Incorporating Leadership into the Engineering Technology Classroom Through Cooperative Learning: Theories Used and Lessons Learned

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Abstract – Leadership can be defined by many people, with no consensus on the dynamics of the ever-important trait. Likewise, the integration of leadership skills into the classroom has become a mainstream goal of many educational professionals. Research suggests ways in which teachers can facilitate the leadership process in their classes, along with sound pedagogical ideas behind helping students realize their leadership potential. The ineffectiveness of “chalk and talk” activities has been widely discussed with substantial research supporting new methods of facilitating student learning.

This paper will address basic leadership theories and methods for facilitating learning activities in the engineering technology classroom to provide opportunities for students to develop leadership skills through cooperative learning. Cooperative learning provides critical skills such as positive interdependency, individual accountability, face-to-face promotive interaction, interpersonal skills, and group processing.

Cooperative team structures have been incorporated in several engineering technology classes at Western Carolina University. Among these are rapid prototyping and parametric modeling and design. In this paper, these experiences will be described, analyzed, evaluated, and the results will be presented.

Keywords: Engineering Technology, leadership, cooperative learning, innovative classroom practices

INTRODUCTION

Leadership has been defined by many people, with no consensus on the dynamics of the ever-important trait; a plethora of leadership theories may be found in journals, press, and on-line resources. Understanding the equally obscure topics of teacher leadership and the teaching of leadership skills in the classroom have become mainstream goals of educational professionals. Research suggests ways in which teachers can facilitate the leadership process in their courses as well as sound pedagogical ideas behind helping students realize their leadership potential. This paper addresses leadership theories and their use in facilitating learning activities in the science and technology classroom to illustrate how teachers can provide opportunities for students to develop leadership skills through cooperative learning activities.

LEADERSHIP THEORY IN BRIEF

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The word “leadership” has only been used in the English language for about two hundred years, although the word “leader” has been in common use for about 700 years [1]. Hersey and Blanchard [2] defined leadership as the “process of influencing the activities of an individual or a grouping efforts to goal; achievement in a given situation” (p. 83). Barker [3] simply defines a leader as someone who people choose to follow to a place where they would not go by themselves. Perhaps the most common and simple explanation of leadership is the ability to motivate people to do something that they would not otherwise do on their own accord.

In an attempt to narrow the concept of leadership, several authors have devised explanations that range from simple to complex. In practicality, the simple explanation may be the most effective at informing and instructing those who desire to learn more about leadership and the traits of those who are deemed leaders. Leaders genuinely care about the needs and desires of the people they are leading; they serve with humbleness [4]. Effective leaders are mentally well balanced; they take things in stride, and act even-keeled even in the face of conflict and chaos [5]. Leaders have a clear and sound vision of the organization’s long and short-term goals and are actively involved in the group decision-making process as well as the implementation of goal related ideas [6]. Schlechty and Cole [7] add to the vision trait by stating, “Leaders must market a compelling vision to keep intended realities and desired futures before people. Leaders need a clear grasp of the nature of the change to be implemented.” Leaders possess a keen ability to listen to others, a keen awareness of their surroundings and environment, and a holistic view of stewardship [8], [9]. Leaders handle authority well, empower others, and support risk taking [10]. Additionally, leaders acknowledge when people are doing the right thing and rewards them for it [11].

These simple statements describe traits that we may all possess. Therefore, is it likely that a person having the combination of those traits classifies him/her as an effective leader? Other authors have suggested that leadership could be described using the metaphors of art and processes. Max Dupree [12] described leadership as an art form. Dupree argued that effective leadership stemmed from a person’s well being in terms of overcoming challenges, enabling lives, joyful engagement, and creative sacrifice. Dupree states, “think about the leader-as-steward in terms of relationships: of assets and legacy, or momentum and effectiveness, of civility and values” (p. 12). Morgan [13] argued that leaders must become skilled at the art of “reading” the organizations in which they manage. Morgan suggested the key skill needed is intuition learned through experience and natural ability.

In terms of processes, Rudolph Giuliani [14], who became a regional leader after the 911 bombings, suggested that leadership requires a narrow view encompassing three mindsets; everyone should be accountable for every action all of the time; everyone should anticipate future events all the time; and leaders should be consistent – being there for the people they serve in good and bad times. Sergiovanni [15] similarly states, “value-added leadership that enhances meaning about tasks rather than manipulating people, enabling staff to do their work rather than giving them directions, leading them with passion instead of calculation, and developing collegial relationships than congeniality.” Additionally, Tomlinson [16] suggested leadership be looked at in terms of processes. Tomlinson believed one should create a positive and enjoyable atmosphere while maintaining a proactive and positive demeanor working through the personal reflection processes of self-understanding and self-management. Deakin [17] and Becall [18] share Tomlinson’s ideas on the process method of leadership. Deakin uses the process method of self-discipline and applies it to the educational leadership arena. Likewise, Becall charges us to create an enjoyable educational environment in which people can flourish through personal creativity.

Metaphorically speaking in terms of systems and the number “five”, leadership has been described through the five disciplines, level-five leadership, and the fifth discipline. O’Neil [19] and Smith [20] make use of Peter Senge’s five disciplines in encouraging organizational leaders to employ the concepts of systems thinking, personal mastery, mental models, shared vision, and team learning to create “learning organizations.” Systems thinking sees the work environment and the world as a whole, where everything is connected and everything has relevance [21]. In terms of network systems, organizations do not have a single mechanism or information source in which people or operations may be controlled, with this, anyone can assume the role of leader [22]. Jim Collins [23], and a team of researchers who examined leadership traits in successful Fortune 500 company leaders, discovered five individual levels of leadership. With level five representing the most potent leadership level, the following is a summary of the researcher’s findings:

- Level 5 leaders encompass all levels of leadership.
Level 4 leaders possess and are committed to meeting a clear vision.

Level 3 leaders organize subordinates and resources to meet goals effectively and efficiently.

Level 2 leaders work well with their managed groups and contribute their skills and knowledge effectively to group efforts.

Level 1 leaders contribute their talent, knowledge, skills, and good work habits.

Additionally, Collins discovered level five leaders believed the “right people” are always an organization’s most important asset; only after the right people are in the right positions should a company decide on its direction and each embraced the Stockdale Paradox; never surrender, but be a realist and face the hard facts.

While leadership traits and manifestations of leadership have been studied and documented extensively, the fostering of leadership in people who otherwise have unrealized potential is similarly interesting topic. Are leaders born? Can leadership be taught to students? Redwood, Goldwater, and Street [24] espoused, “Some leaders are born, but most need help” (p. 64).

INTEGRATING LEADERSHIP INTO THE CLASSROOM THROUGH COOPERATIVE LEARNING

Leadership in the classroom can take many forms from situational leadership moments (where students lead the learning process) to group leadership (where sharing with a larger group takes place). In these classroom situations, Heller [25] suggested that educators should be compassionate, develop personal relationships, and offer rewards for work well done. Thielen [26] revealed that eighty-nine percent of U.S. professors lecture as a mode of instruction. However, Chickering and Gammons’ [27] research showed that listening only accounts for a small percentage of learning.

The ineffectiveness of “chalk and talk” has been widely argued with substantial research supporting new methods of facilitating student learning [28], [29], [30]. The National Academy of Engineering [31] argued that, “engineering faculty should engage students more effectively with learning strategies developed through research” and “incorporating interdisciplinary learning and teams” (p.1). Some professors have elected to move away from lecture-based classes all together [32]. Because active participation and discovery-based learning help students develop the “habits of mind that drive science,” many researchers have argued for a new model [33]. One possible effective learning model is cooperative learning.

Cooperative learning is defined in many ways; however, most agree on the central concept of groups of students working to achieve a common goal. A more complete explanation can be found at The Cooperative Learning Center [34], which states the following definition:

“Cooperative learning is a relationship in a group of students that requires positive independence (a sense of sink or swim together), individual accountability (each of us has to contribute and learn), interpersonal skills (communication, trust, leadership, decision making, and conflict resolution, face to face promotive interaction), and processing (reflecting on how well the team is functioning and how to function even better) (p.1).

Small group cooperative learning environments provide students the opportunity to work in groups, as well as to create a stage for situational leadership to arise. Group activities need to center around a shared problem and common goal with one reward distributed to the entire group [35], [36]. Additionally, creating individual accountability is important for group dynamics and higher levels of achievement [37]. Professors should assign different roles to each member in the group, forcing a situation of interdependence [38]. Encouraging students to
teach each other what they know and have learned reinforces previously learned concepts and promotes face-to-face interaction [39].

Deutsch [40] and Johnson [41] argued that a primary motivating factor in traditional lectures and individual student work settings was competition among classmates. Their research showed cooperative learning removes the competition construct so that students focus on goal achievement independent of others. Specifically, Johnson’s research showed that small group cooperative learning v. traditional learning resulted in (a) higher achievement and greater productivity, (b) more teamwork and committed relationships, and (c) greater psychological health. The Education Consumer Guide’s research showed similar findings; group investigations contribute to higher-order thinking skills involving analysis and evaluation along with teamwork and leadership [42].

When crisis arises, leadership comes forth. To establish a “crisis”, Bain [43] suggested that teachers create a “natural critical learning environment…” so that students are challenged to work collaboratively. These critical environments provide the stage for situational leadership to arise, each group member contributing their “expertise” to solve a common problem. The North Carolina Regional Educational Laboratory [44] supports “engaged learning environments” where students become leaders in small group efforts to overcome a challenge. Additionally, they argue that diverse group makeup provides a wealth of background knowledge and perspectives to different problems, which fosters group effort to develop strategies in which the strengths and leadership of all its members produce a more desirable outcome.

Literature provides insight into effective teaching and leadership in the classroom. Authors have asked us to consider efforts in encouraging cooperation among students, encouraging active learning, and respecting diverse talents [45]. Others have shown the importance of leaders being able to analyze groups in terms on individual strengths then guiding and directing those strengths to achieve a common goal [46]. Cooperative learning environments have been shown effective at teaching engineering and science curriculum to undergraduate students with great success [47]. Additionally, students have high praise for engaged learning environments where “real world” challenges have been met through collaborative group efforts [48]. Cooperative education and other forms of engaged learning is transforming higher education engineering and science instruction.

**Examples of Cooperative Leadership in the Classroom at WCU**

As Ferguson, Sanger, McDaniel, Ball and Stone [48] found, cooperative learning has been successfully integrated into the engineering technology classroom. At Western Carolina University, leadership development through cooperative learning has been demonstrated in several classes effectively.

**Rapid Tooling and Prototyping**

In the laboratory sections for an upper-level Rapid Tooling and Prototyping class, each class section was formed into a team. Team sizes varied from 9 to 14. Each team was given the same assignment of completing a working prototype of a Roots Engine and designing a process to produce the engine. In this semester long project, the complexity of the project allowed for individual students to have component responsibility within the context of a team effort, thereby allowing leadership qualities to emerge. In addition, teams were informed that they were competing against the other teams for a final grade that would be composed of the team grade, the individual grade and the self-assessment rating. The self-assessment criteria was based on a score of one to ten and not rated relative to each other. The performance of the three teams varied widely with one team being outstanding and one team performing poorly. Two of the three teams consisted of some students with cooperative or industrial experience. Team leaders for these two groups were able to apply prior experiences and keep the project moving toward the overall goal. The third group, however, functioned as a non-cohesive group and only focused on individual responsibilities. Not surprisingly, the two teams with leaders having prior industrial experiences outperformed the third.

The competitive teams approach provided students a realistic experience involving leadership, group dynamics, time management, and goal completion. Based on feedback from students and observations by instructors, the authors
recommend conducting a compressed team empowerment component early in the semester. Students should be given specific goals and objectives and required to clearly define their mission and responsibilities. Task assignments should be made early, and project review periods scheduled regularly throughout the semester. Overall, the competitive approach was successful in projects where components and sub-assemblies are combined into a final working prototype. This approach will continue to be refined in WCU’s prototyping classes.

**Parametric Modeling and Design**

In a second example, team concepts were introduced in a lower-level university class. Students in the Parametric Modeling in Engineering Design class are primarily freshmen and sophomores majoring in Engineering Technology and have not been exposed to team concepts heretofore. Students were introduced to informal group processes first, by being required to complete a team project in the first two weeks of class. The first assignment required an ad hoc group of three to be assembled randomly. The project criteria were then distributed and the team itself designated the role of each member, thus allowing a natural leader to emerge. Then, the project was completed and students were allowed to evaluate the effectiveness of the team as a whole, and team members’ contributions. The facilitator also graded the team on the problem’s solution by using a rubric, as well as grading each member’s individual contributions.

As the semester progressed, more formalized types of group processes were introduced in the class. By semester’s end, the students were expected to complete a complex design project where parts were designed and integrated in a team effort. This final project, which Johnson *et al.* [36] describes as “formal” cooperative learning, required the team to complete an assembly from several individual component parts. The teams were selected by the instructor to ensure diversity of talent, culture, performance level, and most importantly, leadership. Each team of four was assigned a number of small component parts of an assembly, varying in difficulty. The team structure allowed for group roles to be self-assigned, therefore each group leader had the opportunity to distribute assignments according to ability. Upon completion of the project, each component part was integrated into the final assembly. If the parts were correctly modeled, and tolerances were correct, the final assembly would be a perfect fit. Obviously, if there were problems with individual parts, it would become evident. Assessment of the project was completed by team members and the instructor, similar to the first assignment. Based upon feedback received, and observations by the instructor, the project was a success. However, it is suggested that pre-instructional planning time and post-project group processing time be integrated into the class. Future iterations of the project might include total random assignment of group members.

**SUMMARY AND CONCLUSIONS**

Students’ responses and performance has been positive, and integrated projects have provided a vehicle for implementing leadership skills in the classroom. This practical approach has resulted in improved collaboration among students, as well as professors. Further, the team project approaches taken at Western Carolina University has provided more continuity within the Engineering Technology curriculum toward promoting leadership. As students take upper level major courses, expectations of leadership will increase. It is hoped that Collins’ five levels of leadership [23] will be realized by most students by the time they graduate. Ongoing program assessment will continue to provide feedback on the effectiveness of the methods implemented with the goal of continued class improvement.

**REFERENCES**


Rutherford, W.L., S. M. Hord, L. Huling, & G. E. Hall, *Change Facilitators: In Search of Understanding Their Role*, Research and Development Center for Teacher Education Austin, TX: The University of Texas, 1983.


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[34] The Cooperative Learning Center, *What is cooperative learning?*, The University of Minnesota, retrieved form www.co-operation.org November 9, 2005.


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