2006-187: CURRICULAR ELEMENTS THAT PROMOTE PROFESSIONAL BEHAVIOR IN A DESIGN CLASS

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Abstract

Student teams are commonly used in engineering classes to integrate learning of teamwork, design, and analytic skills. Learning is greatly enhanced when the teams and individuals exhibit professional behaviors. However, not all students embody these behaviors. This case study examines curricular elements that promoted professional behaviors in a design class at University of Idaho. The study used staged surveys, coded student assignments, questionnaires, and student prioritization of responses to substantiate findings. Our research question is:

"What factors within this design class promoted professional team behaviors and why?"

The data suggests that the *interrelated functioning* of three curricular elements was the most significant factor in promoting professional behavior. The three curricular elements were a challenging team project, teaching and use of teamwork processes, and accountability coupled with coaching. Though the case employed specific implementations of these elements, broader characteristics of these elements emerged. First, the challenging project necessitated the practice of team processes and provided strong motivation. Second, effective teamwork processes exhibited the characteristics of direct applicability to team goals and appropriate investment of effort for returned value. Third, accountability with coaching appeared to be a strong combination to keep students' behavior professional and to keep teams on track with the project.

1. Introduction

Student teams are commonly used to teach design skills side-by-side with teamwork skills. Our experience with these classes is that while many teams produce excellent results other teams unravel. On the low performing teams it seems all learning outcomes are lost. Our assumption is that student choices and ensuing behaviors are the principle determining factors on whether a team blossoms or collapses. If the students choose professional behaviors—that is they are punctual, interactive, collaborative, engaged, complete tasks on time to specified quality levels, etc.—the teamwork will most likely be solid.

At the University of Idaho we teach a sophomore design class where one of the primary objectives is learning to work in teams. To improve learning in teams, new methods and curricular elements were introduced and tested in the class for four consecutive semesters. The intent of this case study is to determine which of these methods and elements are truly important and why. Our question thus is:

"What factors within this design class promoted professional team behaviors?"

This case study follows the class through a semester with 26 students. Several qualitative instruments were used at the beginning, middle, and end of the semester to surface and understand what curricular elements and methods promoted professional behaviors.

The data suggests that the ***integration*** of three curricular elements—a challenging team project, teaching and use of teamwork processes, and accountability with coaching—most significantly promoted professional behavior. Furthermore, important attributes of these elements surfaced in the data.

2. Background Literature

There are two obvious reasons for determining what curricular elements promote well functioning teams. First, several studies have shown that cooperative education can produce high learning outcomes.[1] These high learning outcomes depend on well functioning teams. Consequently, identifying methods to promote teamwork is valuable. Second, since teamwork is intrinsic to engineering practice, ABET requires programs to create learning in this area. ABET criterion 3(d) requires, "…students attain an ability to function on a multi-disciplinary teams."[2]

The choice of what curricular elements were tried and tested was guided by the work of Johnson, Johnson, and Smith, and J. C. Bean. The Johnsons and Smith[3] state five necessities to make cooperative teams work. These necessities can be used as criteria to pre-evaluate curricular elements being considered. Team members must have…

1. …positive interdependence,
2. …face-to-face promotive interactions,
3. …individual accountability,
4. …functioning social skills and,
5. …an instructor insuring group processes are running.

Hence curricular elements that reinforce these criteria should be considered.

From the point of view of how to design cooperative tasks within a curriculum, Bean[4] recommends…

1. Clear directions,
2. Clear processes to fulfill the task and,
3. Specifically defined outcomes.

These three criteria guide *how* a curricular element should be implemented.

Experience using the curriculum and former experience from working on teams in industry also drove curricular choices. Another "voice" from industry also provides direction. In an extensive study of 15,000 team members Larson and LaFasto[5] identify six distinguishing characteristic of effective team members:

1. Technical experience related to the work,
2. Problem solving ability,
3. Openness to deal with problems, issues, and ideas,
4. Supportive to help fellow team members succeed,
5. Action oriented, both personally and promoting it in the team and,

6. Optimistic or positive outlook.

Curricular elements could be created to develop student skills in these areas.

Qualitative methods were chosen to investigate this case because of the multitude of variables involved and the need to understand the naturalistic working of the curriculum.[6] The investigation followed methods common to case studies.[7]

3. Methods: Structure of the Case

This case follows the curriculum of the class. The class consisted of three sequential phases. The first phase taught basic teamwork and open-ended problem solving skills. The second phase taught math modeling topics (departmental requirement). The third phase applied teamwork skills and math modeling to a team based project.

The students were assigned to teams of four or five at the beginning of the teamwork learning phase. These teams remained intact for the semester. Teamwork skills were taught by individual pre-lecture assignments, a short lecture followed by a team practice and/or reinforcement of the skill, and finally individual homework assignments. The lab each week involved team design of simple machines while using the newly learned skills.

During the math modeling phase, topics were presented in the same format of pre-work, short lecture, team learning activities, and homework. Each week a new math modeling topic was presented and the weekly lab applied the topic to a design experiment. Though no explicit teamwork topics were taught during this period, the teams were required to work together to complete the lab assignments.

The final phase focused on a design project. One lecture period each week presented project management topics in the same format of pre-work, lecture, and practice as before. During the other weekly lecture period the instructor reviewed project status and action item logs individually with teams. Labs during this phase were completely devoted to design, building, and testing activities on the student projects.

At various times throughout the semester instruments were used to gather data. The instruments are presented chronologically in Table 1. Details of the instruments are presented in the Instruments and Findings Section.

Phase	Instrument	Timing
Teamwork learning (Weeks 1-4)	Student vs. Professional Freedom of Choice Survey	Week 1
	Team Contract Assignment	Immediately following Professional Culture Survey
	Individual Contribution vs. Team Contract Survey	Week 5
	Factors that Affect Professional Behavior List	Immediately following Individual Contribution vs. Team Contract Survey
Math modeling (Weeks 5-8)	No instruments administered	
Team project (Weeks 9-15)	Ranking Factors Promoting and Hindering Professional Performance	Week 14—end of semester
	Exit Questionnaire	Week 15—class session following ranking factors instrument

Table 1. Instruments and timing.

4. Curricular Elements

Though several curricular elements were used, questionnaire responses identified six elements with much higher frequency. These elements are described here and discussed in subsequent sections.

4.1. Team Contracts

Student teams were required to create a short list of expected professional behaviors to be exhibited by their members. Each student was first asked to create an individual list. The teams then discussed their members' lists and created an agreed upon team contract. The assignment handout specifically identified social loafing and exclusion of team members as behaviors to address, though complete freedom concerning content was given to the teams. These contracts were then turned in as an assignment.

4.2. Constructive Feedback

Constructive feedback was taught as a formula of three sequential pieces: 1) state a specific action or choice that affected the team's performance, 2) state why the action or choice was significant and, 3) state how the insight could be applied to strengthen the team's future performance. Time was set aside at the end of each lab for students to individually give feedback to their team. Each student was asked to cite two positive actions or choices to incorporate in future teamwork and one weakness that could be changed.

4.3. Professional Decision Making Process (PDM)

The students were taught an open-ended problem solving method consisting of six sequential steps: 1) Define the situation, 2) Define the goals, 3) Generate alternative solution ideas, 4) Plan a solution, 5) Do the solution and, 6) Learn from the solution by reflection. This process was practiced as a team process in labs. Our version of PDM is a direct adaptation of Charles Wales work,[8] though very similar methods are cited in cognitive psychology texts.[9]

4.4. Action Items

The teams were required to divide the work to meet each weekly deadline during the project into tasks. A log of these tasks was kept by the team which clearly delineated expectations on each task, named the task owner, and specified the expected due date. These tasks were called action items. Action Items were taught as a formula that follows the acronym SMART: Specific, Measurable, Achievable, Results oriented, and Time bound. Action items were collaboratively set by each team.

4.5. Challenging Project

The teams were required to design a water rocket to loft a digital camera, eject the camera at apex, and actuate the shutter while descending on a parachute. Each team was assigned to design either the lift vehicle, the ejection mechanism, or the shutter actuator. Three teams formed an integrated launch team. During the 6 week project each team was required to generate device specification, multiple design ideas, sketch their best design, math model appropriate parts of the design, fabricate a prototype, and measure performance. Three prototype cycles were completed and a final presentation was given.

4.6. Professor Project Reviews

During the rocket project each team reviewed their progress every week with the professor for 15 minutes. The review covered general status, completion rate of action items, problems encountered, and discussion of questions raised by the team.

5. Instruments and Findings

5.1. Student vs. Professional Freedom of Choice Survey

The first instrument measured the perceived similarities and differences between students' and professional engineers' freedom of choice. The students were asked to rank how acceptable it was for *a typical student* to make certain choices such as missing class or turning in poorly completed assignments. The students were then asked to rank how acceptable it was for *a typical professional engineer* to make parallel choices such as missing meetings or producing low quality work.

Each set of parallel questions was ranked on a five point Lickert scale from "Strongly Agree" to "Strongly Disagree." Aggregate responses to the questions each showed a distribution with strong central tendencies spanning three to four adjoining response option. Table 2 lists the questions with averaged response scores where Strongly Agree = 2, Agree = 1, Neutral = 0, Disagree = -1, and Strongly Disagree = -2.

Score (Ave.)	***Typical Students* consider it acceptable to choose…**	***Typical Professional Engineers* consider it acceptable to choose…**	**Score (Ave.)**
1.0	…how much effort to put into a class	…how much effort to put into a project	-0.8
0.2	…to skip a class	…to be late for work or miss meetings	-1.6
0.7	…to turn in poorly completed assignments	…to produce low quality work	-1.4
0.8	…how well to master material	…to become competent on job skills	-0.3
1.3	…to balance workload between classes	…to miss important deadlines in one area because other areas are hectic	-1.1
0.1	…to let the professor drive the learning	*Typical Engineers* take responsibility to learn new skills	1.4

Table 2. Parallel questions rated on five point Lickert scale by students.

The student ratings showed a marked difference between what was considered acceptable for a student versus a professional engineer. The aggregate responses indicate the class considered it acceptable for students to individually choose their effort level, attendance, etc. In contrast, engineers were not considered to have the freedom to individually choose their effort level, punctuality, etc.

5.2. Team Contract Assignment

Team contracts were coded to identify emergent categories of behaviors. Eleven such categories were identified and tallies of behaviors specified by at least half of the teams are listed in Table 3.

5.3. Individual Contribution vs. Team Contract Survey

At mid-semester the students were asked to rate how well they embodied their team contracts, how evenly the workload was distributed, and how open team communications were. The aggregate response indicated fairly positive results in these three areas. The questions and responses are shown in Table 4.

Behavior	No. of Teams Specifying Behavior	Characteristics
Show respect	6	Most formulas of respect included listening and considering alternate ideas and opinions.
Attend meetings	5	Emphasis on attendance and punctuality.
Meet team expectations for work products	5	Specified individual effort to meet schedule and/or produce high quality work.
Inform team of individual status	4	Inform team concerning difficulties and delays encountered in work and notify if cannot attend a meeting.
Maintain even workload	4	Included capitalizing on special skills and evenly handing out odious tasks.
Actively communicate	3	All members should be active in discussions, open ideas, and feedback.
Mutual agreement	3	Decisions should be by consensus.
Ask for or provide help to teammate	3	No team member should be individually responsible for major problems.

Table 3. Expected individual behaviors identified in the six team contracts.

How much of the time do *you* meet or exceed all agreements of your team contract?				
100%	***>90%***	***>80%***	***>70%***	***<70%***
6 (20%)	21 (78%)	None	None	None
How evenly have all team members contributed?				
All equally	***Nearly equally***	***Similar load***	***Too little/much***	***Grossly uneven***
7 (26%)	16 (60%)	2 (7%)	2 (7%)	None
Your team's strongest teammate contributes "_____" than anyone else.				
Tons more	***Some more***	***A little more***	***No more***	---
none	5 (19%)	13 (48%)	9 (33%)	
Your team's weakest teammate contributes "_____" than anyone else.				
No less	***A little less***	***Some less***	***Lots less***	---
9 (33%)	17 (63%)	1 (4%)	None	
How much of the time are you uncomfortable voicing your opinion in team meetings?				
Never	***<5%***	***<10%***	***<25%***	***<50%***
21 (78%)	4 (15%)	2 (7%)	None	None

Table 4. Individual workload and communication survey.

5.4. List of Factors that Affected Professional Behaviors

The last portion of the mid-semester survey asked the students to identify three major factors that helped their team perform professionally and three factors that hindered performance. The students were asked to consider factors both within the class (lecture topics, instructor, lab, etc.) and outside the class (previous experience, rearing, etc.). The responses were coded and tallied

into categories of like factors. The factors emerged in two major groups—skills taught in the class and personal behaviors. Table 5 shows the most frequently reported factors.

Factors that helped team members perform professionally
• Open-ended decision making process curricular element……(11 responses)
• Team members cooperating……..(6 responses)
• Giving constructive feedback curricular element……..(5 responses)
• Being time efficient……...(5 responses)
• Team members communicating well……..…..(5 responses)
• Team members being aware of situation and teammates…...…(5 responses)
Factors that hindered team members from professional performance
• Time pressure…….(7 responses)
• Team distractions……(5 responses)
• Poor documentation of work…….…….(3 responses)
• Poor punctuality……..(3 responses)

Table 5. Tallies of factors that helped or hindered professional behavior.

5.5. Ranking Factors Promoting and Hindering Professional Performance

Responses to the mid-semester survey generated a long list of factors that helped or hindered professional behavior. To determine which factors had the strongest effect, the students were asked to rank them. The factors were presented in two separate lists. The first list contained curricular topics and other aspects of the class. In this list each student identified the three most helpful and three least helpful curricular factors to develop professional teamwork. The second list presented individual behaviors as paired opposites such as "took extra effort to listen" and "not listening to ideas." Each student was asked to identify the three individual traits that most promoted teamwork and the three that most hindered teamwork.

The tally of the student responses to curricular factors shows two trends. First, certain curricular elements were identified frequently as helpful and certain elements were frequently identified as unhelpful. Second, no curricular elements were frequently identified as both helpful and unhelpful. Table 6 arranges the factors by frequency with most helpful from the top and least helpful from the bottom.

Unlike curricular elements which affected every team in the class, individual behaviors affected only the team on which the individual resided. Consequently, the tally in Table 7 reflects the specific experience of the students on their unique team. Two trends are noticeable in the tallies. First, some positive actions and their corresponding negative actions received significant responses in both. For example "communicating clearly" was identified 18 times and "inadequate communication" was identified 7 times. Second, some positive actions were identified frequently without their corresponding negative being identified much and vice versa. For example "pulled his/her own weight" was identified 16 times but (notably) "coasted on other's work" was identified only twice. Actions that received less than 3 total tallies were eliminated from the table as insignificant.

Curricular Topics and Aspects of the Class	Most Helpful 3	Least Helpful 3
Having a challenging team project to work on	11	1
Open-ended problem solving process (PDM process)	10	1
Using teammate action items	10	3
Brainstorming alternative ideas (subset of PDM)	8	1
Weekly project team reviews with instructor	8	0
Mentors (teaching assistants) in the lab	7	3
Creating team plans	5	2
Team size (too few or too many teammates)	4	2
Following a team meeting agenda	3	1
Product specification/test plan	1	0
Team logbooks	3	3
Lack of tools in the lab	0	1
Project review grading with the rubrics	2	5
Contrast between student vs. professional culture	2	8
Giving constructive feedback	5	9
Too little time in lab to complete a project	0	15
Writing a team contract	0	20

Table 6. Tallies of curricular factors ranked as "most helpful 3" or "least helpful 3" for developing professional teamwork.

Effect of Teammate's Actions on the Professional Teamwork			
Most Helpful 3	**Positive Behavior: Teammate…**	**Negative Behavior: Teammate…**	**Most Hindering 3**
18	... communicated clearly in writing, talking, or sketching	... not able to communicate adequately	7
16	... pulled his/her own weight	... "coasted" on other's work or avoided being assigned responsibilities	2
11	... encouraging equal say and cooperation	... dominated the team or unwilling to cooperate	7
10	... participates fully in meetings and on individual work	... not interested in participating	3
0	... took extra effort to listen	... not listening to ideas	7
7	... pursuing efficient use of time	... encouraging shortcuts	10
6	... actively gave and received process and/or individual feedback	... avoided feedback	10
6	... being punctual	... absent or late	12
1	... encouraged the use of specified process (such as PDM)	... preferred working without specified process	17

Table 7. Tallies of student behaviors during team experience ranked as "most helpful 3" or "most hindering 3."

5.6. Exit Questionnaire

The end of the semester rankings identified curricular topics and teammate behaviors that significantly helped and/or hindered professional behavior. A subsequent exit questionnaire was given to collect the students' perspective of why high-ranking items were ranked as they were. The questionnaire consisted of nine questions which are listed below, each followed by a summary of the student responses.

Question 1: Why did having a challenging team project help your team perform professionally?

Roughly a third of the responses identified that the project provided both the opportunity and necessity to practice teamwork skills. Without this venue, teams would have had little reason to operate as teams. Most students cited teamwork processes in general as necessary, though a few mentioned specific skills such as brainstorming, sketching, and planning.

Another third of the responses identified various motivations the project generated. Several students cited the project as intrinsically interesting. Others noted that the challenge simply motivated hard work and planning. One student wrote that he worked harder since his teammate's grades partly depended on him.

A final quarter of the responses noted that the size of the project kept everyone meaningfully involved and precluded "single-man teams."

Q2: Why did Action Items help your team perform professionally?

Responses indicated that action items were very useful in organizing and running the team's work. Students cited that breaking the work into manageable tasks clarified the work to be done, focused the teams on overall project goals, and increased visibility of individual tasks. Students also reported that individual expectations and accountability were made clear. Finally, some students reported that action items kept their teams on schedule.

Q3: How did weekly project review meetings with the professor help your team perform professionally?

Project review meetings were cited as effective to keep teams on track. Responses identified both short term needs, "keep us on *task*," and long term direction, "…make sure the teams are heading in the *correct direction*." Responses also indicated that team-professor discussions prompted by individual team needs aided team performance. Discussion content covered a broad range of topics such as gaining the professor's perspective on project progress, processes to improve team performance, and clarifying expectations.

Q4: Why did learning to use the PDM process help your team perform professionally?

The PDM process was frequently cited as an effective way to organize team work. These comments ranged from very glowing "I loved using this process to attack any brainstorm design. It allowed us to organize our ideas, make a plan, and run with an idea. Helped a lot with the

design cycle…" to general statements, "Helped keep teams productive." However some students reported the PDM process was not helpful, "…the process only helped to hinder ideas and kept the project limited."

Q5: Why did team contracts not help your team perform professionally?

Four fundamental reasons were cited explaining why the team contracts did not promote professional behavior. First, the contracts did not have a means to hold teammates accountable. Second, the contracts were infrequently reviewed, if at all. Third, many teams performed well and never felt a need for the contract. Finally, the contract described general behaviors that were common sense, and hence did not help the day-to-day work.

Q6: Why did a teammate preferring to work without a specified process hurt team performance?

Half of the responses described how and why teammates would avoid using processes. To avoid using processes students would simply skip process steps, do them out of order (such as building a prototype before designing it), or act autonomously. Motivations cited for such actions included that students preferred to act rather than plan, cut corners due to time pressure, enact their individual opinions, and avoid using an ill-fitting process.

The other half of the responses described team problems created when a member worked without a process. Team problems cited were increases in disorganization, confusion, decreased communication, individual efforts not contributing to the team effort, extra work when individuals work was inadequate, and that one person could prevent the entire team from working.

Interspersed through the above responses were suggestions to improve teaching processes by condensing processes, avoiding them on small tasks, and emphasize using PDM within the design/build/test cycle.

Q7: What was the most important thing in class to promote professional teamwork?

The responses showed a high degree of individuality rather than any strong trends. Three aspects of the class—using action items, using PDM, and structuring the entire curriculum as teamwork—were each mentioned by two separate respondents. All other aspects such as lecture topics, semester long teams, and a challenging project were noted by only single respondents.

Q8: How did feedback help or not help your team perform professionally?
Q9: What simple guidelines helped or didn't help your team use feedback?

In a previous study [10] the students indicated that feedback on their teamwork significantly improved their team performance. In this study however, the student responses were split with several ranking feedback in the "most helpful three" and several ranking feedback in the "least helpful three." Questions 8 and 9 were given to provide some insight into this split.

In terms of being helpful, feedback was cited as being most helpful early on while the teams were still forming. One student noted that the emphasis on feedback focused the team on being efficient. Feedback was cited as an explicit venue for gaining other's perspectives, reflecting on the team performance, suggesting—thought not always implementing—team improvements, staying on track with work, and regulating the workload.

In terms of being unhelpful, feedback was considered to take more time than the actual work and to be redundant because we "all know" what went right or wrong.

The best guidelines for implementing feedback were also split. Modeling and teaching a feedback template such as "2 strengths and 1 improvement" and "stating the content before assessing it" was cited as very helpful. Requiring individual participation in both speaking and listening was also cited as helpful. However one student responded that required feedback wasted time and another cited the template as too rigid. One student suggested that his team's group discussion of performance followed by summary notes worked better than the standard template.

6. Discussion: Integrating Emerging Themes

6.1. Student Perceptions of Acceptable Behaviors and Early Team Performance

The students indicated a sharp difference between "acceptable" behaviors for students versus professional engineers (Table 2). Acceptable student choices were characterized by high individual freedom coupled with individual consequences. In contrast, acceptable professional engineer choices appeared constrained by other factors. Consequently, if a student behaved consistent with acceptable student norms, such as skipping meetings or choosing to do poor work, his or her team would suffer greatly.

The student team contracts mirror acceptable professional engineer choices (Table 3). For example, five of the six contracts specified teammates must be punctual, rather than the student norm of choosing whether to attend class or not. Similarly, five contracts specified that the team determines acceptable quality level of work, in contrast to an individual student choosing to do poor work. If the students followed their team contracts then many team problems would be avoided.

At mid-semester the students reported that over 90% of the time they adhered to their contracts (Table 4). The other questions in the survey support this reporting. Strong team contributors were contributing a little more than peer teammates and weak contributors were contributing only a little less. Most students felt comfortable to voice their opinion more than 90% of the time on their teams.

Comparing the mid-semester composite list of teamwork factors team (Table 5) to the team contracts (Table 3) shows mixed results. For example five students cited good communication helping their team and correspondingly three of the contracts specified active communication. In

contrast, five of six contracts specified punctuality, but three students cited poor punctuality as hindering their teams.

The frequency with which teamwork factors were reported at mid-semester (Table 5) provides a preliminary estimate of their relative importance. For example, the PDM process was reported nearly twice as often as any other factor. However, to more fairly rate all reported factors relative to each other, the end of the semester ranking asked all students to rank all factors. This instrument identified three important factors to team performance: 1) A challenging team project, 2) Teamwork processes and, 3) Coaching with accountability. The following sub-sections discuss each of these individually.

6.2. Factor 1: A Challenging Team Project

The effect that the Team Project exerts on individual behavior was first noted in the mid-semester survey. The response rate was low, perhaps because the projects in the first half of the semester were short in scope. At the end of the semester however, having the challenging team project was ranked as the most important cause for professional performance (Table 6).

As far back as 1985, Hamelink, Groper, and Loson [11] recommended five characteristics for cooperative learning tasks:

> "1. Have several possible solutions.
> 2. Be intrinsically interesting.
> 3. Be challenging but doable.
> 4. Require a variety of skills.
> 5. Allow all group members to contribute."

Since the team design project is an extended cooperative learning task, their recommendations should apply. The end of semester questionnaire responses support these recommendations and further defines two of them.

That the team project had several possible solutions (1 above) can be seen by the comments referencing open-ended problem solving methods. "The situation forced our team to work…made *several ideas, sketches, and drafts,*" and "Forced teams to do much *brainstorming*…."

The project was intrinsically interesting (2) as seen in this student response, "I loved the projects we had…we were lucky to have such a 'cool' deployment phase…." However far more responses identified the project challenge (3) as motivational. "With a challenging team project…it helps keep our brains stimulated…," "Having a challenge makes it more interesting," and "If the project does not challenge us we lose motivation…."

Hamelink, et al. recommend that the project require a variety of skills (4) and allow all members to contribute (5). In our context, where a primary learning objective is teamwork skills, our data suggests more specific recommendations. First, the project should specifically necessitate teamwork skills. "This (project) forced us to really use what we were taught (teamwork

skills)..." and, "This helped the team work professionally because we all had to work together as a team." Second, the project scope should necessitate all group members to contribute, "(a challenging project) requires more out of the team and therefore…keeps everyone involved," and "…This limits the number of one-person teams that can form on easy projects."

It is important to keep the student comments in context. The surveys and questionnaire always asked, "Why is this factor important to professional behavior?" Though a challenging project has intrinsic learning value, in this specific case the challenging problem also promoted professional behavior in the students.

6.3. Factor 2: Teamwork Processes

Teamwork processes are defined as explicit structured methods that coordinate individual teammate activities to meet team goals. Student ranking identified four teamwork processes with high total frequency (Table 6): 1) PDM (and subset process "brainstorming"), 2) Action Items, 3) Constructive Feedback and, 4) Team Contracts. Two important characteristics of these teamwork processes surfaced in exit questionnaire responses and are discussed below.

The most important characteristic of a teamwork process is *to be directly applicable to completing team goals*. Though it is somewhat redundant to state that "what was applicable to the goals helped team members act professionally," the student comments provide many specific examples of *how* a process was applicable. For example, student comments describe several uses of action items. First, the action items allowed them to break the work into manageable pieces, "…helpful to break tasks into more clearly understood tasks." These tasks could then be organized, "It was a great organizational method…." Once the tasks were known and organized they remained visible, "…easy to keep sight of required tasks." Once assigned, the action items provided clear expectations to individuals, "Each team member knew exactly what to do." Clear expectations led to accountability, "Made sure everyone did their share…" and to staying on schedule, "Keeps group on track to make sure deadlines are met." Every response concerning action items highlights some utility to the team.

The PDM process was cited as useful in organizing ideas, "Helped to provide organization to our otherwise chaotic world of idea making," and teamwork, "Helped us follow a procedure and organize ourselves." The PDM process was also cited as interfering with team goals, "…the process only helped to hinder ideas and kept the project limited." Both these positive and negative comments indicate that a process needs to be useful to meet team goals.

Feedback received mixed reviews concerning usefulness. Some teams cited improving their teamwork as important, "Feedback helped our team improve upon the problems we noticed…." Other teams appeared (in class) to be solely interested in finishing work rather than improving their teamwork. This may be what lies behind comments such as, "It really didn't affect our performance very much."

In contrast to the other processes, our implementation of team contracts had little effect on the teams. "We wrote the contract and never looked at it again," and "There was no impetus to

follow the contract." We conjecture that contract items never became explicit goal for each team, were ignored, and hence were not useful.

The second important characteristic of a teamwork process is *to incur reasonable effort relative to the value derived.* Any process that is considered burdensome will most likely be neglected. One student wrote concerning PDM, "I would rather spend time designing/building rather than planning to design/build." Another student wrote, "At some times when the act of taking feedback is more time consuming than the project…it hinders the performance." Nearly all comments that cited PDM or feedback as unhelpful cited too little gain relative to the benefit.

The negative comments about PDM and feedback suggest a potential pitfall. All processes incur effort and should be applied to appropriate situations and problems. In the instructor's effort to emphasize and incorporate processes into the students' practice, some students likely gained an imbalanced view of process use.

6.4. Factor 3: Accountability with Coaching

The weekly project reviews with the professor provided heightened accountability. Since action items from the previous week were reviewed, there was little room to hide. Several student comments noted that this accountability helped their team perform professionally. "This kept us on track. Driven by 'not looking stupid,'" "…forced the team to keep up on their log books…" and "Put us on the spot…it's good to be put on the spot."

Accountability by itself however can also create negative responses, especially if wielded as punishment. In contrast, our review meetings coupled accountability with coaching. The coaching may be considered a "safety net" for the teams. A team could not get too far off target. Each week the teams discussed their immediate hurdles or longer term direction with the professor. These discussions gave the teams necessary perspectives and clarified expectations. "These (discussions) gave us insight and information that we didn't think about," "Provided criteria/processes for project and product development," and "We knew exactly what was expected of us."

Coupling accountability with coaching seems a natural pair. Discussion of project status (accountability) naturally leads to discussion of problems encountered which naturally leads to discussion of alternative solutions (coaching).

6.5. Integrating the Three Factors

The strongest effect to promoting professional behavior was not any single factor, but rather the three factors working together. Many student comments link one factor with another factor when describing what promoted professional behavior. These links demonstrate that the factors were working together in the learning environment. Figure 1 shows the three factors as an integrated professional behaviors learning environment.

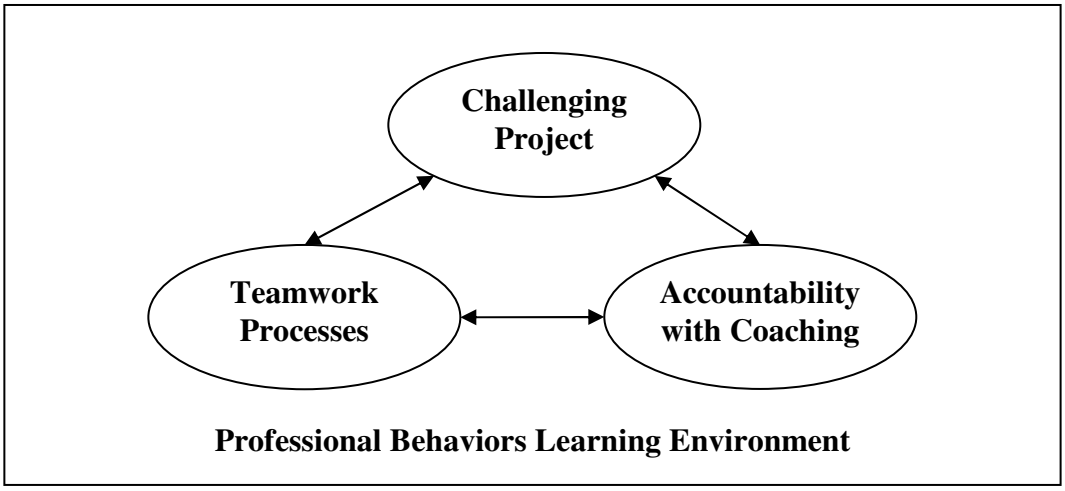

Figure 1. Curricular Factors Integrated in the Learning Environment

The challenging project set the context for practicing teamwork processes. One student wrote, "(the challenging project) provides the reason to apply the skills we learned in lectures," that is, teamwork processes. Another student noted that the most important thing to promote professional teamwork was "A challenging project with individual tasks."

The reverse was also cited—teamwork processes helped the students to perform on the project. The PDM process was noted as, "especially good for solving big problems." Another student notes how PDM was used to run his team's project, "(PDM) allowed us to organize our ideas, make a plan, and run with an idea. Helped a lot with the design cycle." Action items were also cited as helping teams organize their projects, "Most important aspect of organizing the team."

Teamwork processes also supported accountability. Action items are specifically designed to do this and one student noted, "(Action items) made sure everyone did their share and held them accountable." Our implementation of student contracts demonstrates a negative example where a process that should promote accountability did not, "There's nothing special to hold anybody to the contract."

Again the reverse was also cited—accountability with coaching enabled use of processes. One student notes coaching promoted processes, "These (reviews) helped because the Kahuna (professor) informed us of what we need and what we are doing well (team processes). They gave us insight and information that we didn't think about." Reviews also innately reinforced process use because the action item logs, a process artifact, was a primary element of the review.

In summary, the student responses indicate the three factors—challenging project, teamwork processes, and accountability with coaching—interactively created the learning environment. Since the question "what helped your team to perform professionally?" set the context for all responses, they must be interpreted in that light. Consequently, the integration of these factors likely promoted professional behavior the most.

6.6. Additional Consideration for Curricular Choices

The mid-semester instrument surfaced several individual behaviors that helped or hindered team performance (Table 7). These characteristics, both positive and negative, were spread over the teams. Though the effect of these behaviors was not pursued in this study, the list identifies several specific behaviors that curricular elements did or could address. Curricular elements could target both how to embody these positive behaviors and how to respond to these negative behaviors. We suspect that simple formula responses to very specific behaviors would be most helpful for enhancing our curriculum. For example, feedback was taught with a general template. However a specific feedback template could be taught for responding to a teammate who was working without specifying his or her process.

7. Conclusions

Student surveys and rankings identified six curricular elements as significant to professional behavior on our design project teams. Targeted questions then elicited student rationale of why these elements were significant. Trends within the responses suggest that a challenging team project, teaching and use of teamwork processes, and accountability with coaching promoted professional behavior. Furthermore, the responses clearly show these three factors functioned interdependently. We conclude:

1. The ***integration*** of a challenging team project, teamwork processes, and accountability with coaching appears to be a strong effect in promoting professional behaviors. Each of these factors builds on and contributes to the other factors to form the learning environment.

2. The challenging team project promoted professional behaviors in two ways. First it necessitated the practicing of interactive teamwork skills. Second, the project provided strong motivation by simply being a challenge and by being intrinsically interesting.

3. The effective teamwork processes had two common characteristics. First, the teamwork processes were directly applicable to meet team goals. Second, the teamwork processes required a reasonable investment for the returned value to the team. Failure to meet either of these requirements provided strong motivation for the team to abandon them.

4. Accountability with coaching appeared to be a strong combination to keep students' performance professional and to keep teams on track with the project.

Though the data and literature support these conclusions, detailed study of effective ways to construct and integrate these curricular elements would be valuable. The list of significant individual behaviors that effect teamwork, garnered from this case, may offer a lens through which to evaluate the construction and integration of these curricular elements.

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