Development of a Web-Based System for Coaching Engineering Student Design Teams

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Abstract

The practice of engineering occurs in teams. Therefore, engineering educators must continue to develop and evaluate methods to help engineering students learn how to work in teams. One potential way of offering team process knowledge and feedback is through the use of the World Wide Web (WWW). This paper presents a web-based model that trains and coaches engineering students in developing team process knowledge and skills while they are working on a team design project. The students log on to the web-site on a weekly basis and receive team process knowledge and feedback. Each student is given individual assessments to determine their preferences related to decision style, learning style, and conflict resolution style. The web-based model provides structured team process skills training and presents it to individuals on teams 1) when needed based on the stage of team development and 2) customized for individuals based on individual style, learning style and preferred conflict resolution style. A database stores information on individual team members and captures reported team symptoms as the team develops over time. The conceptual model and preliminary observations gained from using the web-based coaching and feedback model with engineering student design teams are presented in this paper.

I. Introduction

Teaming skills are very important in the practice of engineering. Engineers are required to design complex systems and processes in a short amount of time and by necessity are required to work with others to accomplish these tasks. Leaders in industry repeatedly state the need for engineers who can work effectively in teams and they are expecting the engineering educational system to produce these individuals [1, 2].

Most would agree that engineering education has been designed to focus on rewarding individual knowledge and skills and not team skills. When teams are used in engineering

education, a typical scenario might be that students are told that working in teams is important in industry. Students are assigned to a student design team by some method: self-selection or instructor-selection. Then everyone waits to see what the outcome is at the end of the semester. In many situations, a faculty member may not even realize that a team is having problems unless the situation escalates to a crisis. A faculty member's lack of involvement in teaching team process skills may be attributed to the following reasons: 1) lack of time 2) lack of knowledge and or skills in teaching teaming skills 3) lack of interest and/or 4) lack of understanding of the need and importance for teaching team process skills. To satisfy the need for helping engineering students learn how to work in teams and recognizing the constraints on faculty resources to satisfy this need, team knowledge and skills are made available to students through the use of a web-based model called TeamCoach. The TeamCoach model structures team process skills training and presents it to individuals on teams: 1) when needed based on the team development stage and 2) customized for individuals based on personality types, learning styles, and preferred conflict resolutions styles as they function as part of a specific team. The TeamCoach monitors the functioning of the teams based on information reported by the team members. The current system does not require faculty intervention. This paper presents the developmental aspects of the TeamCoach model and preliminary data obtained from the use of the TeamCoach model with engineering student design teams.

II. Description of Model

A. Overview

Design projects provide engineering students with a hands-on, 'real engineering' learning experience and the opportunity to practice and improve interpersonal and communication skills in a safe environment. Using the TeamCoach model during an engineering student design project provides the students with specific team process knowledge and feedback in small, manageable chunks of information. TeamCoach was developed using theories and practices from the fields of cooperative learning [3-7], teams and group performance specifically training and coaching in team process skills [8-15] and the use of educational technology [16-18].

The TeamCoach model shown in Figure 1 focused on teaching team process skills to engineering students who were working on a team-based engineering design project. The TeamCoach model presented team process information to individual students on a weekly basis. The TeamCoach model consisted of three main parts: 1) Knowledge-based system 2) Database and 3) Team Process Modules. The knowledge-based system served as the supervisor of the system by determining 1) what information to present 2) when to present the information and 3) how to present the information. The knowledge-based system determined what information to present based on the team's developmental stage, the specific team composition and the student's particular preferences related to learning style, decision style and conflict resolution style. The knowledge-based system determined when to present information based on the team developmental stage, the week of the semester, and information supplied by the students through the weekly team symptom

checklist and peer evaluations. The knowledge-based system determined how to present the information based on the individual's learning style, decision style and/or conflict resolution style. The second main component of the TeamCoach model was a database that stored all the responses obtained from the students. Students were surveyed initially to determine their prior experiences with teams, their preferences related to learning styles, decision styles, and conflict resolution styles, and their knowledge about team processes. Throughout the semester the students reflected on questions related to their team functioning, completed peer evaluations, weekly team symptom checklists and instruments that measured team cohesion. All of this information was stored in the database and the knowledge-based system accessed the database as needed. The information in the database was also used to perform analysis to determine how the teams functioned and developed over time. The third main component of the model consisted of the seven team process modules that contained the actual learning material on team process skills. The first three modules, *Forming Teams*, *Team Vision and Goals*, and *Group Problem Solving*, were presented to individual students one module per week during the first three weeks of the semester. The other modules were presented to students only if they indicated a problem in their team through their responses to the weekly team symptom checklist or the peer evaluations. Any module that had been previously viewed was available to the students for later review.

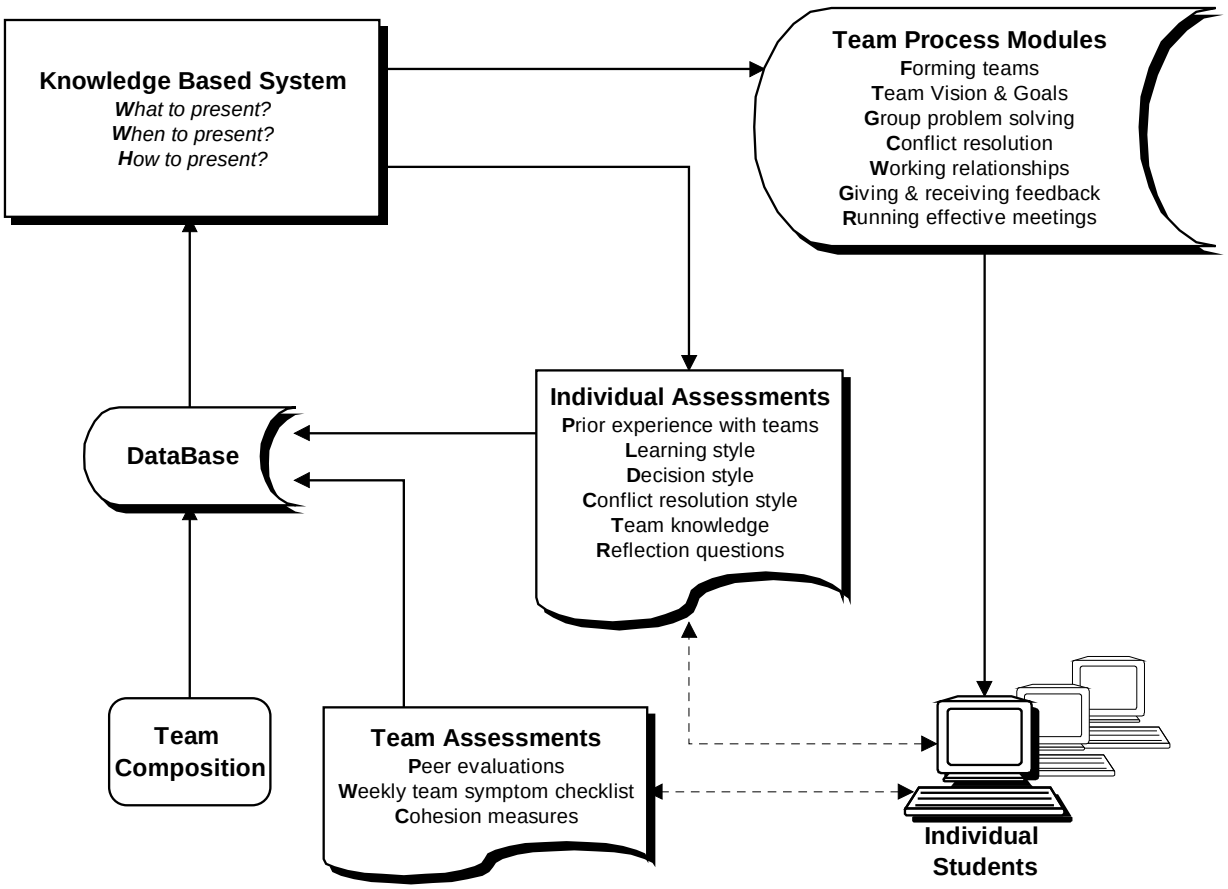

Figure 1: Model of TeamCoach System

B. Team Process Modules

The TeamCoach presents team process skills that are transportable skills and task-generic [9]. This means that engineering students can take the skills that they learn by interacting with TeamCoach and use them on a variety of different team projects in a variety of different contexts. Based on the research of the types of problems commonly experienced in engineering student design teams [14, 15, 19-21], the literature of how to build effective teams [9, 10, 13, 14, 22-24], and the stages of team development [25-28], the modules shown in Table 1 were included in the TeamCoach model.

Table 1: TeamCoach Modules

Module	Topics Presented
Forming Teams	• Rules of conduct • Benefits of teams • Stages of team development • Strengths and weaknesses of team composition based on individual assessment
Team Vision and Goals	• Need for common vision • Need for team goals • Personal vision of ideal team • Team vision • Team goals
Structured Approach to Problem Solving in Groups	• Problem solving method
Conflict Resolution	• Information concerning the different types of conflict strategies • Feedback on the styles of the different team members • Method for resolving conflicts based on styles involved
Developing Healthy Collaborative Working Relationships	• Behaviors that promote trust • Behaviors that destroy trust
Giving and Receiving Feedback	• Method for giving feedback • Method for receiving feedback
Running Effective Team Meetings	• Setting agendas • Keeping on task • Action items and follow up

C. Knowledge-Based System

The knowledge-based system was implemented using the Perl programming language with simple If-Then constructs. The knowledge-based system decided 1) what information to present 2) when according to team development stages to present the information and 3) the format to present the information. These decisions were based on team development stages and the particular team composition and feedback received from the team members. The information presented to the students was sequenced based on stages of team development [26, 28]. In addition, many of the modules presented customized learning material based on the specific team composition. To obtain information about individual preferences, students initially completed a number of instruments that assessed individual preferences related to decision style, learning style and preferred conflict resolution style [29-31]. For example in the conflict resolution module, the student was given not only their own conflict resolution style but also the styles of the other team members. The students were then asked to explore the description of the other styles in order to gain insight and to better understand the other members of their team. In certain modules, the feedback given was different based on an individual's personal decision style or learning style. On a weekly basis the students completed a team symptom checklist. The information from the checklist was used for tracking over time how the team was

functioning and developing. In addition, certain items on the weekly team symptom checklist triggered designated modules that were presented to the team based on the problems reported. This system provided the teams with information as they needed it based on their reporting of problems. Students should be more receptive to the advice and suggestions given by the TeamCoach model when they recognized and reported a problem on their team. TeamCoach was designed to automatically monitor team functioning based on student reports and present information to students through the web-site. The assumption was that the teams would be able to self-correct ineffective team processes without faculty intervention.

D. DataBase

One of the advantages of using a web-based coaching and training system was the ability to capture information about the individuals and teams over time as the team developed. All the information was stored in files with a particular user identification code that allowed for accessing and reviewing the information as needed. The type of information stored in the database included 1) individual assessments, 2) team vision and goals, 3) peer evaluations, 4) team reflection questions, 5) team cohesion measurements and 6) weekly team symptoms. This information was used to track and analyze team cohesion and reported problems over time as the team progressed through the various stages of team development.

E. Individual and Team Assessments

TeamCoach used a variety of assessment instruments to obtain information about the student's preferences as well as the team functioning and to measure change in the student's team knowledge and the student's overall perception of TeamCoach. Team knowledge was assessed at the beginning and end of the semester by using the Team Knowledge Assessment which is described in Section III.B. Early in the semester, students completed assessments to determine preferences regarding decision making styles, learning styles and conflict resolution styles. Students were asked on a weekly basis to fill out a team symptom checklist that indicated areas where their team was experiencing problems. On a monthly basis, students completed peer evaluations of the other team members and this information was provided as feedback to the team members. Also on a monthly basis, students were asked to reflect on some team questions concerning items such as what they see as the strengths and weaknesses of the team and what they personally could contribute to the team. Team cohesion was measured at mid-term and completion of project by using two different instruments. The TeamCoach Effectiveness Survey was given at the end of the semester. The survey was designed to gather subjective information from the users in the following areas:

1) satisfaction with the information available on the site
2) whether the user felt that the TeamCoach model helped their team's performance
3) whether the user preferred interacting with the TeamCoach rather than receiving the information in a traditional class setting.

III. Preliminary Results

A. Participants

The participants for this study were three freshmen Introduction to Engineering classes and two senior design project classes. At the beginning of the semester, there were 80 students enrolled in Introduction to Engineering which resulted in 18 teams with 4-5 students on each team. There were 24 students enrolled in senior design projects which resulted in 8 teams with 3-4 students on each team. Due to students withdrawing from the classes, the semester ended with 17 freshmen design teams and 7 senior design teams.

B. Team Knowledge Assessment

The Team Knowledge Assessment consisted of questions related to a variety of team processes. A sample of the type of questions asked are shown in Figure 2. Students responded with one of three choices: 1) Agree 2) Disagree or 3) Don't Know. The assessment was scored by adding one point for each correct answer and subtracting one point for each incorrect answer and 'don't know' response. Correct answers were determined by what is commonly found in the literature regarding effective team practices. Table 2 shows the results for the pre-test. The students' scores on the pre-test were average scores of approximately 75% correct. This indicates that there is room for improvement on basic knowledge of team processes and functions. This assessment was measuring knowledge only and not any skills in actually applying the knowledge.

1) Under most conditions, individuals working alone can produce a better quality product than a group or team. One bad performer on a team will inevitably lower the performance of the whole team.

❍ *Agree* ● *Disagree* ❍ *Don't Know*

2) A clear challenging goal is the single most important motivator for team performance.

● *Agree* ❍ *Disagree* ❍ *Don't Know*

Figure 2: Sample Team Knowledge Assessment Questions

Table 2: Team Knowledge Assessment Pre-Test (Sept. 1999)

All Students	μ= 76.8 σ= 13.2 n=99
Freshmen	μ= 76.8 σ= 12.5 n=75
Seniors	μ= 76.7 σ= 15.4 n=24

C. Prior Experience with Teams

Students were surveyed initially to determine the extent of their prior experiences with teams and how they felt about those experiences. As shown in Figure 3, engineering students have had a variety of team experiences in their lives. The majority of these experiences have occurred in work settings, in sports groups and musical activities. The majority of the students (86%) reported positive feelings about working as part of a team. Only 3% of the students indicated that they preferred to work alone, while the majority (81%) reported that their preference to work alone or in a group depends on the task. A question regarding previous training in how to work in a team, resulted in an even split with 50% indicating that they had received training and 50% indicating that they had not received training. A majority of the students (88%) indicated that they had been part of a highly effective team at some time in the past.

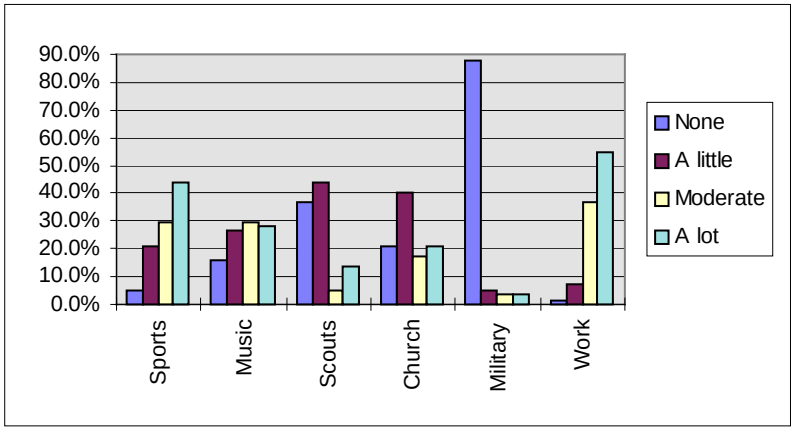

Figure 3: Prior Experience and Level of Participation in Team Activities

D. Team Reflection Questions

Students were asked on a monthly basis to reflect on the team process. The purpose of team reflection questions was to focus the students on gathering, analyzing and processing information that was related to their team functioning. These types of reflective questions can help faculty understand what is happening on the team, help students understand that the team process is important and promote reflective learning on the part of the students [32]. The results shown in Table 3 are from one set of reflection questions given during

week seven that asked students to identify the strengths and weaknesses of their team along with their personal contributions to the team. A total of 18 individual students responded to the team reflection questions and they represented 9 different teams. From the responses given on the strengths of the team, only 55% of the responses indicated that the team had clear challenging goals and only 39% said that their team had a clearly identified leader. When asked to identify weaknesses of their team, 39% said that team members were late, absent or did not participate in team meetings while 33% said their team lacked focus, team members did not follow through on assignments, and they couldn't find a time to meet. It appears that many of the engineering student design teams were struggling without a team leader, did not have clear goals, and were unsure of what to do with team members that did not participate. These are areas where future interventions could be made by either the TeamCoach model or the faculty member. Regarding the question as to what individuals could contribute to their team, the smallest number of responses was received for the skills of motivating the team, running efficient, focused meetings and working to achieve consensus and closure. This is an indicator of areas where benefits could be gained by further training in these team process skills.

Table 3: Responses from Team Reflection Question Set #2

What do you see as the strengths of your team (Mark all that apply)	Number of Responses n=18	Percentage
We trust each other	16	89%
We have a common team mission	16	89%
We listen to each other even when we don't agree	16	89%
Everyone on the team contributes	13	72%
We can solve problems effectively	13	72%
Good leadership	11	61%
We work well together	11	61%
Our team has clear challenging goals	10	55%
Our team has a clearly identified team leader	7	39%
What do you see as the weaknesses of your team? (Mark all that apply)	**Number of Responses n=18**	**Percentage**
Team members are late, absent or do not participate in team meetings	7	39%
Our team lacks focus	6	33%
Team members don't follow through on assignments	6	33%
We can't find a time to meet	6	33%
Lack of a team leader	4	22%
Ineffective group problem solving	3	16%
Lack of clear challenging goals	2	11%
We fail to listen to each other	1	5%
We don't respect other team member's opinions	1	5%
Lack of a clear team mission	1	5%
We have one team member who dominates and wants to do all the work	0	0%
Team members who refuse to work together	0	0%
Lack of trust	0	0%
What do you think you will be able to contribute to your team? (Mark all that apply)	**Number of Responses n=18**	**Percentage**
Listening to other points of view	15	83%
Ability to keep the team on task	14	77%
Creative Ideas	11	61%
Good interpersonal skills	11	61%
Leadership	10	55%
Sense of humor	10	55%
Developing positive working relationships	10	55%
Ability to keep track of details	9	50%
Running efficient, focused meetings	8	44%
Working to achieve consensus and closure	8	44%
Motivating the team	5	28%

E. Compliance

Any system developed to train and coach engineering students in team process skills must provide information without interfering with the task requirements of the project. TeamCoach was developed to require 30 - 60 minutes per week of the student's time. After using the system, it was determined that the time requirement is a very important issue to the students and probably 30 minutes is the maximum that they will devote to interacting with the system. The usage of TeamCoach got off to a very slow start. This is partly attributed to confusion over a human subject consent form that stated that participation was totally voluntary and that students could withdraw from the study at any time. However, each of the instructors stated that use of the TeamCoach was part of the team grade. It became apparent very early on in the project that students were not going to participate if it did not affect their grade. Since the TeamCoach model was designed to have information from all team members it was a problem when all the team members had not completed the weekly assignments. An offer of one free pizza to each team where all members had completed all assignments by mid-term increased participation by applying peer pressure from the other team members. This pizza offer was made only to the senior design teams and resulted in compliance by five of the seven senior level design teams.

IV. Summary

The conceptual and developmental aspects of the TeamCoach model are presented in this paper along with preliminary data from the use of the TeamCoach. The TeamCoach system was designed to train/coach engineering students in team process skills and knowledge. The TeamCoach model was first used in Fall 1999 with engineering student design teams. One major difficulty encountered was getting the students to use the system on a weekly basis. One lesson learned is that it is critical to build the use of the TeamCoach system into the course and to make it a significant portion of the grade so that students will be motivated to use the system. The major conceptual design feature of the TeamCoach was to present team process skills and knowledge to engineering students while they were engaged in working on an engineering student design team. The TeamCoach model used information obtained through individual assessments to customize material presented to students based on their own particular preferences and the specific team composition. The learning material was presented based on the predicted stages of team development. A database was used to capture information on the individual students and the teams as they progressed throughout the semester. Information from the database can be used to analyze team functioning and to identify the most critical areas for future training in team process skills. Further results from this study will be shared in a future paper.

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