

Using Sports Coaching Techniques to Enhance Project Based Learning Instruction

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Abstract

As instructors attempt to apply project based learning as a preferred pedagogy for many aspects of engineering education, countless questions are raised. For instance, how do instructors assess individual performance in a team based environment? How do instructors prepare students for the culminating presentation or report? How do instructors develop the students individually? After reviewing literature on both project based learning and exceptional coaching, we have found that much can be learned from John Wooden, Phil Jackson and other coaches. This paper will organize some of the best practices in sports coaching and draw parallels that will enhance student learning in project based instruction. The paper discusses the parallels between the instructor and the coach and highlights three broad categories of techniques: 1) Practice and games, 2) Teamwork and individual performance, and 3) Individual feedback for improvement. Some of these techniques have been used to successfully enhance learning in a senior design course in Industrial Engineering at Cal Poly. The insights in this article will open up a rich area of information to enhance project based learning in the future.

Introduction

Because Project Based Learning (PBL) is a new technique, much is still unknown about ideal practices. In order to shed light on the subject, the extensive literature and practical knowledge on sports coaching is explored to enhance PBL instruction. Team sports are much like PBL. Students like athletes work together for the team's success. Students like athletes must draw on individual contributions to achieve team goals. Students like athletes must practice their skills in order to be ready for the culminating game or presentation. And students like athletes must have individual feedback in order to improve. The parallels continue.

PBL instruction has only recently been a preferred means of instruction in engineering, while sports have been around for eons. There have been many great coaches through the years that have written much on how to achieve success on the court or field. This paper discusses the ways in which the literature on coaching has been used to influence teaching practices in a senior design course using PBL.

The paper first reviews literature on the subject. Next the roles of both the coach and the instructor are explored to draw parallels between coaching and PBL. This is followed by a discussion on techniques used by some of the best coaches organized into three main areas: 1) Practice and games 2) Teamwork and individual performance, and 3) Feedback for individual improvement. Incorporated in the three areas is a summary of the applications of coaching techniques in a senior design class. Finally, the results from using this methodology in a senior design class are discussed.

Review of Literature

The advantages of PBL for students learning are many¹. Students learn to work on teams, they are able to see the culmination of a larger problem than they could have done alone, and they often achieve better design solutions.

Most engineering schools use team based projects, or team laboratory assignments to help students develop skills necessary for their professional careers. Teamwork skills have traditionally been developed by exposing students to team activities without discussion of teamwork techniques. To some extent, this lack of formal instruction does produce results, but a better approach was undertaken at the University of Dayton² where student teams were instructed on teambuilding and leadership. Many researchers have struggled with the difficult task of assessing teamwork and other soft skills involved in multi-disciplinary PBL teams. Plumb and Sobeck³ put together a framework for developing assessment tools. They urge instructors to develop a rubric to track performance over time.

Teamwork in PBL is unique in that the teams are usually working on complex, ambiguous, and time consuming problems. When PBL is used students achieve many desirable outcomes. Several researchers at the University of Madrid⁴ found that PBL used in the design of electronic systems increased interest in electronics, increased academic performance, and produced better design solutions. In addition, situational factors were found to influence the outcomes of PBL activities for junior engineering students⁵. These situational factors include the type of project selected, the learning of the individual student, and the ability of students to adapt to working under time pressure.

Engagement is often cited as an important component of learning in PBL. In the Civil and Chemical Engineering school at RMIT, researchers⁶ examined the factors that effect engagement in a PBL environment. They examined first year engineering students and identified factors that helped students engage in a project. The first factor is that students need “interesting work.” The second is that students must understand the structure of the problem with clearly defined expectations. Thirdly, students work best when they feel connected to other students in their groups.

Although much has been written on PBL and its benefits, there is a lack of specific techniques that an instructor can use if he is inexperienced in this type of instruction. Conceptualizing PBL instruction as a coaching activity may help satisfy that need.

There are many great coaches and much written on each. In the area of basketball, every passionate coach would include John Wooden⁷ as a fantastic role model. He often mentions his view that coaching is teaching and he took the responsibility seriously⁸.

John Wooden’s “Pyramid of Success”⁸ has informed many on not only sports skills but life skills also. The title of Swen Nater’s book on John Wooden reflects Wooden’s passion for individual development: You haven’t taught until they have learned.

Phil Jackson⁹ extends activities on the court to life lessons. He focuses on success through selfless team play and spiritual practices to help focus team activities.

Jenkins¹⁰ reviewed an interesting book, The Sports Coach as Educator: Reconceptualising Sports Coaching that attempts to conceptualize the coaching function as an education function. He reviews

many theories in education and outline how these can be used in sports coaching. Drawing parallels regarding the two functions is similar to this current paper.

Edwards and Selman¹¹ outline the parallels of coaching to management. They discuss how much can be learned from the great coaches of the past: George Allen, Red Auerbach, Tim Galloway and John Wooden. They have also included an informative list of techniques that have proven successful on the playing field and in business. These include issues like “be clear it’s a game, and that the point is to win” and “Be committed to the players” and “Be a teacher.” Their article is good background on the subject of coaching and its transferability to other disciplines.

Given the need in PBL for specific techniques and the wealth of information in sports coaching this paper explains the use of the later in a specific course in the Industrial Engineering (IE) curriculum at Cal Poly, San Luis Obispo.

Defining Parallels

To begin conceptualizing sports coaching and PBL instruction it is helpful to examine the similarities and differences. Table 1 outlines the major components of each discipline in order to help to reader adjust to the concepts. Throughout the paper some of these components will be used interchangeably. For instance in many instances, the athlete is the same as the student. As Table 1 illustrates, although there are many similarities, there are differences too. For instance there is not as much competition in PBL instruction and the concept of opponent is not as well defined.

Table 1: Parallels between Sports and PBL

Domain	Sports	PBL
Culminating activity	Game	Presentation and report
Mentor/authority	Coach	Instructor
Participants	Athlete	Student
Duration of activities	Season (5 months)	Course (10 weeks)
Motivation	Team achievement	Team achievement
Adversary	Other team	Client
Domain	Court	Company/division
Goals	League champion	Exceptional performance
Level of competition	High	Low

The PBL Course and Projects

For more than ten years the students in a senior capstone IE course at Cal Poly, San Luis Obispo on Facility Design has work on projects for local companies. The local company is the customer and is dealt with as a client in a consulting practice. The students work in teams of four to seven students to produce an improved facilities design expressed in a report and a presentation. This capstone senior level class requires that students draw on their knowledge from many IE topics including inventory control, project management, ergonomics, quality, work design and economics. Clients are usually small manufacturing firms in the San Luis Obispo County area. Typically these firms are so small that they would never have had the opportunity to see IE topics applied in a systematic manner by knowledgeable individuals. An overwhelming number of the clients have been pleased with the results. Table 2 is a partial list of companies and projects. Some of these companies have hired IE’s after

realizing the contributions IE's can make to a company's efficiency. In addition, most companies have implemented at least some of the recommendations made by these students.

Table 2: Sample Projects in Facilities Design Course

Company	Location - CA	Company Type	Project Description
C&D Aerospace	Santa Maria	Aerospace	Redesign of an assembly cell
Hardy Diagnostics	Santa Maria	Biomedical	Design layout for a new location
Left Coast T-Shirt	San Luis Obispo	Screen printing	Re-layout production floor to incorporate new machine
SLO Roasted Coffee	Los Osos	Food	Design new layout to incorporate new packaging process
UVS Thrift Store	San Luis Obispo	Non-profit	Re-layout and methods improvement

Students also learn firsthand topics that are difficult to teach in the classroom. For instance, students learn the importance of positive interactions with clients, methods of dealing with project uncertainty, real deadlines where more than a grade is at stake, and team conflict resolution in real time.

As an example, a student team made up of six seniors worked for a local Unmanned Aerial Vehicle (UAV) manufacturer to develop a plan for their new campus. Initially, the students visited the current location for a tour. This was followed by the students creating a Statement of Work as learned in their project management class. This was discussed with the client and then expanded to include descriptions of tasks, deliverables, and a work breakdown structure. The students spent the remaining seven weeks of the quarter developing a facilities solution that took into account the company's manufacturing processes, economic constraints, management needs, work flow, inventory methodology, and secrecy concerns and put together a comprehensive plan for the new location. A complete report, approximately 100 pages long, a professional presentation, and a physical model of the recommended facility was delivered to the client. The quality of the report was high and the client was pleased with the many creative benefit - cost justified ideas. In fact the client sent the following note.

"I was blown away with the quality and depth of what these students... produced. Ken will be working with Jeremiah to adopt recommendations presented in the Facility Design. Scott will be picking up on the data and trades presented in the Campus Project."

Although this course has created a successful PBL opportunity for students, this last year some coaching concepts were incorporated that have enhanced learning. Specifically the conceptualization of the teacher as coach and the employment of specific transferable techniques were used.

Role of the Teacher/Coach in PBL

The role of a coach and the teacher as a leader is very important. In this leadership role, the instructor or coach serves as a role model. This is most effective when the instructor or coach has a reciprocal respect relationship with the students or athletes. Athletes or students with a good relationship with the coach or teacher will want to achieve in order to please the coach. This type of leadership is also known as charismatic, a very effective method. Some techniques to enhance the coach/athlete or instructor/student relationship are listed below.

Communication

Students and athletes function better when they feel both included in the process and listened to. In the women's basketball program at Cal Poly, open communications are valued. Athletes hear the coach's values and goals everyday at practice and meet individually with the coach every other week. They receive feedback on the court during practice and are encouraged to approach the coach as often as necessary when issues arise. Similarly in the senior design course, the instructor communicates expectations and goals to the entire class in a lecture setting, gives feedback to the students in individual team meetings, and encourages students to attend office hours if questions arise. Every athlete and student must understand the purpose and goal of the activities. Open communication is valued not only with a student or athlete, but with every stakeholder in the activities. The instructor in the design class establishes good communications with the client company. This includes initial contact explaining the expectations for the company, a mid-quarter review of project process, and periodic emails checking on student interactions.

Love the Game

It is widely recognized that good coaches must love what they do. This is often in the context of small or nonexistence monetary compensations, but even if compensated, good coaches communicate their passion for the game. This is also true when an instructor is coordinating PBL. PBL often requires extra work and coordination when dealing with students in such an intense activity. The instructor of this engineering design course often communicates the love for the teaching profession and the joy in the success of the students. This kind of passion is contagious to students.

Ethical Behavior

Coaches must model ethical behavior on and off the court. Good coaches reward good attitudes by athletes and would never want to win if it includes any unethical behavior. This is true in PBL instruction. Teachers encourage ethical solutions and ethical dealings with the client. This includes open communications about ethics, highlighting the opportunities to behave ethically. Issues of team member's participation or lack thereof, client interactions, and professional activities are openly discussed. Through the open communications the instructor can model the expectations in the specific context of the project. As an example of an ethical situation in a project worked on this last year, the company decided they had given us proprietary information regarding processes and asked the students to shred the process instructions. The students felt that the information would help them develop a better solution and didn't want to shred the information. This was discussed openly and the ethical dilemma was clearly explored. Ultimately the students came to the conclusion to destroy the documents following the company's instructions.

Coaching Techniques

Beyond the role for the instructor, there are techniques used in the PBL projects that are derived from good coaching techniques. These techniques are divided into three loose categories. First the relationship between the practice or preparation time and the actual culminating activity, the game or the final presentation, is discussed. Secondly, the concepts around teamwork, particularly the techniques that allow students or athletes to put aside individual recognition for the good of the team, are explored. And lastly the flip side of teamwork, the development of the individual is discussed.

Practice and Games

In basketball, preparation occurs during practice and the results are seen during the game. In PBL instruction, preparation takes place during team meetings, individual task accomplishments, and class lecture, while the client presentation is considered the culminating activity. The reason for practice or preparation time is to develop skills to a point where they become automatic and internalized so that an individual can draw on these skills when they are needed. In the context of basketball this means reviewing basics such as shooting and dribbling, developing new skills such as defensive movement or rebounding, developing plays which focus on team interactions, and preparing for a particular opponent or situations. In preparing for a project, students must do similar activities. They have to repeat basic skills like report writing or preparing charts and diagrams, they must acquire new skills like the design of an assembly line. They also need to work together as a team where individuals develop designs for components that must fit together into the final product. They must also look outside their own team to prepare for the client presentation.

Table 3 below summarizes the techniques along with the application in basketball and the application in PBL.

Table 3: Practice and Games Techniques

Technique	Basketball	PBL
Repetition	-Repeat basic drills -Review plays	-Examples in class -Homework problems
Permission to fail in practice so that we succeed when it really counts	-Push athletes to the limit during practice -Practices should be harder than games	-Students attempt an analysis then review the solution with the instructor -Final presentation is practiced in front of instructor with much feedback before delivery to client
Uncompromising preparation	-Practice many hours everyday -Attempt to improve everyday -Never be surprised by opponent	-There should never be a question the client asks that the student can't answer -Don't leave any stone unturned
Teach	-Introduce quote of the day to highlight learning opportunity -At the beginning of every practice set three objectives for the day	-Define learning objectives for each class or meeting. -Quote of the day used to link IE subjects to learning opportunities.
Make the practice match the game as much as possible	-Mix teams up in practice so that athletes get use to playing with many players. -Use competition when possible to increase the competitive spirit -Practices are set up so that the handling of unfair situations can be addressed	-The instructor must ask hard questions similar to what the client may ask

Teamwork and Individual performance

In basketball the goal is always the achievement of the team, not the individual. In fact, individual performance is secondary to the team's winning record. In PBL, the team's success is the main goal. The client doesn't care who did which analysis, only that the analysis is complete. In this area, basketball and PBL are very similar.

Table 4 below outlines techniques used in basketball and the parallel technique used in the PBL activity.

Table 4: Teamwork and Individual Performance Techniques

Technique	Basketball	PBL
Reward team achievement	-The success of the team is measured by the team's win/loss record.	-When the client is pleased all team members are rewarded with praise and a good grade
Focus on task at hand	-Concentrate on the next game, not the season record or the tournament championship	-Have a clearly defined goal and make sure all activities support that goal
The team is responsible for individual's work	-If individuals do not achieve goals, the whole team must run suicides. -If the team does succeed, no one is punished.	-If a team member is not contributing, the team is responsible for solving this problem. -Individuals are encouraged to explore novel computational techniques
Attention to detail	-Coach notices who is out of position or not contributing	-Instructor must assess individual contribution through questioning in team meetings
Generous with praise	-Good individual achievements are praised in the context of team achievement. -At the end of practice athletes are asked to give specific positive feedback on other teammate's performance.	-Individual contribution is recognized when it helps the team achieve -Students are asked to give feedback in team meetings on the activities of others on the team.

Individual Feedback for improvement

John Wooden was famous for his definition of success: "Success is peace of mind which is a direct result of self-satisfaction in knowing you made the effort to become the best of which you are capable."⁷ Although it is important to achieve something as a team, the reason for both basketball and engineering education is to help individual students achieve all they can. The goal is individual development. To this end each individual deserves attention from the instructor and coach so that growth can be developed and monitored.

Table 5 summarizes the techniques use to enhance individual growth in both basketball and PBL instruction.

Table 5: Individual Feedback for Improvement Techniques

Technique	Basketball	PBL
Track performance	-Record statistics for each individual: Points per game, rebounds per game, -Use stats to set individual goals for growth. -Coaches must know what motivates individual athletes	-Hours spent on the project are tracked to encourage maximum effort. -Getting to know individual students allows for appropriate feedback and motivation techniques.
Immediate feedback	-If an athlete does something incorrectly during practice immediate feedback and correction can occur	-In team meetings, the instructor can catch incorrect application of topics and correction can be made immediately.
Responsibilities matched to abilities	-Individuals on the court are assigned to specific position based on physical attributes, experience, and skills.	-Job applications are filled out at the beginning of the class in order to gather information on skills. Students are assigned to teams by skill set needed for the project.
Individual accountability	-Individual meetings are scheduled with the head coach every two weeks to assess athlete's progress.	-At each team meeting, students are asked to report on their activities for the project. -At the end of the course the instructor writes an individual note to every student outlining their contribution to the team's success.

This framework for thinking about PBL instruction has opened a whole new area of exploration. In some of the parallel areas, experienced PBL instructor will naturally incorporate these good coaching techniques, but in other areas some novel techniques have been used with good success. Specifically, student accountability has been enhanced by collecting data on time spent on the project. In addition, techniques such as positive feedback of peers and the quote of the day have helped team cohesiveness. The most important aspect has been the idea that the coach or teacher is a role model. Students follow the lead of the instructor when dealing with issues whether they are ethical in nature or regarding individual performance.

Evidence of Technique Success

A survey of students involved in the PBL activity queried individuals on four areas: Team functioning, the usefulness of reporting time spent, the effectiveness of team meetings with the instructor, and general satisfaction with the course and project.

In general students felt their team functioned very well in this project. Of course, it is hard to attribute this to the use of coaching techniques, but it is believed that some of these techniques helped quite a bit. When asked "Did your team function well compared to other teams you have been on?" an overwhelming 96% reported "Yes, it functioned well." Several student comments are included below.

“We had a great time; we were all pretty mellow; everyone always had their best input. I also trusted my teammates do get things done if I asked them to, and they took it in stride to do their best. I had lots of fun with this group.”

“...better than I could have asked for”

“Everyone worked hard, and did their fair share which is very important.”

Students have to report weekly the time they spent on the project. Included in Figure 1 below is an example of time spent by the eight groups during the Winter quarter of 2009.

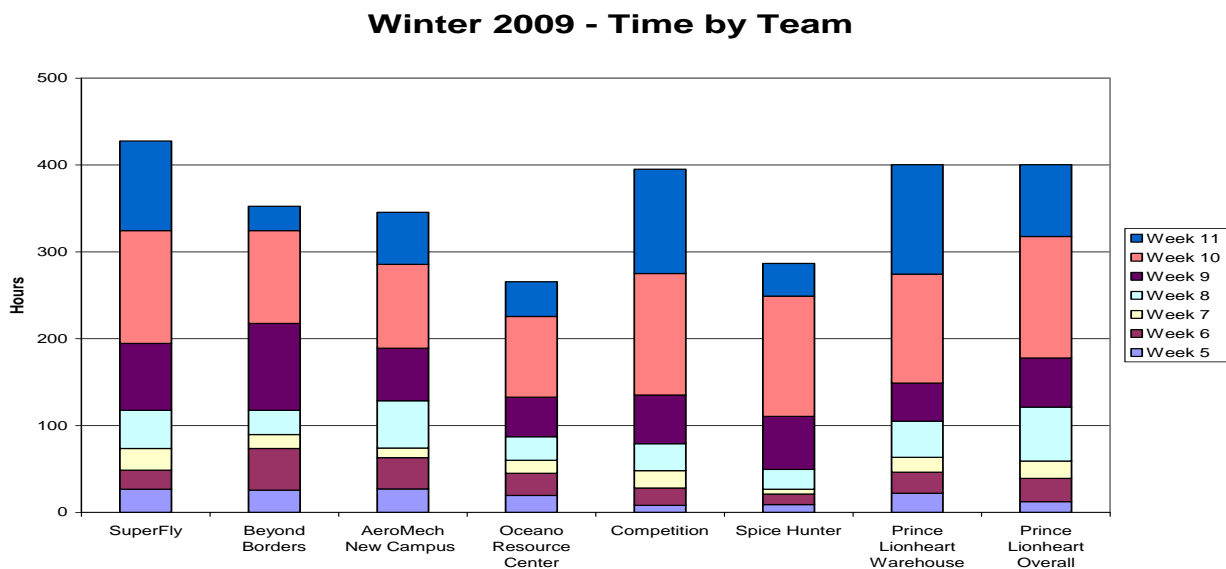


Figure 1: Time Spent by Team by Week for the Eight Projects

When asked, “Did reporting your hours help you work harder on the project?” 69% reported that “Yes, it motivated me to keep working.” When asked “Did it help you seeing how much time others were spending on the project?” 38% reported “It motivated me to spend more time on the project.” In addition, at the end of the quarter, the students received a faux paycheck based on the hours spent on the project. The paycheck also included a personal note to the student from the instructor. When asked “Was it good to get a paycheck at the end of the class?” 84% said “I liked the personal recognition.”

The instructor met with the student groups at least once per week. When asked “Did the individual meetings with the instructor help motivate you on the project?” an overwhelming 96% states “Yes, it was helpful.”

One of the objectives of the class defined at the initiation of the project is that the students should be proud of the work done for the client. Eighty-nine percent of the students felt this objective was achieved at a high level and the remaining 11% felt they achieved this objective at an acceptable level. When asked to give feedback on the course, most students gave suggestions for small improvement, but every comment included an observation similar to those below.

"I loved this class, and would take the class again if it was possible just to work on another project! I really liked that I could experience the "real world" by working on real projects. The practice presentation[s] were VERY helpful. We got excellent feedback and let us make the final presentation superb. Also, you were very helpful!! Thanks for all your help!"

"First off, thank you very much for taking the time to write personal letters to everyone. It means a lot that there are professors who care on that level."

Finally the following comment from a client illustrates the value of this activity to all involved.

"I wanted to thank you and them again for their efforts. I know the primary objective is to support the learning experience through the use of a real-world laboratory, but it would be an oversight to ignore the valuable contributions your projects bring to our company. The content of the final report is not the only benefit, I believe the process itself is valuable in that the interactions with the students give our staff an opportunity to consider their daily environment from a different point of view."

"Please consider me and Prince Lionheart boosters of your program, and don't hesitate to reach out if there is ever a way in which we can be helpful."

Conclusions

Incorporating good coaching techniques into PBL instruction has enhanced the outcomes of PBL and will continue to be a good source of new ideas and techniques for this type of education.

Using some specific techniques have lead to success in the PBL activity. Specifically tracking a "time spent" statistic and reporting this back to students has helped motivate performance. In addition, enhanced team building activities like weekly meetings with the instructor and discussion of teamwork performance, helped produce a high functioning team.

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