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Supporting Capstone Teams: Lessons from Research on Motivation*

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Teaching students in teams presents challenges. A panel discussion concerning methods for supporting successful teams was held at the 2014 Capstone Design conference. This paper summarizes the main discussions from the panel and interprets those discussions using Self-Determination Theory. Self-Determination Theory addresses the internalization of extrinsic motivators, particularly through the experience of competence, autonomy, and relatedness. The panel members represented diverse areas: engineering practice, medical environments, academic, and military teams. Detailed notes from the panel discussion were distributed to and analyzed by all panel members. That analysis revealed eight research-to-practice findings: promote real world experiences, match teams and projects to empower success, teach students to work in teams, develop leadership for more effective teams, encourage regular assessment of team functioning, promote individual accountability, remediate team dysfunction, and train and monitor team mentors. Each finding is discussed, linked to the literature, and to the elements of competence, autonomy, and relatedness. Finally, a suggested approach to implementing team work in a capstone class is presented. The approach synthesizes the research-to-practice suggestions, and attempts to describe, model, and scaffold teamwork- and leadership-related professional skills. The panel participants offer the suggestions because of their belief that students benefit from focused teamwork-related support throughout the capstone experience.

Keywords: teamwork; motivation; dysfunction; coaching

1. The capstone design conference and the foundation of this research

This research is an outgrowth of a panel discussion at the 2014 Capstone Design Conference held at the Ohio State University in Columbus, Ohio, June 2–4, 2014 [1]. The first National Capstone Design Conference was held in 2007 at the University of Colorado at Boulder. The goal of the first conference was "(1) to build and strengthen the community of professors involved with capstone design courses and (2) to exchange and disseminate information about getting started, sustaining best practices, and pursuing future directions in capstone design curricula" [2]. Over 160 representatives from institutions in the US participated, mostly academic institutions. The conference attendees identified the need for a community of design educators and plans were made for additional conferences. The 2010 Capstone Design Conference was again held in Boulder, Colorado, and there were two themes of this conference: (1) capstone pedagogy and (2) international teams [3]. At the 2010 conference, the decision was made to eliminate the traditional oral presentation format and instead use poster sessions and panels "to encourage vibrant and extensive sharing of ideas and experiences" [3]. Papers accepted to the conference were presented in poster sessions. Panels were derived from themes identified in the papers. The 2012 Capstone Design Conference was held in Champaign-Urbana, Illinois, and emphasized industry involvement in capstone design [4].

The 2014 Capstone Design Conference, located in Columbus, Ohio, focused on the theme of multidisciplinary and experiential learning in capstone design [1]. In reviewing papers for themes, two paper on leadership were identified as particularly insightful: *Investigating Shared Leadership in Undergraduate Design Teams* by Brian Novoselich and David Knight [5] and *Leadership Coaching of*

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Interdisciplinary Capstone Design Teams at LSU by David Giurintano et al. [6] A third paper, *Understanding Student Attitudes about the Design Process* by Shraddha Sangelkar et al. [7] seemed to add a depth to the potential discussion. It is quite possible that student attitudes about design could shape student attitudes toward leadership and execution of the project. Finally, to create rich panel discussion having a panel leader with a deep understanding of teams seemed appropriate. Matthew Ohland's background in the development of the CATME systems [8–11] indicated knowledge of teams and their processes.

2. Research methods

This research is a post-hoc analysis of a panel discussion in which themes that emerged in the discussion are interpreted through a motivational lens using Self-Determination Theory. A variety of strategies are used to establish the quality of the panel discussion for use in interpretive research, following the typology of Walther, Sochacka, and Kellam [12].

2.1 Communicative validation

Multiple strategies ensure that the data used in this work are socially constructed within the relevant community. The collection of data through a facilitated panel discussion had some of the features of a focus group, where discussion was allowed to proceed among the panelists, each building on ideas of the other panelists, and where dialogue could create a shared narrative. All the while, the facilitator sought to explore contrasting accounts of practices in managing capstone teams where they arose. Finally, two types of member checks were performed—first, the members of panel audience had the opportunity to both question and comment so that they had a role in the social construction of knowledge regarding the management of capstone teams. A second member check was conducted by having the panelists review the notes of the panel scribe, Patsy Brackin.

2.2 Pragmatic validation

The diversity of the panelists helps ensure compatibility with the reality of capstone practice. Although all panelists have many combined years of experience in the practice of participating in or managing capstone design teams in engineering, they also represent diverse perspectives. Patsy Brackin is a member of the Organizing Committee of the conference and a Professor of Mechanical Engineering at Rose-Hulman Institute of Technology. She crafted the panel, captured the many voices engaged in robust conversation during the panel, and helped ensure that the discussion was interpreted with an eye toward deeper meaning while at the same time preserving the voices of the panelists and attendees. As a retired Captain in the U.S. Public Health Service, David Giurintano has perspective on teamwork in a medical environment. He now coordinates interdisciplinary capstone design efforts in biological, mechanical, industrial, and electrical engineering. Brian Novoselich brings perspective on military teams as an active duty Lieutenant Colonel in the U.S. Army. He is also a Ph.D. Candidate at Virginia Tech, where he studies engineering design team leadership. As an Assistant Professor of Mechanical Engineering at Pennsylvania State University—Erie, Shraddha Sangelkar brings the fresh perspective of a junior faculty member. At the same time, her research focus on design enhances the potential for research-to-practice connections. All have been involved with Capstone Design for several years. Although Matthew Ohland does not teach capstone design, he moderated the panel as a scholar who engages in research and practice in the management of academic teams. In the handling of the data, to ensure that the knowledge produced is meaningful in the capstone design context, various actionable recommendations have been derived from the data and supported with theory.

2.3 Process reliability

It is important for the panel data to be collected in a dependable way. In his role as facilitator, Matthew Ohland was able to ensure that Patsy Brackin had ample time to record the proceedings, including providing opportunities for clarification where needed. The notes scribed by Patsy Brackin were extraordinarily complete, and member checking by the panelists helped ensure that they were properly recorded.

2.4 Theoretical framework

This is translational research, which seeks to identify opportunities for research to influence practice, so this study does not seek to generate theory. Rather, this work uses a theoretical framework to guide the thematic analysis of the panel discussion. Because there was considerable discussion within the panel and audience regarding student motivation, Self-Determination Theory was chosen as a framework to interpret the panel discussion. Ryan and Deci developed Self-Determination Theory [13] and validated it through numerous studies. Among motivational theories, it fits particularly well in the context of learning. Self-Determination Theory addresses the internalization of extrinsic motivators, particularly through the experience of competence, autonomy, and relatedness. Extrinsic

motivation derives from the desire to achieve a particular outcome, whereas intrinsic motivation derives from the satisfaction of engaging in the activity. An important aspect of Self-Determination Theory is that there are degrees of internalization of extrinsic motivators ranging from reward seeking (external) to avoiding negative emotional states or seeking positive ones (introjected) to identifying an action as personally important (identified) to aligning actions with one's values and beliefs (integrated). As motivation becomes more internalized, effectiveness, persistence, and well-being improve. The drivers of internalization are competence, autonomy, and relatedness [14]. Competence is the ability to learn something and demonstrate that learning. Relatedness describes a person's connection to a larger community. Autonomy is the extent to which a person is able to make choices that influence their situation. Fig. 1 provides a graphical description of our research methods and how they establish the quality of our data and our findings.

3. Research to practice findings

3.1 Promote real world experiences . . . but with care regarding what students see as "real"

Many capstone design courses attempt to simulate real world engineering work [15, 16], which situates student learning in a professional engineering context. The greater the fidelity of this simulation, the more connected students are to the profession. It is relatedness, therefore, that drives the interest of students in "real world" projects. Salzman has noted that students are sensitive to the fidelity of the simulation—if students believe that an industrial partnership is artificial, students become less motivated [17].

Unfortunately, student views of the "real world" are shaped too much by stereotypes. Just as a company focused on the needs of a single project may achieve a better result using short-term strategies, students may sacrifice their relationship with teammates as they strive to demonstrate their individual competence. Leonardi, Jackson, and Diwan identify the work habits of "completing work alone," "ensuring one's contribution stands out," "rank self against others," and "excluding technical inferiority" as enacting the norm that "success is measured by individual (rather than team) accomplishment". Engineering students rationalize these work habits and norms by defining professional engineering work to be consistent with those practices [18].

By immersing students in a situated learning environment late in their undergraduate experience, capstone design courses present a new paradigm for engineering practice, unlike students' previous experiences. Although empirical studies of professional engineering work are extremely limited [19], the disconnect between engineering work experiences of undergraduate students and professional

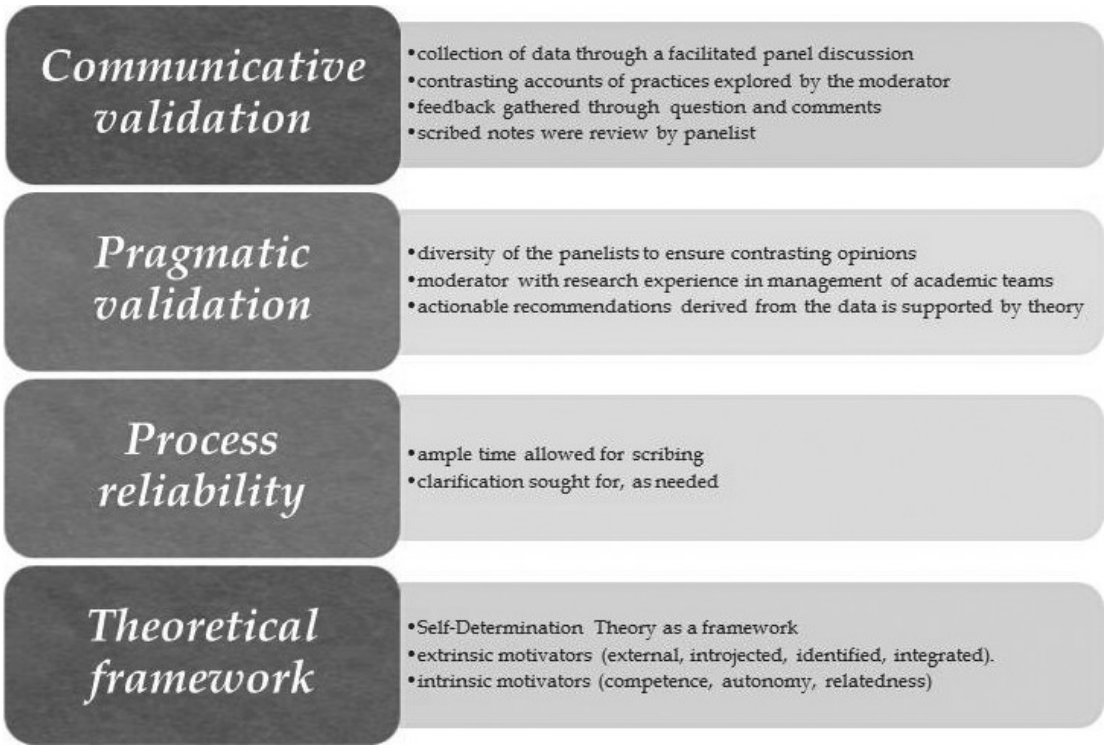

Fig. 1. Summary of research methods and how they ensure quality.

engineers is well documented [19–21]. Undergraduate engineering students are typically trained in a well-structured engineering environment where problems are discipline specific and convergent on a single solution [19, 20]. As such, students often adopt views of engineering that de-emphasize non-technical and social skills [19, 22]. Empirical research of professional engineering practice indicates that professional engineering work is much more heterogeneous and ill-structured, involving both technical and social aspects [19, 23]. Students entering a truly situated learning environment for the first time may be unprepared for this transition [24] and react with confusion or anger regarding the dichotomy [22].

To ensure success of student capstone teams, therefore, faculty need to be mindful of the transition their students are enduring and assist in the transition by paying particular attention to the students' professional skills and capabilities. This brings the focus of student motivation back to competence, but making sure that the focus is not only on technical competence, but on competence in non-technical/professional skills as well. The amount of resources industrial organizations spend on developing employees to successfully work in teams is well documented [23]. Consequently, to help foster successful teams, capstone faculty should expect the need to purposefully develop students' design teaming skills. Bolstering students' understanding of the crucial role professional skills such as communication and teamwork while simultaneously increasing the competence in these skills through role modeling and scaffolding can greatly increase their motivation as mentioned previously.

3.2 Match teams and projects to empower success

In capstone courses, the selection of a team and the selection of a project are frequently a mutual decision. Allowing students to choose or have a say in selecting their teammates and/or the project they work on provides autonomy. At the same time, it is important to match the teams with the project, because this affects competence. To the extent that teams may be formed without all the needed skills, teams must have the opportunity to develop them, which will be discussed later. Self-selected teams have been shown to result in both the best and the worst team experiences reported by students [25]. Central to ensuring the positive outcome is that the students know each other well—not just socially, but that they know each other's work habits and that they can work well together. At Penn State Erie, capstone mentors have let students select their own teams for ten years. Students are aware of the self-selection in their junior year so the alliances are formed well ahead of time. In most cases, the PSU Erie students have worked with their teammates before the senior year, which helps establish communications protocols within the team and develop awareness of the team's strength and limitations. Whether student teams are formed prior to or concurrent with project assignment, if students have complete choice over their project, capstone instructors may "give teams enough rope to hang themselves." Concerns for competence dictate that capstone teams must have some way of scoping the problem—using existing problem scoping skills or through access to a mentor who will help them with problem scoping to ensure the project can be done with the time, resources, skills, and mentorship available. One method of guiding student project selection is to have a limited number of project choices for teams to select from. The Penn State capstone mentors allow students to select their projects from a list of available industry-sponsored projects. Students also get to choose a faculty member as their project mentor. The projects on this list have already been scoped appropriately, but it is challenging to ensure that all projects are the same level of difficulty and that all mentors provide the same level of guidance. Just as it is important to prevent student teams from overreaching, it is important to guide students to select projects that are challenging. If students feel over-qualified, there is a risk that they will lose motivation and reduce effort and quality [26].

3.3 Teach students to work in teams

Ideally, students will have had an introduction to working in teams earlier in their education that will have included instruction as to how to behave in a team. This instruction should continue as students enter into capstone design teams. Faculty should set the example of how teams of professionals behave. Some key areas to consider are responsiveness to team information and communication as well as forethought toward upcoming requirements. To set the example for positive reinforcement of effective teamwork, faculty should recognize and praise positive engagements among students. In this way, students not only learn to recognize positive behavior, but gain increased motivation through increased relatedness and competence in the non-technical requirements of the design process. By engaging in reflective practice [27] early in the project, faculty can model meta-cognitive practices that can increase students' understanding. By influencing teams to learn from key successes and failures early in the project, faculty can help create a learning organization that can use previous performance to prepare for future tasks. These reflective moments also help foster effective team leadership

processes. Salas et al. [27]. assert that team leaders play an essential role due to their synchronization of task and development cycles and their ability to set conditions for task cycles.

Beginning in 2012–2013 academic year, students enrolled in Capstone Design at LSU in the Mechanical and Industrial Engineering Department and the Division of Electrical and Computer Engineering were exposed to teamwork and leadership training. Lecture topics included improving dysfunctional teams, developing leadership in teammates, and managing team roles through team contracts. Instructors also modeled appropriate team behavior to students as part of the classroom dynamics—instructors and teaching assistants present themselves to the students as a team. Students understand that any issue not resolved by the section instructor or the teaching assistant will be brought up to the larger teaching team at their weekly meeting. Once a team issue is resolved, the modification is presented to the class by the lead instructor. When presenting a lecture, all instructors always use the word ''we'' when referring to issues related to the class rather than the word ''I''.

Among the tools that students can use to improve team functioning is a team contract. Particularly as this contract is shared with the instructional team, it improves relatedness with teammates and the instructional team. Since the team contract provides guidance for a team to manage itself, it also fosters autonomy. In a team contract, the team is required to document various aspects of team and project functioning. The signed team contract then becomes a binding agreement among its members. A team contract promotes the development of a shared mental model, which improves productivity and success [28]. Team contracts are implemented at PSU Erie and the students are formally trained in developing them. The implementation of the ''consequences'' from the team contract is rare. Functional teams rarely need to implement the consequences outlined in the contract and dysfunctional teams are typically far beyond the issues that can be resolved by the contract. Nevertheless, as intended, developing the team contract itself establishes ground rules and clarifies expectations within the team, which contributes to relatedness and autonomy.

A few advanced topics have potential to improve the performance of capstone design teams. To the extent that the capstone design project has sufficient complexity that it can be divided into subsystems, *system modeling* can be of direct benefit to the project success. In all projects, system modeling would improve team dynamics and communication, because the team itself is a system and the team members are subsystems within it. Coaching teams in goal setting can have a positive impact on team performance by focusing efforts and encouraging strategy development [29]. In their meta-analytic review of groups' goal effect, O'Leary-Kelly, Martocchio, and Frink [30] found the performance of groups that create goals to be one standard deviation higher than those that do not. Interestingly, in further analysis of study results, the authors found that studies indicating a negative effect of goal setting on group performance did not involve student teams [30]. Capstone design teams commonly set goals for themselves in a number of design tools such as Gantt charts and performance target lists. Unfortunately, student capstone teams may not recognize the goal setting processes enabled by using these and other tools. Newstetter, in her ethnographic look at one mechanical engineering student design team, found that although faculty presented design tools and learning activities to students in an effort to improve their project management processes, students interpreted these activities as busy work and impediments to design task completion [31]. Knowing the potential for this to occur, faculty should routinely reinforce the utility of the design tools and the team goals documented within. As teams begin to recognize their work as goal setting rather than strictly busy work, the team may be more apt to internalize these goals and mobilize action toward goal achievement.

Providing teams with instruction on how to plan and conduct team meetings develops important competence. As Weinstein [32] suggests, carefully planned and executed team meetings can be extremely effective at disseminating information, tracking progress, and coordinating efforts, which may increase team relatedness and overall motivation. Ineffective meetings, conversely, can diminish motivation by decreasing team relatedness and sense of competence by wasting students' often most precious commodity—time. Effective meetings do not happen by chance, but rather through a well-structured agenda [32]. In addition, a physical location for the meeting that fosters collaboration and parallel participation can greatly increase overall team effectiveness [33]. To improve the ability to trust teammates, in the fall of 2014, capstone students at LSU were required to have the first team meeting as a team meal. Students were encouraged to discuss who they were, where they were from and their life interests. Anecdotally, several students reported the positive effects of the meeting on team spirit. Ongoing study will yield more data on the effectiveness of this required team activity.

3.4 Leadership improves team effectiveness, even if leadership is shared

Stagl, Salas and Burke [34] summarize current work

in team leadership research and finds, "the totality of research supports this assertion; team leadership is critical to achieving both affective and behaviorally based team outcomes" (p. 172). In the development of their integrative team effectiveness framework, Salas et al. [35]. assert that leadership plays a central role over the lifespan of the team, claiming that despite the complexities of team leadership, "most would agree that team leaders and the leadership processes that they enact are essential to promoting team performance, adaptation, and effectiveness" (pp. 220–221). Orienting students to the fundamentals of effective team leadership while also delineating the fundamental differences between leadership and management can help prepare students to recognize and confront leadership challenges before they adversely affect team performance. Orienting all students to team leadership fundamentals can also help foster leadership sharing within the teams. Hill [36] cites Morgeson et al. [37]. when she asserts that, "leadership is provided by anyone that meets the needs of the team" (p. 289). As such, ensuring that all student team members have a baseline knowledge of effective team leadership practices can increase the potential of each team member to contribute to the effective leadership of the team when necessary. At PSU Erie, a shared leadership model as opposed to a strong leader model is encouraged. This shared leadership model is consistent with the assertions of Pearce, [38] who advocates shared leadership for creative, complex, and interdependent knowledge work, which is often found in the capstone team environment. Students are introduced to the shared leadership model in the first year and it is reemphasized in the senior year. The shared leadership model reinforces individual accountability.

3.5 Encourage regular assessment of team functioning

If capstone design teams are being actively coached, the mentor is very likely to know about the struggles that each team is facing. Even so, there is much benefit in providing students with the tools to conduct regular self-assessment of team functioning, [39-41] which develops a valuable skill—increasing competence—that helps teams operate independently—empowering autonomy—and improves the operation of the team—improving relatedness. Peer evaluations should be collected multiple times and typically after a major deliverable, such as proposal presentation [42]. Cognitive distortion occurs when raters incorrectly remember teammates' behaviors, so it helps to have multiple evaluations throughout the project. Peer evaluations make students more accountable to their teammates (improving relatedness) and reduce the chances of a student taking credit without contributing [39], which is a major cause of teamwork dissatisfaction in students [43].

Peer evaluations have been found to reduce social loafing, improve student satisfaction, raise perceptions of grading fairness, and promote positive attitudes toward teamwork [43–46]. Self-ratings are often included because ratees want to have input in their evaluations and because they can inform discussions about team member performance [47]. Self and peer evaluations also help set expectations for appropriate team behavior and accountability [48]. The ability of evaluating self and peers and the ability to use the feedback from the evaluations is a critical lifelong skill [49–51].

3.6 Promote individual accountability

Peer evaluation scores commonly influence students' grades either directly or by adjusting students' team grades based on each student's contributions to the team [42]. Peer evaluations and individual student evaluations by project advisor can support the judgment of the instructor in adjusting individual grades for variations in the team efforts. The project advisor can also keep a log of individual contributions in weekly project meeting to encourage individual accountability. At LSU, peer evaluations, and feedback from the teaching assistant, advisor, instructor, and sponsor factor into an individual scaling factor of team work contribution, called "the Ax factor", which is normalized so that the team's average Ax is equal to 1. The minimum Ax is 0.5 and the maximum is 1.5. A student's grade is a combination of an individual effort—design notebook effort and individual biweekly reports—and a team effort—midterm and final presentations and interim and final design reports. The Ax factor is then used to scale team grades based on an individual contribution. CATME Peer Evaluation is a free tool that is validated in multiple contexts for measuring teammember effectiveness [8]. In addition to generating adjustment factors that can be used with other input to make adjustments to each individual's grades, the system also identifies exceptional conditions that warn of possible team dysfunction.

3.7 Remediate team dysfunction

Whether team dysfunction is identified from peer evaluations, mentoring meetings, or other sources, faculty must address it when it arises. When confronting dysfunctional teams, faculty advisors may need to coach the team's leadership (if there is a formal leadership structure) or step in as an interim leader to help identify problem areas for the team and get the team back on track. Team leadership is a critical factor in team success and ineffective leader-

ship is a primary reason for team failure [36]. To turn around a dysfunctional team, creating an accurate model of the team's problems is an important first step [36]. An inability of the team members to work together may be an integral part of dysfunctional teams, manifesting itself as destructive conflict. Qualitative research indicates that capstone faculty members experience student capstone team conflict in four categories: design decision, workload imbalance, capability deficiency, and miscommunication [52]. To address these sources of conflict, capstone faculty members often focus on addressing the issues with the whole team collectively. Other intervention strategies include addressing team members at the center of the issue or through training a specific team member to intervene [52]. To intervene effectively, faculty members often see their roles as providing guidance on project scope, providing guidance on finding technical information, and maintaining student involvement and motivation [16]. If the team is not willing or able to identify and fix its own internal issues, the faculty mentor must bear the burden of leadership to correct the team's course for future success. In the case of extremely dysfunctional teams, allocating sub-parts of the project to individuals by faculty mentor helps the team to complete the project at an acceptable level and keep track of individual performance.

When a team makes a report in a biweekly oral presentation at LSU, the section instructor will observe the language being used by the team with respect to teamwork and team spirit. If inappropriate language is used or issues related to team spirit are detected during the reporting, the section instructor will mentor the team and provide feedback on how to improve the shortcomings. Student feedback indicated that over 70% of the students found this training valuable. When issues on teams arose, direct coaching of individual teams to arbitrate conflicts and promote problem solving led to improved team dynamics.

Hill [36] provides a model of team leadership that expands the breadth of team leadership decision making. This model opens the aperture to encompass internal team task or relational problems as well as external problems. Hill's task and relational categories are conceptually similar to the findings of Paretti et al. [52]. Hill's model also provides a good overview of a leader's corrective actions for task, relational, or environmental issues. Faculty should capitalize on early team issues or short term failures to provide teachable moments that illuminate team problems. By scaffolding reflective practices, faculty can help illuminate the root cause of team issues. Knowing where to look for the root cause and being able to isolate the problem may be the coaching required by the team to re-orient for success. If the capstone course requires team contracts, re-visiting the contract and making necessary changes may be an effective way to document problem resolution strategies. If the team contract is not required then getting the team to draft a contract may be a positive outcome of purposeful reflection. Once team problems are successfully illuminated, giving the team the autonomy to choose its mitigation strategy can go a long way in motivating adoption of that strategy.

Remediating team dysfunction is a path to improved relatedness—both within the team and with the team mentor or coach. Yet there is much more to be gained in the process. Whether the resolution is managed within the team or with the help of a coach, students have the opportunity to develop valuable competence related to managing that team and future teams. The latter strategy provided above—of guiding the team by encouraging leadership and self-management—has benefits for autonomy as well. The team will learn that it can solve its own problems. For this reason, among the most motivating experiences in capstone design teams is guiding teams to solve their own problems, because such experiences engage all three motivational strategies—relatedness, competence, and autonomy.

3.8 Train and monitor team mentors/coaches/ industrial partners

Having a senior project mentor creates substantial relatedness, yet there is also a concern for competence—capstone mentors must not only have the technical competence to advise teams on the project they pursue, but they must also have the competence to be effective mentors. While training programs for mentors exist [53], the training materials are not necessarily public. It is necessary to set expectations with project mentors, so it is important to gather the whole administrative team (instructors, teaching assistants, project advisors and sponsors) before the projects begin. At this meeting, all relevant materials can be shared—samples of team contracts, meeting agendas, meeting minutes—and course goals can be discussed. Experienced mentors may already be able to recognize team dynamics issues, whereas new mentors will need coaching on what issues are likely to arise, how to respond to them, and when to involve others. Fig. 2 summarizes the capstone team conditions and how they affect the motivation —relatedness, competence, and autonomy. The dashed line indicates the required aspects and the solid lines indicate what is promoted. For example, real experience requires good teamwork that promotes relatedness.

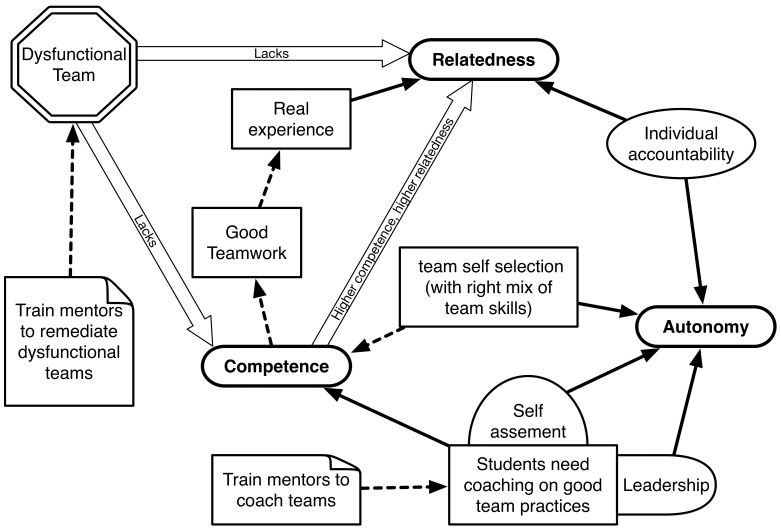

Fig. 2. Capstone design team conditions and how they affect motivation.

4. How to implement these recommendations in your capstone class

Below is a timeline for implementing the recommendations above into a capstone design course. It is likely that not all will seem appropriate in any particular context. Nevertheless, just as with the many approaches to active learning, the practice of managing a capstone class will benefit from including whichever approaches a particular instructor or instructional team is prepared to implement. Our discussion of the underlying principles of competence, relatedness, and autonomy should empower instructors and instructional teams to develop or adapt still other approaches to be effective.

(1) Prior to the start of the semester,
   a. Gather instructors, teaching assistants, project advisors, and sponsors (if possible).
   b. Model good team behavior.
   c. Provide templates of teaming tools (example team contracts, example meeting agendas, example meeting minutes) used during the semester.
   d. Model how to develop a team contract.
   e. Model how to prepare for a meeting.
   f. Model how to run a good meeting.
   g. Model how to document the results of a good meeting.
   h. Model how to deal with a disengaged team mate.
   i. Have all members of the administrative team practice b–f.

(2) At the first class of the semester,
   a. Present administrative team to the class (instructors, teaching assistants, project advisors and sponsors). Remember to model good team behavior. Always use "We" rather than "I".
   b. Define expectations for the course—team contract, team meetings, and project management.
   c. Discuss the importance of honest peer evaluation.
   d. Discuss how team grades will be scaled for individual contributions.
   e. Provide templates of teaming tools (example team contracts, example meeting agendas, example meeting minutes) used during the semester.
   f. Coach on how to develop a team contract.
   g. Coach on how to prepare for a meeting.
   h. Coach on how to run a good meeting.
   i. Coach on how to document the results of a good meeting.

(3) At the second class of the semester,
   a. Provide information about the team and project selection process.
   b. Present projects available for selection.

(4) At the third class of the semester (after team and project assignments have been made),
   c. Provide personal development and teamwork lecture.
   d. Define expectations of a good team member.
   e. Discuss the reasoning behind the social team activity (such as a team meal).

The administrative team needs to meet frequently to discuss status of the teams. The sooner a team issue is discovered and dealt with, the sooner the team can move forward toward solution of their design problem. Remember, model good teamwork, provide positive reinforcement when students model good

teamwork, and coach when poor teamwork is exhibited. Finally model good behavior—start early, keep organized, acknowledge mistakes when they occur, and work as a team to resolve them.

5. Conclusion

Through an interpretive research methodology, this research capitalized on the focused discussion of capstone design faculty to illustrate the importance of capstone design team support. Examined through the lens of Self-Determination Theory, the results of this discussion are clear. To foster team success in the capstone design experience, students require focused effort from capstone design faculty to describe, model, and scaffold teamwork and professional skills. A wide variety of practices contribute to student motivation in capstone design teams. Some of those practices are common, but can be made more effective through thoughtful consideration by how those practices contribute to internalization of motivation through autonomy, competence, and relatedness.

A successful capstone design experience starts with faculty's efforts to plan for success. Developing relationships with peers, instructors, industrial partners, and others have obvious contributions to relatedness. Student team development is a critical initial facet. Assigning teams and projects should balance the needs of the students, the teams, the learning objectives, the instructional team, and industrial partners, as appropriate. Faculty must pay particular attention to how and why teams are formed within the capstone course and weigh the benefits and challenges of students working relationships as well as the balance of skills in the team to foster student relatedness and team level competence.

Due to the situated nature of the capstone course, which may depart from the well-structured classroom environment students typically experience, a focused initial effort by faculty on teamwork and professional skills can set the tone for long-term team success. Initial efforts by faculty to model effective teamwork and leadership related professional skills can provide examples for students to emulate. This modeling should be reinforced by purposeful instruction in teamwork, leadership, goal setting, and team meetings. Approaches to scaffold effective team interaction improve relatedness and, to the extent that students develop the ability to function in a team and to the extent that they learn more in a positive team environment, those approaches improve competence as well. Building upon a foundation of professional skills, faculty must facilitate relatedness within the teams through member communication. Team contracts can codify team level interpretations of professional skill instruction and foster team spirit. These contracts provide a means by which student teams structure their relatedness for the duration of the project. To relate concepts associated with the design projects, faculty should also consider various modeling techniques to ensure adequate development of shared mental models. These modeling techniques can situate the individual team member's effort within the collective efforts, providing an additional mechanism for relatedness.

To foster long term engagement by students and resulting team autonomy, faculty should provide mechanisms for individual student accountability. Peer evaluations can provide this mechanism through either course specific peer review incentives such as the "Ax factor" or developed peer review software such as CATME. These feedback mechanisms must be bolstered by well devised schemes to identify and mitigate team dysfunction either through internal team processes or external faculty intervention. Coupling these interventions with reflective student practices can exploit teachable moments toward increased student learning and greater team autonomy.

This focused capstone faculty discussion illustrates the widespread belief that students benefit from focused teamwork related support throughout the capstone experience. Although individual course and program level interventions vary greatly, the overall faculty goal of fostering student motivation is evident. An examination of these practices shows how each can contribute to increased student internalization through increased relatedness, autonomy, or competence. This increased internalization ultimately results in a more positive learning environment for all students involved.

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