Team Assessment and Pedagogy as Informed by Sports Coaching and Assessment

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INTRODUCTION

Sports psychology and team training literature offers a wealth of examples on the development of expert teams, where individual high-performing players are trained to succeed as a group. Compared to many problems where expert teams operate, sports very often have the advantage of clear criteria for success and an increasing amount of data collection on both team and individual performance. As such, effective training techniques for sports teams may offer insights that inform general team training pedagogy, particularly for psychomotor domains such as military operations. Our investigation into this area is exploratory. Here, we examine a few well-documented cases of how assessment and feedback are utilized in the context of sports team training. Given this focus, our work cannot be considered representative of training in any specific sport. However, by comparing between sports, we hope to identify certain qualitative differences in the types of training that are effective for different psychomotor domains that incorporate elements of team dynamics.

Training differs substantially between sports, not just in terms of the physical tasks but also in terms of the coordinated team activities that occur. For example, while only some baseball fielding events involve dependencies between players (e.g., double plays), nearly all plays in football require multi-faceted coordination (e.g., blocking by the offensive line to support a running or passing play, with specific routes run by receivers, etc.). These issues will be considered in the context of three sports: baseball, basketball, and football. These sports differ in terms of key game characteristics such as simultaneous coordination, micro-games within the sport (e.g., at bats, tip-offs), and team roles (Elverdam & Aarseth, 2007; Mueller, Gibbs, & Vetere, 2008; Ward, Farrow, Harris, Williams, Eccles, & Ericsson, 2008).

In this chapter, we consider pedagogical insights offered by three different sources of information from sports coaching and assessment: published reports of sports training, first-hand accounts of team training, and a review of assessment approaches for measuring team performance. These issues are considered in the context of an integrated taxonomy of feedback that considers when feedback was given, who it was given to (e.g., individual vs. team), the type of feedback (e.g., positive vs. negative), and the specificity of feedback (e.g., detailed issues vs. brief note). The goal of this work is to consider how these patterns might generalize to a wider range of learning tasks, to improve both learning and assessment of team performance.

We are particularly interested in how coaches communicate feedback that is directly aligned with training activities (i.e., information conveyed during training, or after training but based on those events). This focus is not because we believe that this is the most important role of a coach: there are many types of coaches with different specialties and there are many roles that feedback can play in different contexts, such as during reflection, mentoring, off-the-field, and more. However, this exploration is focused on how insights from team coaching relate to what is known about feedback in educational settings, and how it might enrich the automated delivery of feedback through intelligent tutoring systems (ITS) or other learning technologies..We are focused on this subset of coaching feedback and activities.

Decades of research has focused on the delivery and effects of feedback on performance (Kluger & Denisi, 1996), learning (Shute, 2008), academic emotions (Pekrun, Cusack, Murayama, Elliot & Thomas, 2014),

self-regulation (Baumeister, et al., 2006), and more. In the subset of this literature that investigatedfeedback delivered in ITS platforms, multiple publications have been produced that systematically breakdown what effective expert tutors do from an instructional strategy standpoint, so as to enable an automated system to enact those interaction types (Durlach & Spain, 2012; Shute, 2008). Similarly, it is believed that team-based applications should be based on what strategies and tactics effective coaches apply, along with identifying the conditions and variables that dictate what strategy to apply for what individual team-member, and when. While this chapter only scratches the surface of this research challenge, we aim to establish a theoretically derived taxonomy to guide future studies that aim to code expert coaching practices through observational methods.

ROLES FOR TEAM TRAINING: TYPES OF TEAMS

Fundamentally, one question for all team training research is what constitutes a team, such as how to distinguish between a "team of experts" versus an "expert team" (Salas, Cannon-Bowers, & Johnston, 1997). For example, Olympic teams for sports such as boxing or downhill skiing often train together but do not necessarily compete simultaneously or in coordination with each other. Even when such teams compete in the same event (e.g., relay races), some teams are closer to a "team of experts" rather than an "expert team." This distinction has often been raised with examples such as the United States Olympics men's basketball team. Historically, these squads have been viewed as including elite players but having minimal practice as a team, and which has been cited as one cause for their losses in the 2004 Summer Olympics (Leopold & Teitelbaum, 2016). With that said, the United States squad won prior Olympics competitions despite limited practice together.

This raises the issue that while an expert team provides a competitive edge, the advantage for well-practiced coordination likely depends greatly on the task or sport. For example, new members of a professional football team coordinate based on extensive playbooks that can take weeks to learn. On the converse, baseball players are often traded and start on their new team the next day. Even within a sport, team training can vary: pitchers and catchers report a week or more earlier to baseball spring training than position players (for 6+ weeks rather than 5 weeks). Despite the variance across these examples, a desired end-state is operationally defining what characteristics and behaviors are congruent with “expert teams”, based on context, and then defining what coaching tactics can be applied to accelerate the acquisition of those defined attributes. While there are recent contributions to the literature that define the framework and behavioral markers that make up a good team (Sottilare et al., 2017), there is little written on how to use those measures to drive pedagogical decisions at the team level.

Accordingly, at the professional or higher amateur level, coaches and managers serve a key role for building an expert team. Part of their contributions are certainly to assemble the initial team of experts (e.g., recruiting players). However, on an ongoing basis coaches must set the tone for the team culture, the systems and strategies that the team trains to master, and deliver the feedback to improve how the team executes these strategies (Lyle, 2002; Ericsson, 2003). This touches multiple areas of how coaches support athletes:

1) Training: Communicating knowledge to the team to help build skills and develop expertise through deliberate practice methods (Ericsson, 2003)

2) Motivation: Reinforcement and punishments that encourage improvement and “buy-in”

3) Culture: Establishing the team's motivation, goals, and self-regulated strategies for training and enforcing norms (e.g., how a team supports and polices itself)

4) Leadership Structure: How a coach determines and trains leaders within a team

As noted earlier, this coaching behavior occurs in many contexts- not just during practice, but also in the locker room, at team dinners, when meeting the families of athletes, and in other venues (Lane, 2004). From the standpoint of this research, we are focused on the types of interventions that coaches perform during or adjacent to training opportunities (e.g., post-game, reviewing video tape, etc.), since these are likely to be the ones that produce the most direct learning impact. This is because coaches can ground their statements in specific practice or game plays that have occurred, as well as direct players to apply the feedback immediately (e.g., retry a task).

CODING FEEDBACK IN COACHING IN TEAM SPORTS

To consider how and when coaches intervene during or after practice and training, we must first identify the features that distinguish between different types of feedback. For this purpose, we outline a potential typology for coding the types of messages that coaches may deliver to players. This outline of feedback messages is based on speech act coding, which considers the functional purpose of dialog as actions (e.g., "Great job" could be coded as "positive feedback"). This approach has a long history in research on human tutoring and instructional systems, with a variety of taxonomies for speech acts (Cade, Copeland, Person, & D'Mello, 2008; Samei, Rus, Nye, & Morrison, 2014). These taxonomies distinguish between qualitatively different categories (e.g., questions vs. answers) and also between different subtypes (e.g., positive vs. negative feedback).

Many of these taxonomies assume a two-person conversation, however, and also fail to consider factors that may be relevant to the context where feedback is delivered (e.g., the difference between yelling from across a field versus taking someone aside to talk quietly). Table 1 notes features that we think are particularly important for feedback in team sports. In this description, we assume that a team task with multiple players is occurring, such as a training exercise, scrimmage, or game. While these represent only one possible set of facets, we believe that they capture some important differences in feedback that may be relevant to different coaching styles. For example, managers are often dichotomized into player-friendly managers versus more authoritarian archetypes, which imply quite different feedback (Boswell, 1984). The types of feedback that coaches use are also almost certainly affected by the composition of players and the context of the team (e.g., part of the season, recent performance/streaks).

Table 1: Features to Code Types of Feedback

Feature	Description	Options
When Given	The timing of feedback in relation to the ongoing task actions.	- Immediate (talk over task) - Abort (stop task) - After-action (after task finishes)
Direct Targets	Who is the primary target of the feedback?	- Individual - Subgroup of participants - Task participants - Full team
Secondary Observers	Who else receives the feedback? This may impact peer influence or vicarious learning (e.g., from others' mistakes)	- Individual - Subgroup of participants - Task participants - Full team
Valence	What is the overall directed tone of the feedback? e.g., feedback used to reinforce effective behavior (positive), correct or punish incorrect behavior (negative), or does not directly advocate correctness	- Positive - Negative - Neutral
Stress/ Emphasis	The level of emphasis for the feedback, from calming to direct to aggressive	- Calming - Direct - Aggressive
Information	The type of task-relevant or learner-relevant information shared (if any). Classifies if the feedback: (1) directs attention to specific elements that affected the outcome, (2) explains a pattern, (3) explains the whole outcome/status, etc. There are likely to be many other information types that might be relevant	- Cue ("Watch your footwork") - Command ("Now 10 throws") - Explanation ("That's because..") - Outcome ("Sloppy play") - General ("Winners don't quit") - Process ("Listen harder") - Progress ("Three more left") - Motivation ("You'll get this.") (others)
Post-Feedback Task Command	Common activity types applied by coaches following a feedback intervention.	- Continues (task not interrupted) - Resume (go where team left off) - Repeat (start activity from the beginning…"start from the top.") - Interject (start new activity based on feedback or assessment) - End (complete activity and move into next training exercise)

TRAINING FEEDBACK: EXAMPLES FROM DIFFERENT SPORTS

To examine how feedback is used for team training across different sports, we consider the differences between three common sports in the United States: baseball, football, and basketball. Table 2 outlines some of the similarities and differences between the team coordination required for each sport. These include the team size, the typical number of players substantially involved in a play, and the typical pacing of tasks in the sport (e.g., mostly discrete versus relatively continuous play). While some numbers shift for different leagues (e.g., college versus professional), the order of magnitudes remain the same. Pacing issues might substantially impact how and when feedback can be delivered during practice. An example of a game task with high coordination is also noted, and contrasted against one with relatively little coordination.

Table 2: Comparison between Sports Team Coordination Tasks

	Baseball	**Football**	**Basketball**
Games/Season	162	16	82
# of Players	9 roles (25 active)	11 roles (45 active)	5 roles (13 active)
# of Players in a Typical Play	4 (Pitcher, catcher, two fielders)	11 (all)	5 (all)
Role Switching Points	Offense/Defense switch every half inning (e.g., after 3 outs)	Offense/Defense switch at change of possession (e.g., following score, punt, turnover)	Shifts in offense/defense roles following possession change (e.g., following score, rebound, turnover)
Pacing	Discrete plays, with coordinated fielding	Discrete plays, with multiple coordinated activities	Mostly continuous play, broken up by scoring, out of bounds, etc.
Example of High Coordination	Infield double-plays (infrequent)	Offensive line blocking (frequent)	Pick and roll (frequent)
Example of Low Coordination	Hitting with bases empty (frequent)	Punting (infrequent)	Free throws (frequent)

Baseball: Discrete Plays with Well-Defined Individual Contributions

Of the sports considered in this exploration, baseball contains the strongest individual contributions. Even during fielding, plays are coded with the fielders who touch the ball and players who do not touch the ball. Others involved typically only need to coordinate in real time by ensuring proper backup behavior (e.g., the pitcher covering a base when its fielder needs to pursue the ball). While teams may coordinate on fielding patterns (e.g., shifting to the right or to the left), the optimal positions for these plays tend to be relatively deterministic. Within baseball, the two highest-coordination activities tend to be pitchers and catchers (selecting, throwing, and catching pitches) and double-plays (e.g., which tend to require rapid throws from the shortstop to the second baseman, then a second throw to the first baseman). While at bats are common, double plays are infrequent. On the converse, batting is mostly individual.

Baseball training is structured around a manager (head coach), with assistant coaches that include the bench coach (second in command), batting coach (offensive expert), pitching coach (defensive expert), bullpen coach (works with secondary pitchers for a game), and a pair of on-field coaches at first and third base to help call plays. The on-field and bench coaches are often responsible for training on fielding. Above all of these is the general manager, who does not directly manage the players but who may set guidelines for the manager's decisions. In recent years, this has increasingly involved guidance based on statistical data (Thorn, Palmer, & Reuther, 2015). A number of studies have examined the characteristics of baseball managers (e.g., James, 2014). Boswell (1984) categorized managers into four archetypes:

1) Little Napoleons: Authoritarian and intense/stressful styles that emphasize competition;

2) Uncle Robbies: Player-friendly, often humorous leaders who lead with wisdom;

3) Peerless Leaders: Disciplined and dignified styles who lead by embodying this character;

4) Tall Tacticians: Intellectual, clever leadership based on trust in their judgement;

Koppett (2000) reinforced this work with a study of the "family trees" of manager lineage, which traced three managers who served as archetypes for Boswell (the Little Napoleons, Peerless Leaders, and Tall Tacticians). As such, these different managerial styles appear to be not just by chance but also by training and recruitment. In terms of in-game management, there has also been some discussion that traits from Uncle Robbies may be increasingly common among baseball managers (Diamond, 2016). This is potentially due to both the increase in player salaries, which could make authoritarian approaches unfavorable for recruitment and retainment. It may also be due to the increasing influence of stats-based guidance from general managers, which makes managers the lynchpin for building buy-in so that players support front office decisions (as opposed to only justifying their own coaching decisions). This shift may also be due to increasing initiative by baseball players, who are more active in self-regulating their training than in prior decades. As such, due to shifting power dynamics, earlier stages of baseball might offer better models for feedback on psychomotor tasks, while major league baseball might be a better model for studying how managers build and maintain team cohesion among experts across a long season with continuous games and travel. These distinctions are important, as GIFT supports multiple pedagogical models that enact variations in coaching methodologies. As such, coaching styles can be configured and called upon at run-time based on team characteristics that dictate the most appropriate coaching strategy.

Given that this exploration is primarily focused on team learning, we looked further into the coaching practices at the college baseball level. A review was made of publicly posted videos about college coaching practices. Franco (2018) explains a division 1 schedule where players were responsible for three types of training to prepare for their season: weights training (5h/week), conditioning (3h/week), individual instruction with a coach (3h/week), and about 4 game-length practices each week (12-14h/week). Some notable themes of baseball coaching include center around deliberate realistic practice (Ericsson, 2003), such as "perfect practice makes perfect" and "practice like you play" (e.g., moving away from massed drills). The majority of practice consists of either of individual tasks (batting practice, pitcher-catcher bullpen sessions), simulated at-bats (tee-ball drills, fungo bat fielding), or practice games. After-action practice includes verbal feedback and videotape reviews, which might be used to demonstrate models of good performance, discuss an individual player's performance, or discuss team performance.

Individual mechanics (e.g., batting stance, throwing shoulder) appear to be a primary focus for baseball training, even in the context of pair exercises (throwing practice) or games. Coordination is achieved by players independently recognizing the same game state, then following well-practiced procedures that assume their teammates will be in position (e.g., beginning a throw to first base before the first baseman is set up yet). The secondary focus appears to be conditioning exercises. Notably, in reviewing certain tapes,

the primary feedback for conditioning (e.g., endurance) exercises is primarily supportive or progress feedback from other players. Finally, team coordination feedback appears to be the tertiary focus (e.g., adjusting fielding positions relative to others). Coordination is primarily practiced through repeating scenarios (e.g., fielding balls hit to a certain area). To help illustrate this balance, a brief "hot mic" video of the assistant coach for Oregon State was coded using the features from Table 1 (OSU Beaver Athletics, 2011). Across a 2 minutes of edited drill footage, the most common speech acts are noted in Table 3.

Table 3: Coding Speech Acts for Two Minutes of a College Baseball Fielding Practice

Count	Feedback Type	Feedback Example
6	Positive-Outcome	"good"
4	Neutral-Explanation	"shorter arm circle out of here it's here"
4	Neutral-Command	"defense let's go one and around five to forty five"
3	Positive-Specific	"ground up very nice"
2	Negative-Specific	"a little lower long and lower long and lower"
2	Neutral-Cue	"light on feet"
1	Positive-Motivation	"you make that play you're our guy"
1	Neutral-Specific	"this way so our knees a little more"
1	Negative-General	"it still needs a little more work"

At least in this clip, the coach provides feedback nearly continuously (24 statements in 2 minutes), as the mechanics unfold, and supports retries to practice issues that he identifies. While multiple players are involved, they each are the primary focus of coaching feedback at different times. In one example, a player is taken aside for a longer explanation of his specific areas to address. However, in later portions of the tape the coach stops active practice and provides a demonstration and strategic feedback to the current practice squad (e.g., directly addresses the group). While this is only one example, it shows a potential process for examining how coaches work with players under different practice conditions, as well as how and when they provide their feedback. The frequency of feedback and its delivery patterns (throughout practice or across practice sessions during the season) might also provide valuable input in terms of how coaches respond to success or failure of the team as a whole, such as by the intensity or attention of feedback given (e.g., showing that they care about the success of the team, either through more frequent, more positive, or even more negative feedback). This level of analysis can form the basis of feedback and coaching patterns that could be implemented in a pedagogical model for a system such as GIFT, such as for tasks which resemble baseball activities (e.g., strong individual contributions, well-defined team interactions).

Football: Discrete Plays, but Highly Interdependent Contributions

The sport of football is an example of team dynamics that requires the coordination of multiple explicit roles to execute a single discrete play/action at a time. For each designated play, both on the offensive and defensive side of the ball, each individual player is assigned a specific role with conditions and standards

that determine their behavior during execution. The nuance here is the interdependency across each role during play execution, and how a shared situational understanding across all interacting parts is required to optimize objective outcomes.

From a pragmatic stance, this requires: (1) knowing what specific role you are responsible for and how to execute those functions consistently, (2) knowing how your role fits within the conceptual context of the team across all potential scenarios, and (3) knowing how to adapt your role and communicate those changes based on tactics and behaviors observed within the operational environment (Baker & Côté, 2003). These categorical distinctions of situational understanding are important as they can be used to define training approaches that target the Knowledge, Skills, and Abilities (KSAs) associated for each designated role and at each designated phase (see Table 4). With this framework in place, targeted skill objectives can be deconstructed to identify specific components that drive the selection of practice activity types. In this instance, one can apply a mastery learning paradigm as it adheres to team situational contexts (i.e., an individual cannot integrate within a team until that individual can consistently perform an assigned role at a high level and understand how that role serves the team as a whole). Training programs should begin to target each KSA and apply pedagogical techniques that promote acquisition and retention. For this purpose, the team feedback taxonomy presented above (see Table 1) can be applied to configure feedback and coaching features as they adhere to who and what is being trained within each phase of the Team Situational Understanding taxonomy. Similarly, speech act analytic techniques, like the one described above, can be applied to generate initial feedback policies that associate with coach-athlete dynamics at both the individual and team collective level.

In the domain of football, the type of KSAs trained within each phase will dictate the feedback and motivation approach applied at both the individual and team-context level. Similarly to baseball. Coaches are designated across distinct levels of team composition (e.g., head coach, offensive/defensive coordinators, position coaches, and conditioning coaches) and serve a distinct purpose during training, practice and game execution. Accordingly, each coach applies variations in training strategy based on the situational understanding phase they are responsible, as each phase is directed towards disparate, but complementary skill sets.

Just as a member of the team must maintain situational understanding appropriate to their role and assignment, a coach must also apply situational leadership, where they adapt styles based on environmental indicators and individual differences (Hersey & Blanchard, 1969). This nuance can also be seen above in the baseball example, where the coach varies their coaching technique based on the goal of the interaction and their desired audience. When directing subordinates, coaches often exhibit both relationship and task dimensions as a means to influence future task execution, with most common leadership styles being a mix between *Autocratic, Democratic, Positive Feedback, Social Support,* and *Training and Instruction* leadership philosophies (Turman, 2001). From an ITS standpoint, pedagogical approaches can be designed for each phase that adhere to different coaching philosophies and style; however, it is important to note that these pedagogical determinations are bound by the assessments captured within each specific activity or exercise. In the space of interdependent team interaction, a major focus is on scenario-based interventions that challenge skill application at both the individual and collective level, with situational understanding serving as a guiding framework to ground all training functions. For this purpose, ITS applications designed to train and build relevant team-oriented skill sets are recommended to adhere to structured pedagogical formalizations that associate with phases like the ones described above. To support a domain-agnostic representation, the framework must also extend across variations in team composition and role interdependencies, as many team contexts operate outside of discrete events, where play is much more continuous and dynamic.

Table 4. Situational Understanding Framework Applied for Team Skill Training

Training Situational Understanding (Phase)	Training Strategy	Example	Assessment and Feedback Factors
Know and execute assigned role (1)	*Individual:* Focused interventions that target fundamental application of skill. Deliberate Practice (Ericsson, 2003) *Team:* Working in subteams for practice and peer-learning opportunities	*Individual*: Wide Receiver executing catching drills across multiple flight trajectories and speeds. *Team*: Wide Receiver executing catching drills with cornerback providing coverage.	*Individual*: - Technique and Execution - Mechanics - Reinforcement *Team*: - Challenge and Motivation - Competition
Know how an assigned role fits within the context of the team (2)	*Individual*: Understand role for each individual play, with ability to recall all decision points *Team*: Drill-repeat exercises to promote deep understanding and consistent application	*Individual*: Wide Receiver studies playbook and knows all routes and blocking assignments. *Team*: Offense-only drills with wide-receiver applying proper technique based on given play calls.	*Individual*: - Declarative & Procedural knowledge about context of plays *Team*: - Role Interdependency - Shared Mental Models - Trust
Know how to observe, communicate, & adapt (3)	*Individual*: Study film and prior use cases/examples. *Team*: Subject team to variations in context that require role execution. Scenario-based practice events designed to challenge communication and adaptation across team-members and roles.	*Individual*: Case-based exercises that test ability to predict play outcomes based on pre-play observations. *Team*: Multiple scenarios that require communication between wide receiver and quarterback (e.g., identify single coverage and communicate a play audible to exploit recognized weakness)	*Individual*: - Conceptual Understanding of Opponent Behaviors - Counter-measure tactics based on opponent observations. *Team*: - Communication - Context Analysis - Coordination - Leadership

Basketball: Continuous Play with a Mix of Individual and Team Contributions

Basketball is another excellent domain to guide pedagogical considerations for Team ITS development as it introduces new elements not captured in the examples provided above. In this arena, basketball teams are composed of highly interdependent positional players with roles that are more loosely defined; meaning that roles are transferable at any moment. They are transferable in the sense that each teammate has both offensive and defensive responsibilities, as well as transferable in the sense that each teammate might switch roles within a given play to assist in meeting team objectives (e.g., a forward taking over defensive responsibilities on an opposing guard due to a screen). Three common characteristics of this type of team interaction is high task interdependence (Landi, 2001), high interaction, and uncertainty, which is due to the consequence of interacting team members and an evolving context (Wall, Cordery & Clegg, 2002; Ramos-Villagrasa, Navarro & Garcia-Izquierdo, 2012). In these instances, game flow is much more continuous, where team dynamics are highly reactive and often spontaneous. These dynamic characteristics are seen in many other relevant team compositions, including hockey, rugby, and even in military teams.

Due to these continual shifts in task context, team situational understanding is critical to success, with communication playing a pivotal role in collaborative coordination and cohesion. To address this shifting context, coaches are responsible for designing practice activities that build and strengthen foundational team behaviors, with direct abstraction from the phases defined in Table 4. This involves individual ability drills to build functional skills (e.g.,, dribbling, shooting, passing, etc.); team-/collective-drills to build flow, cohesion, and coordination (e.g., fast-break drills, play rehearsal, scenario-based walk-through); and scrimmage drills that recreate game situations for dedicated practice under the operational context. Formative assessment and directive feedback are applied across all activity and drill types, with task context (i.e., practice activity objectives and the interacting parts) and coaching philosophy (as based on configurations across Table 1) being the determining factors that drive pedagogical interventions.

In the domain of continuous play environments with shifting contexts, an additional element of situational understanding that plays a critical factor in practice and coaching design is team familiarity (i.e., shared mental models; Fletcher & Sottilare, 2017; DeChurch & Mesmer-Magnus, 2010). In this instance, familiarity relates to all parts that constitute a team and the environment for which they operate in. Each serving member of a team must be aware of the strengths and weaknesses not only of their contributions to the team objectives, but across all potential interacting parts, including opposing elements. Knowing what each interacting individual provides to the task environment enables effective decision making for the purpose of exploiting specific strengths and weaknesses for the good of the team (e.g., calling plays to exploit situational weakness, such as taking advantage of an undersized defender). In these scenarios shared mental understanding is critical, where decision cycle times are reduced and automated based on shared understanding of task interdependencies and location and role of each interacting element. It is through initial well-designed practice activities that familiarization is acquired, with advanced application leading to individualized and often creative communication techniques (i.e., using gestures and subtle signals to communicate intent and coordination). In these instances, while the coach emphasizes the importance of teaming behaviors, it is often up to the interacting team-members themselves to devise a specific solution to the coaches defined objective.

The activities and deliberate practice techniques will vary across domain, with the defined team characteristics providing guiding principles to start from. For basketball, the activities will vary from football, as the defined characteristics of that team require it. In these instances, scenario-based team exercises will be created that target specific skill sets. In addition, the specific coaching practices seen across collegiate basketball programs may be of extra relevance for the design of a team pedagogical philosophy for military relevant contexts, as the turn-over for NCAA teams is high, where athletes are eligible for the pros after

one year of post high school activity. In these instances, it may be relevant to code specific strategies executed by collegiate basketball coaches that address new additions to an already existing team structure. Accelerating cohesion in these instances is critical to team success.

CHALLENGE POINT FRAMEWORK

When establishing coaching strategies that target accelerated team development, it is also important to consider how GIFT and ITS can manage challenge in a generalized capacity that applies across domains. The Challenge Point Framework is an approach to model these interactions, which is based on the relationship between task difficulty and the learner's ability. Tasks can become more difficulty, for example, with greater accuracy requirements, more pressure on success, or more to the point of this chapter, a decrease in the feedback presented.

Figure 1 shows the relationship between task difficulty and immediate (practice) performance and learning. Immediate performance (e.g., during practicing) is the solid orange line. As task difficulty increases, performance decreases. The dotted, green line represents long-term learning. As task difficulty increases, learning also increases, up to a point. That point is known as the optimal challenge point (OCP) and designates the point where the individual is being optimally challenged for long-term learning. You will notice that at the OCP, practice performance is compromised. In other words, OCP creates short-term struggle for long-term gain. As shown in the graph, the level of difficulty at which learning is optimized is not the same level of difficulty that promotes the best immediate performance.

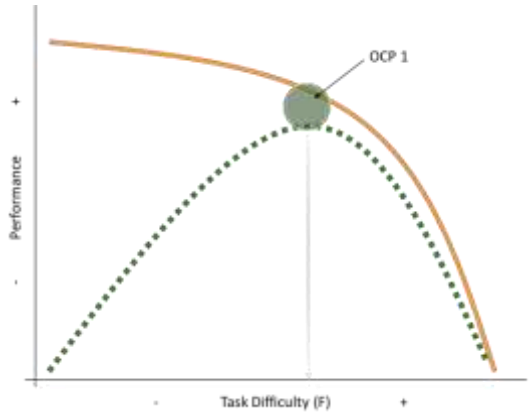

Figure 1. A graphical representation of the optimal challenge point (OCP). Image adapted from Guadagnoli and Lee (2004).

As the learner progresses so does the OCP. Figure 1 models performance/learning for a relatively experienced learner. Figure 2 models performance/learning for both an experiences learner (OCP 1) and a novice learner (OCP 2).

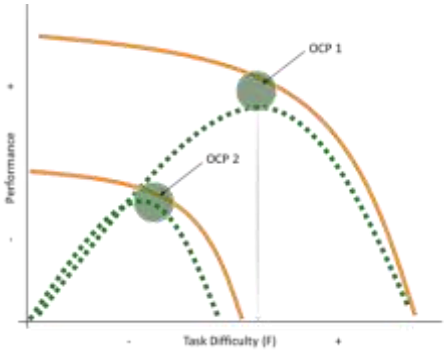

Figure 2. A representation of optimal challenge point for relatively novice (OCP 2) and relatively more experienced learners (OCP 1). Image adapted from Guadagnoli and Lee (2004).

As you see, the same basic relationship between task difficulty, immediate performance, and learning is maintained, but the optimal challenge point (OCP) is at a lower difficulty level for the novice learner than for the experienced learner. As a result, knowing how to increase and decrease challenge for the individual is a key component to optimized learning. As mentioned, feedback is one way to change the level of challenge. Decreases feedback provides less guidance and therefore requires the individual to rely on intrinsic feedback mechanisms. This increases the task difficulty for the individuals, and for more experienced individuals decreased feedback degrades immediate performance but enhances long-term learning.

Based on our understanding of the Challenge Point Framework, it would be much more effective for the coach to deliver less frequent feedback to this level of skilled performers. This would likely yield more struggle during practice but greater performance in the game (as a result of greater learning in practice).

CONCLUSIONS AND POTENTIAL OPPORTUNITIES

In the design of team-based ITSs, sound pedagogical practice is critical. In this chapter, we argue for the use of sports psychology and sports coaching lessons-learned to guide the design of a generalizable pedagogical model for use in the Generalized Intelligent Framework for Tutoring (GIFT; Sottilare, Brawner, Goldberg & Holden, 2012). In its initial implementation, a major requirement is first establishing instructional strategy functions that adhere to the taxonomy presented in Table 1. This involves establishing variables with configurable enumerations in GIFT's team pedagogical model that will inform a set of production rules or agent policies used at run-time. This requires identifying all team-level strategies (i.e., a GIFT strategy requires domain-generalizability) and establishing tactic level representations and their associated dependencies (i.e., how feedback is presented and how adaptations are managed).

With a set of supported pedagogical functions that can be enacted by GIFT, the next requirement is generating a set of policies and/or rule sets that are used at runtime. An overarching objective is to establish empirically informed policies that determine how best to coach a team based on the composition of that team (i.e., team structure, roles, and interdependencies), the personalities that make up that team (i.e., individual differences), and the domain for which they execute as a team (i.e., context to guide strategy configurations). Before a coaching philosophy can be applied, as defined through dedicated policies, there are certain tenets that drive the design of team training events when a specific domain is specified. As seen in the Situation Understanding Model defined in Table 4, a major component of team effectiveness is applying deliberate practice techniques that target specific skill sets and objectives at both the individual and team context. This highlights a need for pedagogical consideration at two levels of interaction: (1) what each individual role of a team experiences before, during, and after a specified exercise (e.g., macro-adaptation),

and (2) what assessment and feedback is applied at each managed interaction before, during, and after a specified exercise (micro-adaptation). The goal is to establish generalized rules based on the feedback taxonomy in Table 1, where configurations can be parameterized based on loggable performance and behavioral data sources. As an example, pedagogical model policies will have to differentiate and resolve conflicts across feedback and drill-repeat strategy types (e.g., when to yell feedback vs. when to interrupt an event and instruct the team to start from the beginning).

In a traditional ITS, these policies are derived from interactions observed across expert tutors, where their actions and strategies were coded for strategy analyses to determine what common practices effective tutors consistently utilized. The resulting pedagogical 'best-practices' are then translated and programmed as algorithms that serve as the pedagogical logic that guides feedback delivery and adaptation practices. In the case of team-based ITSs, similar methods are recommended. An approach is to design an observational study that incorporates multiple coaches across multiple disciplines for the purpose of deriving effective strategies applied across the team context in multiple instances. This would require establishing coding schemas that adhere to the taxonomy elements in Table 1, where representations are required that link observable performance/behavior indices and their association with coaching related tactics. These assessment indices to coaching tactic relationships can be configured across distinct coaching philosophies (e.g., *Autocratic, Democratic, Positive Feedback, Social Support,* and *Training and Instruction),* where a training developer can customize the coach type that drives feedback and strategy interventions.

At a fundamental level, when compared to one-on-one tutoring strategies, the strategies and tactics used by team coaches are only anecdotally understood: while coaches' small decisions in a game are picked apart by sportscaster talking heads for days, how much time is spent rigorously analyzing the content and patterns of how they interact with their players on a day-to-day basis? From a research standpoint, there could be great value in extensive data collection across a number of expert coaches with the goal of building generalizable policy sets for feedback and motivational interventions for a team. However, this would require a major study with deep data collection. An alternative approach that can be applied in the near-term would be to build pedagogical coaching models that are based on specific individuals and/or philosophies that are well documented in the literature (i.e., building models from documented theory, rather than training from data). An example would be explicitly studying one well-represented expert coach (e.g., Duke Basketball coach Mike Krzyzewski) and building policy sets on that individual as represented through books, interviews, video observations, and peer assessments. The results of this approach would probably be too coarse-grained to infer the specific tactical philosophy of that coach regarding their expertise within a domain (e.g., how they provide feedback). Instead, the goal is to extract coaching strategies and methods that focus on managing team behavior and development. Based on these insights, GIFT could build a set of alternate "coaching" pedagogical models based on team training experts. These models could then be analyzed and compared for different kinds of teams and learners, using data from these studies to improve our understanding of how virtual coaches can improve team training.

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