diagnosis of movement is not based on "snapshots", but on preceding and following motion, also. The second shortcoming is that the recognition of these single events may not be related to the decision-making skills evident in expertise, but may only be a secondary phenomenon unrelated to expertise.

Knowledge-Based Paradigms

A second paradigm that has been borrowed from cognitive psychology (Andersen, 1980) is the knowledge-based approach which has also been used to investigate instructor expertise. This paradigm draws a distinction between what knowledge is known (declarative knowledge) and how that knowledge is used (procedural knowledge). Expert instructors purportedly have a larger factual knowledge base than novices, and they better understand how to use that knowledge to effect change in the movement skills of students. This has been demonstrated in the cognitive domain with chess skills (Chi, 1978; Chi, Feltovich & Glaser, 1981). It has also been demonstrated in the sport domain in sports as tennis and baseball (McPherson & Thomas, 1989; French, Nevitt, Spurgeon, Graham, Rink, McPherson, 1996). McPherson and Thomas (1989) demonstrated that with sport specific knowledge in tennis, expert children tennis players produce planning strategies during competition. Similarly, it has been shown that young baseball players with limited sport specific knowledge fail to recognize critical game situations and executed actions that were irrelevant to game situations (French et. al., 1996).

Leas & Chi (1993) have applied the knowledge-based approach to study novice-expert differences in a coach's conceptualization and diagnosis of sport-specific skills. In a conceptualization task, swimming coaches were audiotaped as they verbalized their ideal prototype of the competitive freestyle stroke. The mental image furnished by the coach's conceptualization is thought to be the referent to which actual performances by learners are compared. In a follow-up diagnostic task, instructors also identified errors in imperfectly executed videotaped performances of the same stroke. The discrepancy between ideal and actual performance thus becomes the focus of instruction.

Similar to the pattern-recognition paradigm however, the knowledge-based approach has shortcomings. This approach requires the investigator to develop taxonomy that is a reliable and valid representation of the area of interest. Critics of this methodology claim that these taxonomies can be arbitrary (Abernethy et al., 1993). Furthermore, the taxonomies are typically sampled through interviews, questionnaires, and various think-aloud protocols. Implicit in this technique is the assumption that knowledge is centrally stored and both experts and novices have access to that store. In terms of athletes, the case can be made that automated movements are intuitive and are not centrally stored (Abernethy et al., 1993). In fact, expert athletes who perform skills at a high level of automaticity would likely have less access to cognitive processes than do novices, who in early stages of learning are functioning at a cognitive level (Fitts, 1964). This distinction may not apply to instructors though, who are thought to not only have a memory representation of movement as it should be performed, but also a store of corrective measures that would serve as prescriptions. The fact that they routinely verbalize their thoughts to effect changes in a learner's performance would indicate that their expertise is conscious and accessible.

Anderson (1982) has further addressed the role of memory in the acquisition of cognitive skills, which is similar to Fitts (1964) three-stage approach to the learning of motor skills. In Anderson's theoretical framework, the learning of cognitive skills is first characterized by the encoding of information about the task, labeled as declarative memory. In a second stage, knowledge is compiled into a procedural form, resembling the associative stage of Fitt's (1964) motor learning model. It is in this phase that the learner links the elements from declarative memory, reducing the load on working memory. In a third stage, procedural memory is refined, allowing automatic and intuitive access to solving specific problems.

Novice/Expert Group Selection

The selection of novice and expert groups has been a controversial area in expertise studies. The assignment of undergraduates to a novice instructor group is a standard and generally accepted practice (Biscan & Hoffman, 1976; Imwold & Hoffman, 1983). Expert groups are generally comprised of individuals who are highly experienced in the skills of interest, although no standardized criteria across studies have been accepted. The novice-expert comparisons are usually those that are of most interest to the researcher.

In the Leas and Chi study (1993), the criteria for being classified as a novice coach was a maximum of two years experience as a full-time head coach or three years part-time experience. In contrast, experts had a minimum of twelve years experience as a full-time head coach, were formally recognized by their colleagues as expert, and had coached 20-100 national caliber swimmers. While this division would seem to qualify both groups as having some background in skill analysis, the novice group had very little experience evaluating the skill of interest (competitive freestyle stroke) from an underwater viewing window. Whether this lack of underwater viewing experience affected the results is unknown, but Knudson and Morrison (1997) have indicated that the observation phase of skill analysis is just as important as the diagnostic and prescriptive phases. That is, it is important to know, among other things, the viewing angles, number of repetitions, and whether slow motion and/or freeze-frame videotape are needed before an accurate diagnosis can be rendered.

Theories of Expertise

Dreyfus and Dreyfus (1986) have specified five levels through which instructors progress to obtain expert status: novice, advanced beginner, competent, proficient, and expert. Berliner (1987) has subsequently provided data to support these stages. Ericsson, Krampe, and Tesch-Romer (1993) have identified the theories of how individuals become experts although they have not yet been tested in the coaching domain.

Two common positions proposed to explain expertise are innate ability (natural ability) and experience. A theory of innate ability would indicate that expert instructors become so through a genetic gift. A theory of experience would indicate that expert instructors become so through field experience. Ericsson et al. (1993) have found little support however, for either position as a predictor of maximal performance. They provide evidence that expertise is the result of deliberate practice.

Deliberate practice is distinguished from general practice in that it requires sustained effort from the learner, the goal of which is improved performance. A consistent pattern of expertise as a result of deliberate practice has been shown across several professions including writers, musicians, artists, and athletes (Bloom, 1985).

In terms of time, the minimum requirement for attaining expert status as a performer is suggested to be 10 years (Ericsson et. al., 1993) or 20,000 hours of practice (Hayes, 1981). In the teaching domain, Dreyfus and Dreyfus (1986) have similarly indicated that at least eight years is required for attaining expert status. It has been suggested that expert radiologists have looked at over 100,000 X-rays (Lesgold, Rubinson, Feltovich, Glaser, Klopfer, & Wang, 1988) while chess masters will have played chess for 10,000 to 20,000 hours (deGroot, 1965). To put this in perspective, at 40 hours per week there are only about 2,000 working hours per year. If the four-hour per day yardstick is applied, there are only 1,000 working hours per year.

In the coaching domain participation in the sport of interest has been found to be a factor in instructor expertise. DiCicco (1990) investigated the role of tennis playing and teaching experience on tennis diagnostic ability. Results indicated that instructors with both high teaching and high playing experience were superior in diagnostic ability to other groups with less teaching or less playing experience. The results of this study were further supported by Gould and colleagues who surveyed 130 elite coaches from 30 different Olympic sports. A majority of the coaches they surveyed had competed in the sport in which they were coaching (Gould, Giannini, Krane, & Hodge, 1990).

It was not the specific intent of this study to test a theory of expertise although it is necessary to have such a theory in order to devise instructor-training programs. A theory of innate ability would indicate that training programs with instructors would have limited results. A theory of experience would indicate that there would be no substitute for field experience in order to achieve expertise. A theory of deliberate practice would indicate that goals for improvement could be addressed through effortful practice and study.

Models of Qualitative Analysis

Motor skills are primarily analyzed using quantitative and qualitative methods. Quantitative methods often include kinematic, kinetic, and EMG instruments. While the research scientist often uses these objective measures, physical educators and coaches primarily rely on qualitative observational techniques that are subjective by their very nature.

Several models have been advanced to explain the qualitative analysis of movement. Early models have been categorized as observational models and later models have been categorized as comprehensive. The focus of observational models has been the observation of movement, assessment of critical features, and diagnosis of error. The focus of comprehensive models has been broader, including the methods for accumulating the knowledge base for observation, and the use of motor learning principles in interventions with the student. The following section reviews several of these models.

Hoffman (1983)

The Hoffman (1983) model is routinely cited in the literature for its simplicity and clarity of observational analysis. The diagnostic process requires the analyst to have a mental template of the prototypical skill and make an active comparison between that and actual performance. Any difference between the two is the discrepancy upon which the instructor prescribes action.

A hypothetico-deductive model is subsequently used in which the discrepancies that arise are determined to be the result of deficits in the student's abilities, skill, or psychosocial attributes. If the ability of the student is the cause of the discrepancy, a determination is made as to whether the shortcoming can be improved, or if the goals of the movement should be changed.

If the second category, skill deficiency, is determined to be the source of the discrepancy, one of three faults is considered. These include technical, perceptual, and decision errors. Technical errors are mechanical differences between desired form and executed form. Perceptual errors are misunderstandings of sensory input, as in the case of a tennis player misinterpreting the flight of an opponent's serve. Decision errors would be illustrated by the case of a tennis player striking balls that travel out of bounds.

The third category of discrepancies is that of psychosocial factors. Athletes with ability and no apparent skill deficiencies will often not perform at their best due to motivation, fear, or anxiety. Interventions addressing these factors would subsequently be conducted.

Hudson (1985)

Hudson's (1985) system of observation is a biomechanical approach that links the purpose of the movement with observable attributes. Termed POSSUM (purpose/observation system of studying and understanding movement), it requires that the purpose of movements be identified and that those purposes must be observable qualitatively. These observations can be made holistically in terms of whole body movements, or in parts. Multiple core concepts of kinesiology (range of motion, speed of motion, balance, coordination, compactness, etc.) have been provided that give the practitioner definitive measures on which feedback can be given to the learner.

Arend and Higgins (1976)

This model is an integrated approach including many subdisciplines in movement science such as biomechanics, pedagogy, and motor development. Analysis is divided into a skill category if learning over time is of interest, or a performance category if a particular task is the object of interest. Qualitative analysis is partitioned into three components; pre-observation, observation, and post-observation. This model is so general and comprehensive that it accommodates all movement tasks. This was the first model to acknowledge information that must be accumulated before the observational phase. Likewise, this model was one of the first to acknowledge a post-observation analysis.

Hay and Reid (1982, 1988)

This is a four-step biomechanical model that encloses an observational model in the middle. The first step is the development of a model in which the objectives of the skill are determined. In sports such as basketball or javelin throwing, outcomes such as total points and the total distance are considered. In sports such as gymnastics or ice skating it is the points awarded by judges. The factors, which can produce these outcomes, are subsequently determined.

The second step in this comprehensive model is the observation of performance. The third step is the prioritization of error, and in the fourth step remedial cues are given to the student. The fourth step in this comprehensive model recognizes the role of motor learning principles and has made some attempt to include these concepts as a part of intervention.

The Hay and Reid model and several others are worthy of description at length, but all of them by the 1980's began to share similarities. Knudson and Morrison (1997) have proposed an integrated approach including preparation, observation, diagnostic, and intervention phases. Their model furnishes a contemporary vantage point from which other models and literature can be reviewed. That review is as follows:

Knudson and Morrison (1997)

Preparation Phase

Preparation is the first stage in this model. This stage explains how the knowledge base is acquired for the three stages that follow: observation, evaluation/diagnosis, and intervention. The preparatory stage though, is further subdivided into several categories including knowledge of the activity, knowledge of the performers, and knowledge of effective instruction.

Knowledge of an activity. Knudson and Morrison (1997) argue that knowledge of an activity is gained through three primary sources. They are experience, expert opinion, and scientific research. Experience, in particular, has been credited with being the greatest predictor of expertise, probably because there seems to be few experts with little experience. The assumption is that many interactions in one's field, over time, is likely to yield deeper understanding than few interactions. And yet, experience would apparently be no guarantee of expertise as evidenced by those that have spent numerous years in their field without being recognized as experts (Berliner, 1987).

Numerous studies have been performed that have investigated the novice/expert relationship in coaches and teachers. Most investigators have used experience as the major criterion for distinguishing between groups, and typically differences have been found based on that standard. In a diagnostic task on tennis, DiCicco (1990) selected groups based on playing and teaching experience. Group differences were found using that guideline. In the diagnosis of a gymnastics skill, Imwold (1980) divided novices and experts based on the amount of time they had been teaching. He further divided subjects based on the specificity of the gymnastics setting in which they were working. That is, the first group was specialists whose primary focus was the coaching of competitive gymnastics. Physical education teachers were a second group and had no gymnastics training. The third group was undergraduate physical education majors who likewise, had no gymnastics training. Significant results were found for specialists, suggesting that both the amount (experience) and type of training were factors in the diagnosis of gymnastic movements. Both the quantity and quality of experience would therefore, appear to be factors in novice/expert differences.

The second source of information for knowledge of an activity to which Knudson and Morrison (1997) allude is expert opinion. To rely only on our own experiences with the environment and not seek expert opinion ignores the work performed by others. This can account for an instructor having a lack of expertise despite an extensive background. That is, if they do not have encounters with others in their respective field, they will not be able to take advantage of what others know.

The third source of information from which knowledge of an activity should be gained is scientific research. Scientific research, however, often requires some background in order to interpret. Also, controlled settings in which much research is conducted may not generalize to the applied setting. Still, refereed journals provide the most reliable source of information and should perhaps be valued over experience and expert opinion.

Knowledge of the performer. Knowledge of motor and cognitive components of the individual affects the choice of intervention. The selection of equipment (size of ball, for example) will be affected by motor capabilities. The cognitive stage of children will influence how material is presented, even though diagnostic defects in movement may be the same as adults. Errors in movement by children may be caused by muscle weakness, mistakes in technique, or be developmental. Each of these requires different choices for intervention.

Knowledge of effective instruction. When analyzing movement patterns, analysts must be able to identify the critical features and know an array of cues to be used in feedback. Not all students respond to the same cues, even though discrepancies in movement may be the same.

Knowledge of effective instruction also requires instructors to know motor learning principles, many of which are counter-intuitive. Instructors have found that a) abundant feedback, b) blocked practice, and c) part teaching methods are good strategies for achieving immediate performance gains in students. These strategies, however, run counter to what the literature supports as being conducive to long-term retention.

Observation Phase

This is the second stage in a four-stage comprehensive model (Hay & Reid, 1988; Knudson & Morrison, 1997). It would appear that the observation of movement is so closely affiliated with the diagnosis of movement that they should be used synonymously, or at least under the same heading. Indeed, some authors have made this choice or perhaps did not realize they deserve distinctive consideration.

Consider a referee in football whose express goal is to be constantly positioned to make correct judgments. There is a reliance on visual, aural and even tactile feedback. There is a constant battle to be close to the action without being a part of the action. Were a map made of the referee's path across the field during the course of a game, a science in movement would be apparent. And the goal of this science would be to place the individual in the right place at right time at the right distance to make as many correct judgments as possible. Such is the rationale for including the observation of movement in a separate category from diagnostics.

A good starting point for an observational strategy would be to first know what to observe (Barrett, 1979). Unfortunately, many movements have critical features in three different directions (x, y, and z planes) requiring more than one vantage point. A second strategy then, would be to know how the critical feature is to be observed. For the football referee, there is a constant search regimen for that optimum vantage point in a continuously changing environment. The third criterion that arises is to determine if numerous or extended observations are needed. Unfortunately for the referee, this is not an option (didn't we have instant replay for referees?)

Assuming that correct vantage points can be achieved, some consideration should be given to the scanning strategies for critical features. Four methods of scanning are commonly recognized:

Temporal scanning. This is a common scanning strategy in which the critical features of movement are observed across time. Time is divided into three different phases; preparation, execution, and follow-through. This method can be especially effective in open skills, such as tennis, where the environment plays a key role in the preparation of shot selection.

Balance scanning. This scanning strategy focuses on balance and the base of support. There are now numerous settings in which this is used. Balance retraining programs cue patients, in a multitude of movements, to focus their attention on their center of mass as it relates to their base of support. Control of the center of mass in relation to the base of support is considered prerequisite to postural stability (Rose & Clark, 1995). Some martial arts explicitly focus on the movement of center of mass over the base of support, combining these elements for control and power. Coaches in numerous sports often scan lower body elements first, using balance as the criterion for proper movement.

Importance scanning. This scanning strategy is driven strictly by what the analyst determines to be important. This can include the temporal phasing or balance objectives previously mentioned, but can function without those strategies as well.

General to specific scanning. This strategy stresses the overall quality of the general movement as the first objective. If there are anomalies, the scanning strategy becomes more specific and it is left to the analyst how to proceed.

Evaluation and Diagnosis Phase

Evaluation and diagnosis comprises the third component in the comprehensive model of Knudson and Morrison (1997). This stage is similar to the third stage in the Hay & Reid model (1988), evaluation of faults. Likewise, the corresponding third stage in the McPherson model (1990) is the diagnostic stage in which primary and secondary errors are determined.

The two terms, evaluation and diagnosis, have been used interchangeably, but really mean different things. Evaluation is an assessment of the quality of movement, particularly in respect to the good points in a performance. Diagnosis examines the disparity between a problem and it's physical manifestations.

Hay and Reid (1988) suggest two methods of evaluation: sequential and mechanical. The sequential method involves an ongoing comparison between a mental image of the ideal movement and the movement as executed by the student. Hoffman (1983) identifies these subsequent differences as discrepancies, resulting in feedback to the learner.

The mechanical method emphasizes that biomechanical principles generalize to many tasks, and the difference between ideal and actual execution of the biomechanical components is a method of evaluating movement.

Diagnosis is the most critical component of qualitative analysis. The best intervention or feedback to the student will not make up for an incorrect diagnosis. Unfortunately, diagnostics in movement studies are lacking in theoretical groundwork, and tend to vary in execution from analyst to analyst. There is little consensus among experts as to what constitutes the critical features in each skill (Knudson & Morrison, 1997). While professionals often identify their perspectives in textbooks and videotapes, there tends to be little agreement on discrepancies between ideal and actual form.

Due to the limited attention capacity of students, diagnosis of movement must culminate in a single intervention (McPherson, 1990). This single intervention must best address the most relevant underlying problem in the diagnosis (Hay & Reid, 1982, 1988). The primary intervention can be affected by many different approaches. Although there has been little research investigating which approach furnishes the best logical rationale for determining that which is most effective, six different methods have been identified:

Temporal relationships. This identifies interventions based on the actions that occurred prior to the observed error. Intervention focuses on the earlier executed movements that would be the etiology of following symptoms.

Maximization of improvement. This approach uses as selection criteria the intervention that will effect the greatest improvements in performance. While this has intuitive appeal, it focuses primarily on outcome variables and ignores some of the underlying processes within the individual that may need to be re-defined. If instructors, for example, choose to have students work on fundamental mechanics, there may not necessarily be substantial, immediate improvements in performance.

Orders of difficulty. Interventions, in this method, are prioritized according to their order of difficulty. This has the advantage of providing early success to the student and is elevates feelings of self-efficacy in the learner. This method, however, may not produce the most improvement in the student.

Correct sequence. This approach bases the prioritization of corrections strictly on the order in which they occur. This method may have merit for novice analysts while the selection process is still in question. More expert analysts, however, would probably prefer to address corrections that need to be made based on responsibility for error, rather than the order it occurs in the sequence.

Base of support. This rationale was identified earlier as a scanning strategy in the observation of movement. As a technique, it assigns prioritization for corrections to balance and the base of support. Evidence of use is available across a number of disciplines including golf, baseball, and martial arts, and gait analysis.

Critical features first. This technique identifies the critical features of movement as the focus for correction. While this has logical merit, there are two major concerns associated with this technique. First, there is little consensus as to what constitutes critical features. The determination of what should comprise the make-up of critical features must be established through strict guidelines including an examination of professional manuals and consultation with professionals in the field.

Second, even when critical features are identified they must be prioritized according to importance in order to establish the first intervention. Ordering according to importance is, again, highly subjective. While many professionals, depending on the discipline, may agree on the critical features, their comparative importance is even less established.

Intervention Phase

Although it goes by many other names, intervention is the fourth stage in comprehensive models. This is still an area of weakness in most models. Many researchers have just started to apply motor learning concepts in the field. In so doing, one of the first concepts the analyst must understand is the distinction between performance and learning. Performance is the short-term acquisition of motor skills and, as motor learning practitioners have found, is not necessarily the same as what students can perform in long-term retention and transfer tests. Different techniques of instruction have been found to promote short-term performance than those that promote long-term learning. Specifically, the instructional strategies that promote short-term skill acquisition (hereafter referred to as performance) are: a) blocked practice b) low practice variability and c) abundant feedback. These techniques are reinforced for the coach by immediate performance benefits seen in the student, something that can easily be mistaken for long-term learning. Strategies that promote learning are a) practice variability b) random practice, and c) reduced feedback.

High variability vs. low variability in practice. Limiting the conditions under which a skill is practiced results in a narrow set of rules defining that movement (Schmidt, 1991).

The performance of a skill in different ways and in different settings expands the breadth of those rules and facilitates learning. This phenomenon has been explained by a schema theory of learning (Schmidt, 1975) but has recently been challenged by ecological theorists who argue that expertise emerges in the learner as a result of attunement to the environment (Abernethy, Thomas, & Thomas, 1993).

Two distinct methods of varying practice are available to the coach. He/she can change the task demands by altering the parameters of movement (velocity, direction, etc.) or vary the conditions under which the practice is taking place.

The question of whether practice should be varied, however, is not as difficult to decide as when the practice should be varied. Similar to the random practice effects discussed earlier, there is a period during skill introduction when the attentional capacities of the learner should be considered. A skill should presumably not be varied when the basics are not understood. This is consistent with Gentile's model (1972) in which she explains that the first encounters with novel skills should be spent getting the idea of the movement.

Blocked vs. random practice. Blocked practice is a favorite technique of coaches, especially when working with students on new skills. The idea of blocked practice is to master a skill through repetition before moving on to the next skill. Random practice, which is the random alternation of the practice of one skill with others, has been found to be a superior method for long-term retention (Schmidt, 1991).

Two explanations have been offered for this effect. The elaboration/distinction view indicates that the performance of multiple variations of a task (random practice) requires that these variations be held in working memory. Random practice trials require an ongoing comparison of these variations, and they are deeply stored for retrieval. No such comparisons are made in blocked practice since the same variation of the task is stored after each trial. Shea and Morgan (1979) have interpreted their findings according to this view.

The action-plan reconstruction view (Lee & MaGill, 1985) stipulates that random practice results in forgetting between trials and therefore the action plan must be regenerated prior to execution of the next movement. Blocked practice requires no such regeneration because the same movement is practiced repeatedly. The reconstruction of the action plan, as required by random practice, is thought to result in better recall or learning.

The use of random practice, however, can also be influenced by a) task and b) learner characteristics. While it has been repeatedly demonstrated that random practice promotes learning in certain populations, the nature of the task would seem to have an influence. When the variation in task is only the result of a change in parameters (e.g. velocity, force), there would appear to be little random practice effect. If the variation in task demands a change in coordination patterns, random practice effects become larger.

This difference has been interpreted to mean that changes in parameters are still controlled by the same generalized motor program (Schmidt, 1975). Conversely, changes in coordination are controlled by different generalized motor programs (GMP). Magill and Hall (1990) have indicated that random practice learning effects will only be evident for those tasks that are controlled by a different GMP.

In the category of learner characteristics, studies have reported mixed finding so far as to whether age is a factor. Significant effects were found for using random practice with

5-8 year olds by Edwards, Elliot, and Lee (1986), but other studies have reported no effects or found support for blocked practice.

A more defined trend has been shown for the level of experience of the learner. Specifically, novices do not seem to benefit from random practice until they get the idea of a movement (Goode, 1986). It would appear that during the earlier stages of learning, attentional capacities are already strained to their limits, and the further loading of random practice produces no effect.

Reduced frequency of feedback. A third mechanism of the intervention phase is the use of feedback. It can be sensory information we interpret from the way we "feel" about a movement, or augmented information that comes to us from an external source. The coach controls a large amount of the augmented information that the learner receives. Certainly any verbal feedback is under his/her control, but other feedback, such as the direction a golf ball is hit, is generally available to the learner regardless of the coach's wishes.

Early research in feedback concluded that more feedback was always better (Bilodeau & Bilodeau, 1958). These findings, however, were based on tests of performance and not learning. Later tests of learning conducted without feedback demonstrated the reduced feedback condition to be superior (Ho & Shea, 1978; Johnson, Wick, & Ben-Sira, 1981). Just as in random practice and variability of practice, performance results were reversed in tests of learning.

Theoretical rationales have been advanced to explain this reversal. The guidance hypothesis stipulates that abundant feedback result in the learner using that feedback as a crutch. Problem solving is necessarily diminished, and leaves the learner ill-equipped for retrieving information.

The consistency hypothesis states that high feedback frequency results in a corrective adjustment by the learner after each trial. This prevents the learner from developing consistent movement patterns, and results in higher variability.