1. Introduction

The identification of effective models of teaching sometimes must come from activities that are related to some degree but found in completely different applied areas. Among these models, the researchers have proposed the use of “enhancers,” such as group activities involving a variety of assignments to be completed within the group, the use of video materials, the addition of computer-oriented techniques to cover drills, and so on. One of the most complete and efficient models of teaching for the engineering profession is the one based on the activities used by a sports coach, and more specifically, a developmental team coach.

The activities proposed by a coach for a group of developmental players must follow a very active approach of learning where the many aspects of the sport are introduced and immediately put into practice by the players. The coach, however, must still follow a set of well-established principles within this active learning approach and this is precisely what may be used for improving, perhaps in a remarkable way, the effectiveness of teaching in engineering classes. In this presentation, we will review some of the basic coaching principles and connect these ideas to the engineering classroom. Afterwards, some of the key activities will be illustrated with examples that will attempt to show the dramatic parallelism between coaching techniques and teaching methodologies by an active learning approach. In addition, in this contribution we will focus mainly on “progressive approaches.” These topics are included in the section below.

2. Coaching a Sport in General: Characteristics and Some Comparisons with Engineering Teaching

Coaching can be viewed as a set of strategic activities used to introduce, promote, and implement all basic skills, knowledge, and techniques (i.e., individual and team) to players in order for them to perform effectively during a game. Within this framework there are numerous levels of coaching. For example, coaching found at the professional level involves players that display a very high level
of skill and understanding of the sport. On the other hand, coaching is also practiced at a beginning level where the players have very little knowledge of the sport and they must be introduced to all aspects (of the game), including the skills required to practice at an effective level. The techniques and methodologies used for the two different situations described above must be different and usually, they require a different set of objectives and philosophies from the coaching standpoint. In this contribution we are interested in the beginning or developmental level of coaching.

Goals and objectives are the two important items that differ among the levels of teams. For example, one important goal for a professional level team is usually to defeat an opponent team. However, for the developmental level team, the goal of winning sometimes is not the most important. Instead, a list of objectives becomes the focus. The process of making mistakes and consequently, not being able to win, introduces a very strong gradient in the desire of the player to improve and learn when the coach uses these results properly. In addition, the coach could have set an a priori set of objectives that do not include winning the game necessarily, but rather to master a given skill for the players.

The paragraph above illustrates clearly the situation that one can find in an engineering classroom. Here, activities and methodologies used by the developmental coach become very relevant. Recall, the coach of the developmental level team must follow a set of objectives to be able to successfully introduce the player to the different skill and techniques of a given sport that he/she is teaching. Likewise, the instructor in the engineering classroom has to follow the same list. Therefore, the organization of activities in a coaching environment is a very close formula that an engineering instructor can use to transform the usually passive (and boring) solo lecture into a dynamic learning environment.

In order to accomplish the set of objectives that she/he thinks are important for that practice, the developmental coach must prepare ahead of time a “lesson plan” that she/he must be able to carry on. For example, a lesson plan that is not carefully linked to the objectives will probably waste time and therefore, the significance of the activities (to maintain the level of motivation and involvement of the players) will weaken. Thus, the players will be more apt to lose interest in the subject matter and the coach becomes useless. Aside from encouraging active learning, the coach should use feedback gathered from the first practice to tune up the second practice to the level of efficiency that she/he wants. Similarly, an engineering instructor that does not prepare herself or himself for delivering the basic objectives of a piece of engineering material will not be as effective as he/she should be. In addition, the approach just described above is adjusted to fit the needs of the students (rather than forcing the learning of an outline first introduced to students at the beginning of the class).

Another important aspect is the use of “progressive” sequences in the introduction of the players to a given skill. When used as an effective teaching tool, it allows the player to be exposed to a limited amount of material at a given time in order to master it before a different aspect is introduced. For example, in soccer, Brazilians are famous in the development of the player by a progressive approach of learning. Almost every skill or task is sliced into (easier) pieces that are first mastered and only thereafter put together by the players. Because of this breakdown of skills, the developmental coach becomes a master in identifying several pieces of the whole, and so can
construct exercises that will help the players to master the pieces. Then, the coach will propose a learning sequence that will enable the player to easily combine these pieces into the whole.

The strategy presented above could be used almost entirely to teach difficult concepts in an engineering classroom. This new type of coaching instructor will come to a class with a clear idea of the central topic to teach, slice this topic into smaller sub-topics, and then proceed to actively engage the students in the learning of the “whole” by learning the different pieces progressively.

3. Examples of Progressive Tasks in a Soccer Team.

In this section, we will introduce one sequence used for the learning of a skill needed to practice soccer. Others will be discussed in the actual presentation of the material during the conference. In the next section, we will adjust this sequence with appropriate examples to relate it to the engineering classroom.

Learning to head a soccer ball may appear simple to the average spectator, but in order to acquire the greatest advantage from it (i.e., passing, scoring, trapping) control of the ball must first be achieved. For each of the three activities mentioned above there lies a different set of objectives, while some common knowledge from general heading carries over. For example, for a player who would like to learn how to score with a header, the objective to focus on would be placement. First of all, the basics of heading would be introduced to the player. He/She would need to learn how to reach his/her full power potential by using various parts of the body. Using only the lower back would not achieve this, and likewise, only using the neck would not either. Therefore, the coach would need to design a drill that targets the two aspects individually first, and then puts the two together. After that, the player could be introduced to the importance of using their arms. A separate drill for only arm use could be given and then, of course, all three techniques would be put together. Finally, the player also has to consider moving to the ball (by running or jumping) as well as defending themselves from other players. Only after mastering all these basics can a player begin to focus on the objective. Again, individual drills for these applications would be introduced first, but then later incorporated into one final drill that involves all aspects of scoring with a header.

4. Illustrative Sequences in Engineering Classroom.

One sequence that parallels very well the learning sequence for the skill of soccer described above is the learning of free-convection flows with homogeneous and/or heterogeneous heat sources. The entire problem from the point of view of the student is fairly complicated, since concepts from heat transfer, momentum transfer, and mass transfer are coupled. A very effective way of introducing this important problem to the undergraduate engineering student is by dissecting the entire problem into smaller problems that can then be integrated (by the students with guidance from the instructor) effectively in the learning of the whole problem. One such progressive sequence is dividing the problem into the following sub-problems: first, discuss the solution of a problem without heat generation and introduce the student to the different aspects of heat transfer driven by buoyancy forces. Second, the basic knowledge can then be integrated to learn the solution of the problem with
heterogeneous heat sources. Finally, the most difficult case of homogeneous heat sources can be built up based on the knowledge acquired in the previous two cases. Furthermore, the knowledge that is accumulated (by the student) can then be effectively used to learn about the behavior of the concentration profile through the solution of the species continuity equation. The instructor must be able to identify a number of smaller tasks within the different sub-problems mentioned above, in order to be an effective “coach”. During the presentations, several aspects of the selection and construction of this task will be discussed and illustrated. In addition, other engineering examples taken from fluid mechanics, mathematics, and reactor analysis will be addressed.

In the sequence of tasks described above, the instructor will have the opportunity of observing the performance of the students and assess their progress in the understanding of the material. If she/he detects aspects that are not being mastered by the student, then she has the opportunity to design a different sequence of activities or, alternatively, to recommend others that will help to improve such understanding. This aspect parallels very well the activity known as “game analysis” that many coaches use to detect weak aspects in the team performance and then design corrective drills.

5. Summary and Concluding Remarks

We have discussed several of the basic aspects used by developmental coaches in teaching various skills required to practice effectively the game of, for example, soccer. We have then introduced examples of progressive approaches used to teach complicated tasks to the player. Finally, we have illustrated those sequences with engineering applications. The discussion in the oral presentation will address in detail several of the aspects introduced in the above sections.

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