ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/332186339

Assessment of Effectiveness of Teamwork Skills Learning in Collaborative Learning

Article · December 2018

CITATIONS
8

READS
4,856

1 author:

Andrzej J. Gapinski
Pennsylvania State University
51 PUBLICATIONS **52** CITATIONS

SEE PROFILE

All content following this page was uploaded by Andrzej J. Gapinski on 05 May 2019.

The user has requested enhancement of the downloaded file.

JOURNAL OF MANAGEMENT AND ENGINEERING INTEGRATION

Editor-in-Chief
Sandra Furterer, Ph.D., MBA
Associate Professor
University of Dayton
sfurterer1@udayton.edu

Associate Editor
Daniel Zalewski, Ph.D.
Assistant Professor
University of Dayton
dzalewski1@udayton.edu

AIEMS President

Nael Aly, Ph.D.
California State University, Stanislaus
naly@csustan.edu

Scope: The Journal of Management and Engineering Integration (JMEI) is a double-blind refereed journal dedicated to exploring the nexus of management and engineering issues of the day. JMEI publishes two issues per year, one in the Summer and another in Winter. The Journal's scope is to provide a forum where engineering and management professionals can share and exchange their ideas for the collaboration and integration of Management and Engineering research and publications. The journal will aim on targeting publications and research that emphasizes the integrative nature of business, management, computers and engineering within a global context.

TABLE OF CONTENTS

Assessment of Effectiveness of Teamwork Skills Learning in Collaborative Learning

Andrzej J. Gapinski[1]
[1]*The Pennsylvania State University*
ajg2@psu.edu

Abstract

The article gives the historical background and current status of the collaborative learning in higher learning institutions. By exploring the collaborative and cooperative modes of learning the article points out the similarities and differences between them. A theme of learning styles and its significance is revisited. A collaborative learning in engineering education is analyzed and followed by a description of methodologies employed by engineering and engineering technology programs. As teamwork skills play a vital and often determining factor in any successful collaborative activity the article provides an example of an assessment method employed to check the effectiveness of learning the teamwork attributes in the engineering and science sophomore course. The article assesses the learning effectiveness of teamwork attributes using hypotheses testing based on student self-evaluation.

1. Introduction: Historical Background of Collaborative Learning

Collaboration and cooperative activities are as old as humanity itself. Actions taken among collaborating persons allowed groups to survive. This led to the rise of civilizations and the architectural and civil engineering marvels of antiquity and present day. So it is not surprising that the collaborative type of activity found its way into education. As Johnson and Johnson (2017) wrote, already in the seventeen century Johann Amos Comenius "believed that students would benefit both by teaching and being taught by other students." In the last fifty years or so there was an increasing conviction among researchers supported by empirical evidence that collaborative activities in learning and teaching processes offer improvements in attaining planned learning outcomes over traditional passive and competitive learning environments. Johnson and Johnson (2017) refer to over 375 studies conducted in the past 90 years which show that "working together to achieve a common goal produces higher achievement and greater productivity than does working alone." Thus active, collaborative learning environments offer, as these empirical studies suggest, an improvement in learning outcomes as compared to more traditional passive and competitive or individualistic learning settings. The educational changes initiated by academia in the last few decades went further and included crossing disciplinary barriers (Bordogna and Ernst, 1993; Miller and Olds, 1992; among others) and a refocus on soft or "socio-engineering" skills (Augustine, 1994; among others).

Naturally, there were other factors at play outside of academia that prompted universities to look at improving the effectiveness and efficiencies of teaching and learning processes. Budgetary constraints mainly due to diminishing state support for higher learning institutions as reported already in the 1990s (Meade, 1991; Major, 1994) has only deepened in the recent decade. On average, U.S. states have not returned to pre-crisis of 2008 expenditures for higher education (Center on Budget and Policy Priorities, www.cbpp.org). Mitchell et al. (2017) reported that "states cut funding deeply after the recession hit. The average state spent $1,448, or 16 percent, less per student in 2017 than in 2008." While only a few states such as Indiana, Montana, Nebraska, North Dakota, and Wyoming,

according to the report, increased expenditures compared to 2008, "per-student funding in eight states — Alabama, Arizona, Illinois, Louisiana, New Mexico, Oklahoma, Pennsylvania, and South Carolina — fell by more than 30 percent over this period." (Mitchell et al., 2017)

Higher learning institutions are turning to new ways of delivering courses that would improve overall efficiencies and retention. The issue of retention is an important one considering the fact that while up to 1995, around 20 percent of the USA population held at least a 4-year academic degree; in 2010, that number reached 30 percent. According to the USA National Center for Educational Statistics the percentage of 18- to 24-year-olds enrolled in college and university was 35.5 percent in 2000 and 40.5 percent in 2015. Thus, a larger and larger portion of eligible members of society, traditional high-school graduates, but also an increasing number of non-traditional working adults enrolled at colleges with many who lack necessary skills for success. Weismann (2014) reported graduation rates of 59 percent for traditional students and 40 percent for older students as of 2008. The reported high attrition rates (Smith and MacGregor, 1992; Weismann, 2014) made colleges realize that more students need assistance to improve their study skills and academic aptitudes, which are critically important to overall academic success. Emotional isolation and passivity, which were observed in student cohorts are other factors that traditional education was poorly equipped to deal with. In addition to these issues, the nation will face a shortage of skilled workers. The Bill and Melinda Gates Foundation (2018) writes "unless we dramatically improve student success in higher education, our nation will suffer from a shortage of skilled workers needed to ensure global competitiveness and national security. We are currently on track to produce at least 11 million fewer career-relevant certificates and degrees than our economy will require by 2025."

Thus, academia realized that new ways of teaching and learning were needed to address these pressing issues (Levine and Weingart, 1973; among others). Collaborative learning offered a hope to tackle the listed above shortcomings and to improve learning outcomes.

In the next section a brief history of collaborative learning with current trends and the differences between collaborative and cooperative learning are provided, followed by a review of collaborative learning in engineering with an assessment of the learning process of teamwork attributes.

2. Collaborative Learning: Status and Trends

In this section the collaborative learning's origin, status and trends, and the differences between collaborative and cooperative learning are provided and analyzed.

2.1 Collaborative Learning

Collaborative learning is a term which covers a variety of educational approaches where students work together to achieve educational objectives under an instructor's guidance or supervision. According to Bruffee (1984), the term "collaborative learning" was coined by British teachers in the 1950s involved in a ten-year research study of medical students performed at University College, University of London suggesting that diagnosis as "the key element of any successful medical practice is better learned in small groups of students arriving at diagnoses collaboratively than it is learned by students working individually." Furthermore, Bruffee (1984) points out that the origin of implementing collaborative learning at the college level "lies neither in radical politics nor research." The roots lie, Bruffee (1984) writes, in "the nearly desperate response of harried colleges" to address "[the] pressing educational need" in which increasingly students had "difficulty of doing well in college studies" and "adapting to the traditional conventions of [the] college classroom."

Smith and MacGregor (1992) wrote "collaborative learning represents a significant shift away from the typical teacher-centered or lecture-centered milieu in college." It encompasses a variety of pedagogical methods which submerge students directly in their education process through

engagements in active learning through working with others to achieve common goals. In traditional learning the focus is on individual performance – low level of interdependence, teamwork skills are essentially ignored, learning engagement with others is limited, and the reward system is tailored toward individual success (MacGregor, 1992; Smith, 1986; Jonson and Johnson, 2013). In collaborative learning, on other hand, a positive interdependence is needed, communication, social and team-work skills are expected, and both individual and group accountability play important roles in educational tasks (MacGregor, 1992; Smith, 1986; Smith, Johnson and Johnson, 1992; Johnson and Johnson, 2013, 2017; McCown, 1994). Authors (MacGregor, 1992; McCown, 1994; Smith, 1986) point out the differences between traditional and collaborative or cooperative learning groups with respect to level of interdependence, accountability, responsibility for individual and group learning progress, level of application of teamwork skills, and group processing in attaining learning objectives. Usually, cooperative learning provides a more structured setting with precisely defined roles, expectations, and time schedule with deadlines in comparison to collaborative learning.

Although the concept of a *group* is used interchangeably with a *team* in the literature dedicated to collaborative learning, here it is assumed that a team is a more formally formed structured group often with an imposed, non-volunteer based membership with a specific objective and time frame for achieving it.

2.2 Collaborative vs. Cooperative Learning

Although the concept of collaborative learning has been and still is used equivalently and synonymously with cooperative learning, the two concepts do differ. In both approaches the educational goal is to facilitate learning by "changing students from passive recipients of information given by an expert teacher to active participants in the construction of knowledge" (Goodsell et al., 1992). The two approaches differ "according to the amount of structure provided for students and the degree of constructed knowledge presented" (Goodsell et al., 1992). Both methods encompass a variety of learning and teaching methods and strategies. Collaborative learning, as Smith and MacGregor wrote in Goodsell et al. (1992) is "an umbrella term for a variety of educational approaches involving intellectual effort by students, or students and teachers together." In this approach "students are working in groups of two or more, mutually searching for understanding, solutions, or meaning, or creating a product" (Goodsell et al. 1992). In cooperative learning, by comparison, the learning is much more structured. As Smith and MacGregor wrote in Goodsell et al. (1992) "cooperative learning structures group learning around precisely defined tasks or problems." Johnson, Johnson and Smith (2014) point to the social interdependence theory for laying the foundation of cooperative learning. They credited work by Koffka, Lewin, and Deutsch (1949) of the early 1900s to the study of interdependence among group members affecting cooperation and competition, and their mutual impacts for providing theoretical foundations and rationale for cooperative learning. According to Johnson and Johnson (2005) cooperative learning is a pedagogical method where "students work together to maximize their own and each other's learning." Smith and MacGregor (1992) and Johnson and Johnson (2017) stipulated that cooperative learning have five essential elements:

- positive interdependence,
- promotive interaction,
- individual accountability and personal responsibility,
- social skills, and
- group processing.

Positive interdependence, according to Johnson and Johnson (2017) is based on a belief that a successful outcome is a group effort, where "one cannot succeed unless the other members of the

group succeed (and vice versa)." This learning strategy has to be planned well ahead and facilitated by an instructor where the teaching and the learning process is designed with a "positive role independence" structured in. The strategy requires facilitating a situation where students see the advantage of working together, which is not always a straightforward task. In this scenario a specific role, let it be a leader, facilitator, record keeper, or secretary, etc., may be assigned to each group member to attain a "mutually shared group goal." In *promotive interaction* students "promote each other's success" by "assisting, encouragement, and support" in face-to-face activities. *Individual accountability and personal responsibility* is critically important in group based goal oriented settings and require assessment of individual performance with feedback given to group members for improvement. Johnson and Johnson (2017) gave a useful strategy of meeting this requirement "by giving an individual test to each student and randomly selecting one student's work to represent the efforts of the entire group." *Social skills* are important in group interaction as well as communication, leadership, trust-building, and conflict-resolution abilities.

The mentioned elements are essential features of teamwork skills in any group work setting. The topic of teaching teamwork principles in one of the courses in an electrical engineering technology program is the subject of a subsequent section. In group learning, the group needs to reflect on their own activities and draw conclusions on what was successful and what was not. The analysis of group performance may include reflections on the most helpful contributions by individuals, possible ways to improve outcomes by individual contribution within group, etc. Cooperative learning may include, according to Smith, Johnson and Johnson (1992): "informal learning groups" that focus on short time assignments in less structured settings , "formal cooperative learning groups" that are longer in time duration in more formal settings, and "cooperative base groups" designed for long-term "peer support and accountability." Other approaches may include "circles of learning" (Johnson, Johnson, Holubec and Roy, 1984), jigsaw method, student teams formed by Slavin's technique as in "Student Team Achievement Divisions" (STAD) (Slavin, 1990), techniques of "Structural Approach" by Arends (1997), among others. In engineering settings the preferred choice has been a formal cooperative group for projects, laboratory work, and capstone assignments.

Many authors discussed and listed the advantages of collaborative learning including: changing students from passive receivers of information to active participants, improvement in critical thinking, problem-solving skills, communication, social and teamwork skills, and making students more responsible for their own progress in the educational process (Barkley et al., 2014; Bruffee, 1984, 1993; Felder, 2010; Felder and Silverman, 1987; Goodsell et al., 1992; Granger and Lippert, 1999; Griesbaum and GÖrtz, 2010; Johnson and Johnson, 2013, 2017; Johnson, Johnson, Holubec, 2013; Johnson and Johnson, Smith, 1998, 2014; Kagan, 1994; Mason, 1972; Meyers and Jones, 1993; Nerona, 2017; Rennels, 1993; Slavin 1990; Smith, 1986, 1989; Smith, Johnson and Johnson, 1992; Smith and MacGregor, 1992; among others). Ruiz-Gallardo et al. (2012) reported based on their empirical study a positive impact of cooperative student-centered teaching on improving "teamwork, self-understanding, communication, decision making, and leadership skills" in self-perception assessment although without presence of a control group. Barkley et al. (2014) in their review of collaborative learning literature reported an increased "student persistence" and "motivation" level. Recently, Nerona (2017) reported an empirical study performed in various engineering courses, which showed that collaborative learning "attained significantly better learning outcomes than the lecture groups in areas of collaborative learning, problem-solving, feedback, and interaction with peers, group skills, and communication skills." Miller and Peterson (2002) in their review of cooperative learning listed an improved retention, a positive behavioral climate, and ability to serve better students with disabilities. Barkley et al. (2014) in their book reported a correlation between participation in collaborative learning and improvement in higher-order thinking and learning skills beyond cognitive skills. Similarly,

Pascarella and Terenzini (1991) deduced that advantages of collaborative learning go well beyond just cognitive and intellectual skill sets and reach "attitudinal, psycho-social, and moral dimensions."

Heffernan (2015) in her analysis of business management settings mainly outside academia pointed out the advantages of collaborative activity which offers an increased productivity, creativity, and overall more successful outcomes for organizations. She contrasts traditional competitive business settings leading to "aggression, dysfunction, and waste" within organizations with "creative collaboration" supported by "social capital" based on trust and social connectedness. Heffernan (2015) cautioned, however, about "echo chambers" and importance of having "constructive conflict" within group settings.

Regarding collaborative activities in academic settings researchers noted some concerns or negative experiences caused by a lack of sufficient preparedness and maturity on the part of students, resistance, and uneasiness of changing learning and teaching ways (Göl and Nafalski, 2007). MacGregor (1992) pointed out student's hesitation to get involved with collaborative and cooperative activities due to apprehension, misconception or preconceived notion that cooperation does involve a certain level of obedience or may involve cheating. Barkley et al. (2014) listed concerns such as inequitable participation, student resistance, poor attendance, and other behaviors which adversely affected group work.

Barkley et al. (2014) wrote that the research suggests that nontraditional students prefer and value collaborative and cooperative learning more than traditional students. In the light of the fact mentioned above, that the current college student population is increasingly comprised of older, non-traditional students, it seems that higher learning institutions should support collaborative learning in their academic offerings and provide backing for faculty who engage in those types of activities.

With their handbook, Barkley et al. (2014), provide a very useful resource for teachers on collaborative work and how to implement it in a university setting.

Collaborative or cooperative learning environments differ from competitive and individualistic learning settings with different value systems, pedagogical methods, and the level of students' involvement and participation in the process (Johnson and Johnson, 2013, 2017; Johnson, Johnson, and Smith, 1998; MacGregor, 1992). Overall, cooperative learning has to be well designed and structured by an instructor. The educational objectives must be formulated clearly with specific roles assigned within groups, sometimes on a rotating basis depending on the duration of assignments. Barkley et al. (2014) discussed various collaborative learning techniques (CoLTs) organized into the following categories of general learning activities: "discussion, reciprocal teaching, problem solving, information organizing, writing, and using games." Whatever collaborative activity is chosen a careful planning must be paid to all five stages of the learning process (Barkley et al., 2014):

- Before (preparation – group assignments, time schedule for tasks)
- Beginning (explanation of objectives, setting the expectations)
- During (facilitating, monitoring)
- Ending (presenting the findings)
- After (analysis of results, reflection, strengths and weaknesses, possible improvements).

Barkley et al. (2014) in their book clarify what activities do, and more importantly, what activities do not constitute a collaborative and cooperative learning, which could be helpful for any instructor who attempts to set-up a proper pedagogical environment with any type of collaborative learning.

Kirschner et al. (2004) in their review of literature, drawing examples from science and medical education in "the context of expert-novice differences, cognitive load and cognitive architecture," compared the effectiveness of unguided and guided learning and pointed out that the "evidence from empirical studies over the past half century consistently indicates that minimally-guided approaches are less efficient than learning approaches that place a strong effort on guidance of the student

learning process." Thus, a mistake would be to turn group members "loose" and let them function in an unguided setting. Collaborative learning requires preparation and selection of the right pedagogical methodologies with carefully designed student engagement in a guided learning. Consequently, the preparation and implementation of a collaborative or cooperative learning process cause a series of challenges to educators for various reasons. Gillies et al. (2008) pointed out "that many teachers often do not have a clear understanding about how to establish effective cooperative groups, [of] the research and theoretical perspectives that have informed this approach, and how they can translate this information into practical classroom applications."

Gillies et al. (2008) also noted that lack of time for learning about peer-mediated approaches and introducing them in a classroom vis-à-vis increased responsibilities, needed a strong "commitment to embedding the procedure into the curricula and implementing, monitoring, and evaluating it." Gillies et al. (2008) provide guidelines and useful suggestions on implementation of collaborative learning.

There is no doubt that collaborative and cooperative modes of learning require additional efforts on the part of an instructor compared to traditional educational settings. After all, as Wankat and Oreovicz (1994) pointed out, "students who have been pitted against each other for years cannot be expected to suddenly blossom as cooperators without some practice and guidance." Faculty offering collaborative learning should expect administrative backing (Smith, Johnson and Johnson, 1992), which may include training and other appropriate support measures, to ensure successful learning outcomes.

3. Learning Styles and Teaching Styles: Topic Revisited

In the 1980s and 1990s, academia proposed an experiential learning style theory (Kolb, 1984; Felder and Silverman, 1987; Stice, 1987) which asserted that learning effectiveness depends on matching teaching of teachers and learning styles of students. Regarding engineering education, Felder and Silverman (1987), pointed out that there may be a mismatch in engineering programs between students and professors with regard to the preferred learning styles of students and teaching methods chosen by the instructors. They postulated that learning outcomes could be improved if there is a match between the teaching methodologies chosen by teachers and the learning styles of the students.

It was the author's conjecture (Gapinski, 1994) that relative to engineering programs, engineering technology program instructors tend to be more application oriented and consequently may offer a better match with learning style of the students.

Since 1990s, Felder (2010), Sternberg et al. (2008) among others, focused their research effort to show that matching teaching methods to the learning styles of students would improve learning outcomes. Has been the assertion proven right?

Pashler et al. (2008) published a paper in which the authors claim that there is no strong scientific evidence that supports the "matching idea" of teaching and learning styles. Pashler et al. (2008) do not dispute the existence of learning styles but state that "no one has ever proved that any particular style of instruction simultaneously helps students who have one learning style while also harming students who have a different learning style" (Glenn, 2009). Pashler et al. (2008) pointed out various reasons as to why the "meshing hypothesis" (matching teaching to learning styles) might have attained great influence in the educational field. Among them: the success of the Myers-Briggs categorization in predicting people's occupational decisions or appeal of the notion that instruction not tailored to learning style, and not lack of efforts or aptitude of a learner, is responsible for unsuccessful learning. Pashler et al. (2008) pointed out an existence of an educational business associated with the promotion of learning styles literature, seminars, training and testing material for schools and businesses which helped to publicize the matching concept. They listed, as an example, testing

material commissioned by the National Association of Secondary School Principals for testing learning-styles (Keefe, 1988). Interestingly, Pashler et al. (2008) suggested a possible connection between the appearance of "meshing hypothesis" and "the self-esteem movement," which rose to prominence around the same time, in the 1970s.

According to Pashler et al. (2008) very few authors presented empirical evidence to substantiate the claim and none of them pass the scientific requirement of testing on a randomized selection of students. Gleen (2009) wrote that in the eyes of Pashler et al. (2008) the empirical study presented by Sternberg et al. (1999) that substantiated the matching argument where "students who were strongly oriented toward 'analytical,' 'creative,' or 'practical' intelligence did better if they were taught by instructors who matched their strength," was "'tenuous.'" Pashler et al. (2008) concluded that instructors should not be concerned very much with the learning styles of their students, but rather devote their attention to matching the instruction's methods to the content being taught. While some concepts are best taught via hands-on oriented methods, others are best delivered through lectures or group based assignments or discussion sessions. Pashler et al. (2008) indicated that "at present…the widespread use of learning-style measures in educational settings is unwise and a wasteful use of limited resources." Proponents of the meshing hypothesis defend the findings and point out the extensive literature on the subject.

Fedler (2010) in his critique of the detractors of "meshing hypothesis" points out that a significant body of empirical research indicate a correlation between engineering students' performance and attitudes and their learning styles. Further, he writes that learning styles detractors are missing the point and that "teaching to address all categories of a learning styles model is not a radical idea and specific suggestions for how to do it should look familiar to anyone who has studied the literature of effective pedagogy." So it seems that Fedler (2010) in his critique of detractors and in the defense of the meshing hypothesis states that the key is the right mixture of teaching styles to match the various learning styles.

So, while it appears that the assertion of "meshing hypothesis" is currently inconclusive there is an unforeseen consequence of the educational trend of focusing on learning styles. Namely, Glenn (2009) writes "the mere act of learning about learning styles prompts teachers to pay more attention to the kinds of instructions they are delivering." So, it seems that an increased level of awareness and attention to the learning styles of students prompts instructors to experiment in the delivery methods and to offer, as a result, a richer variety of pedagogical approaches in attaining the teaching objectives. And these efforts through enriching the learning environment may contribute to an improvement of the teaching skills of instructors and consequently of learning outcomes, and facilitate a more nurturing learning environment.

4. Collaborative Activities and Collaborative Learning in Engineering

Long before the concept of collaborative activity appeared in the lexicon of psychological and pedagogical literature, collaborative activities were used for engineering undertakings since antiquity. Various civilizations built marvels of architecture and engineering on vast scales such as cities, pyramids, ports, irrigations systems, canals, aqueducts, bridges, etc., using collaboration in the planning, design, and implementation stages. So working together toward a common goal was and continues to be an essential part of most engineering activities. Engineering education was employing various elements of collaborative activities from the beginning of the establishment of engineering programs in the USA in the 19th century. Although, many if not most of engineering courses are still delivered traditionally through lecture type of activity with students being passive recipients of knowledge (Felder and Silverman, 1988; Goodsell et al., 1992; Nerona, 2017), the situation has been changing. An interest in collaborative learning increased in the last few decades due to the

advancement in the understanding of cognitive processes developed by disciplines such as psychology, and the behavioral and social sciences that offered new insights and possible ways to improve the learning process. More recent pedagogical scholarship has offered new "permutations" for group work such as process-oriented guided inquiry learning (POGIL) and peer-led team learning (PLTL) (Barkley et al., 2014). Current pedagogy attempts to build learning communities and teams beyond campus settings and into the online domain (Varma-Nelson, 2018). Engineering education is in the forefront of pedagogical knowledge and methods and is constantly adopting methodologies from other fields of education as well to improve learning outcomes.

Today, the pedagogical repertoire of engineering education related to collaborative learning is quite rich ranging from short-term informal and formal group activities to long-term less or more structured group based assignments. The learning and teaching activities in most cases are campus based, but increasingly involve distributed classroom environments with digital technologies (Clark and Maher, 2006; Gapinski, 2012a&b; Lazakidou and Retalis, 2010; Varma-Nelson, 2018).

Many authors provide guidelines and suggestions on how to set up learning environments with collaborative activities (Burns, 2016; Johnson, Johnson and Holubec, 2013; Johnson and Johnson, 2017; Johnson, Johnson, and Smith, 2014; McCown, 1994; Smith 1989; among others) applicable to engineering. In their review of various collaborative learning techniques mentioned above, Barkley et al. (2014) discuss the following methodologies: think-aloud pair problem solving (solving problem aloud with a peer), send-a-problem (group solves a problem and sends solution to the next, etc.), case study (analysis of real-world scenario), structured problem solving (structured setting), analytic teams (critical analysis, rotating the roles of members), and group investigation in the category of problem-solving collaborative techniques. Felder and Silverman (1988) offer practical teaching approaches used by collaborative learning activities such as, for example: providing intervals in traditional teaching where students working in small groups tackle brainstorming activities or an assignment of drill-like exercises to small groups. GÖl and Nafalski (2007) discussed various forms of collaborative learning used at their engineering program, which comprised of: group work in laboratories, short-term team projects, and capstone group projects, which are still the dominant collaborative learning settings in most engineering programs today worldwide. Nerona (2017) reported improvement of effectiveness of learning outcomes in engineering courses such as differential equations, engineering economy, and engineering management when conducted in collaborative settings.

A propensity for collaborative activity in the form of teamwork found its place as one component of expected competencies of engineering graduates expressed by industry (Leake, 1999) and the engineering program accrediting agency - ABET (ABET, 2018).

ABET (ABET, 2018), in its formulated program objectives and student outcomes, expressed specific guidelines regarding expected proficiencies for various engineering programs. ABET program objectives for Electrical Engineering Technology (EET) programs were adopted by the PSU-Fayette campus for its EET program and expressed in terms of the following competencies/abilities:

1. Demonstrate broad knowledge of electrical and electronics engineering technology practices to support design, application, installation, manufacturing, operation, and maintenance as required by their employer,
2. Apply basic mathematical and scientific principles for technical problem solving in areas that may include circuit analysis of both analog and digital electronics, microprocessors, programmable logic control, and electrical machines,
3. Utilize computers and software in a technical environment,
4. Demonstrate competence in written and oral communication,
5. Work effectively as an individual and as a member of a multidisciplinary team,
6. Show awareness of social concerns and professional responsibilities in the workplace, and

7. Matriculate into a baccalaureate degree and/or continue their professional training and adapt to changes in the workplace, through additional formal or informal education.

Many of these expected competencies are attained through collaborative activities in course work either in lecture, laboratory experiments, or projects. Collaborative activities include various forms of informal ad-hoc groups formed for short duration to tackle smaller engineering problems to formal longer in duration capstone final projects (Gapinski, 1994, 1997).

Industry has a permanent voice in ensuring the quality of the PSU-Fayette EET program by advising the campus program through the EET Industrial Advisory Board (IAB) (Gapinski and Sokol, 1994).

In frequently administered surveys, employers of campus graduates continuously stress the importance of skills related to leadership, communication both oral and written, and collaborative teamwork.

5. Assessment of Learning of Teamwork Principles

Early on in the electrical engineering technology program (EET) courses, to facilitate a teamwork conducive learning environment, the author (Gapinski, 1994) introduces students to the "code of cooperation" adopted from the Boeing Corporation (Evans, D., Linder, D., 1993):

- "Every member is responsible for the team's progress and success,
- Attend all sessions and be on time,
- Listen to and show respect for the contributions of other members; be an active listener,
- Criticize ideas, not persons,
- Resolve conflicts constructively,
- Pay attention-avoid disruptive behavior,
- Avoid disruptive side conversations,
- Only one person speaks at a time,
- Everyone participates – no one dominates,
- Be succinct, avoid long anecdotes and examples,
- No rank in the room,
- Attend to your personal comfort needs at any time but minimize team disruption, and
- Have fun."

The above listed behavioral guidelines, one may note, share many commonalities with canons of good savoir-vivre or business etiquette. In the author's experience, plain discussion and review of these guidelines of expected behavior and conduct sets the proper stage for a productive environment in team based activities.

Through instructions dedicated to teamwork principles and teamwork assignments, students in the EET program develop the skills for collaborative teamwork. The idea is to expose students to the topic from many application oriented contents and reinforce the taught principles. The program, throughout the progression of courses, many with laboratory components, allows for students to build on previous course experiences and consequently to strengthen their teamwork skills.

The teamwork principles were taught as a segment in a course dedicated to ethics for sophomore engineering and science students at Penn State – Fayette campus (Gapinski, 2017). The course was structured to teach canons of ethics, morality, and teamwork skills. The author, motivated by the result of Fitzgerald el al. (2003) who have shown that the accurateness of self-assessment rating was proven to be "reasonably stable when compared with stability of actual performance," used self-assessment by students to assess the learning outcomes. To assess the effectiveness of learning the teamwork attributes the author used the questionnaire by Carr et al. (2005), administered in pre-test and post-test formats. In self-assessment students were asked to evaluate their skills listed in Table 1

using a seven point Likert scale (from 1-srongly disagree to 7-strongly agree; see Appendix A). The results were analyzed and used to test the eleven hypotheses formulated for variables or items listed in the questionnaire posted in Appendix A.

For the purpose of assessment of the effectiveness of learning teamwork principles (Table 1) the hypotheses were formulated for each skill set listed. It was decided to assess the effectiveness of learning and understanding teamwork principles on an individual skill basis using self-assessment by students. To facilitate the assessment, the eleven hypotheses were formulated and tested to reflect eleven essential teamwork skills based on: listening, communication, leadership, adaptability to differences in work styles and cultural norms, coaching ability, ability to provide feedback/evaluate, skill to negotiate, among others using the list presented by Carr et al. (2005) (see Table 1). Notation wise the "j" subscript denotes jth teamwork skill as listed in Table 1.

Null hypothesis H_{oj}: There is no difference in sample means: $\mu_{0j} - \mu_{aj} = 0$; which represent no improvement in understanding of teamwork skill jth as enumerated in Table 1 for j = 1,…,11.

Alternative Hypothesis H_{aj} : the sample mean of post-test, μ_{aj}, is smaller than mean of pre-test, μ_{0j}: $\mu_{0j} - \mu_{aj} > 0$; which represent improvement in understanding of teamwork jth skill.

Thus, the rejecting of the Null jth Hypothesis and accepting of the Alternative one shows that the learning and comprehension of jth Teamwork skill (see Table 2) was effective. Alternatively, rejecting of the Alternative Hypothesis, H_{aj}, shows that there was no improvement in understanding of specific skill, jth.

Table 1. Teamwork skills (Carr et al., 2005)

Item	I need to improve:
1	Listening skills
2	Skills to evaluate the performance of other team members
3	Skills to provide constructive feedback to team members
4	Skills to receive feedback from other team members
5	Coaching skills
6	Negotiating skills
7	Skills to communicate with other team members
8	Skills to manage a team project
9	Skills to be a team leader
10	Skills to adapt to differences in team members' work styles
11	Skills to adapt to different cultural norms of team members

Assuming a significance level $\alpha = 0.05$ or 5% the following hypotheses H_{aj} (j = 1, 4, 5, 7, 10, 11) are rejected: 1. Listening skills, 4. Receiving feedback, 5. Coaching skills, 7. Skills to communicate, 10. Skills to adapt to differences in work styles and cultural norms, 11. Skills to adapt to different cultural norms. The hypotheses H_{aj} (j = 2, 3, 6, 8, 9) are accepted: 2. Skills to evaluate the performance of others, 3. Skills to provide feedback, 6. Negotiating skills, 8. Skills to manage the team, 9. Leadership skills. For details, see Table 2.

Table 2. Results of Hypotheses Testing

Variable/Item	1	2	3	4	5	6	7	8	9	10	11
P-value	.093	.043	.039	.107	.141	.015	.224	.01	.004	.392	.229
Hypothesis Rejected	H_a	H_0	H_0	H_a	H_a	H_0	H_a	H_0	H_0	H_a	H_a
Hypothesis Accepted	H_0	H_a	H_a	H_0	H_0	H_a	H_0	H_a	H_a	H_0	H_0

The sample of statistical data based on hypotheses (Hypothesis 1 and 2) testing using Excel are provided below (Table 3 and Table 4):

Table 3. Variable 1: I need to improve listening skills

	Pre-Test	**Post-Test**
Mean	3.17	2.6
St. Error	0.35	0.23
Median	2.5	2.0
Mode	2.0	2.0
St. Deviation	1.71	1.05
Sample Variance	2.92	1.09
Kurtosis	-1.45	1.03
Skewness	0.28	1.54
Range	5.0	3.0
Minimum	1.0	2.0
Maximum	6.0	5.0
Sum	76	52
Count	24	20

t-Test: Two-Sample Assuming Unequal Variances

Item	**Pre-Test**	**Post-Test**
Mean	3.17	2.6
Variance	2.93	1.09
Observations	24	20
Hypothesized Mean Difference	0	
df	39	
t Stat	1.35	
P (T<=) one-tail	.093	
t critical one-tail	1.68	

Conclusion: Ha1 is rejected.

Table 4. Variable 2: I need to improve skills to evaluate the performance of other team members

	Pre-Test	**Post-test**
Mean	3.8	3.1
St. Error	0.29	0.29
Median	4.0	3.0
Mode	4.0	2.0
St. Deviation	1.43	1.33
Sample Variance	2.06	1.78
Kurtosis	-1.23	-1.20
Skewness	0.12	0.09
Range	4.0	4.0
Minimum	2.0	1.0
Maximum	6.0	5.0
Sum	92	62
Count	24	20

t-Test: Two-Sample Assuming Unequal Variances

Item	**Pre-Test**	**Post-Test**
Mean	3.83	3.1
Variance	2.058	1.779
Observations	24	20
Hypothesized Mean Difference	0	
df	41	
t Stat	1.75	
P (T<=) one-tail	.043	
t critical one-tail	1.68	

Conclusion: Hypothesis H_{a2} is validated.

The tests were performed for one cohort of Science, Technology, and Society (STS 233) Ethics and the Design of Technology course of sophomore science and engineering students. The results showed that the teaching segment of the course dedicated to teamwork principles offered an improvement in understanding of the most important elements of teamwork skills such as: skills to evaluate the performance of others, skills to provide feedback, in negotiation, team management, and leadership. The results will be taken into account in future EET course offerings in order to plan appropriately and focus on areas where improvements can be made. Although the majority of students were at a sophomore level, they had already taken courses in science and engineering courses, which have a

component of teamwork based projects, so they were exposed to teamwork principles and that may explain the lower progress than expected in improving of understanding of some teamwork skills.

6. Conclusions

The article reviews collaborative and cooperative learning approaches utilized in higher learning institutions today. As institutions of higher education face multiple challenges such as: student attrition rate, student passivity and isolation, reduction of financial support by states' legislatures, they focus on improving the efficiency of the educational process. It was hoped that collaborative learning can provide new solutions in improving learning processes. As collaborative learning was being implemented on a wider and wider scale by educational institutions, the growing body of empirical evidence indicates its positive contributions in addressing education's shortcomings. In engineering education, collaborative activities contribute to positive learning outcomes and strengthening of the professional skills required by industry. The article provides an example of an assessment of effectiveness of learning teamwork principles based on a self-assessment by students using pre- and post-test format performed in an engineering ethics course taught by the author.

7. References

ABET (2018). www.abet.org.

Arends, R.I. (1997). Classroom instruction and management. The MacGraw-Hill Companies, Inc. New York.

Augustine, N.R. (1994). Preparing for the Socioengineering Age. ASEE Prism. Feb. Pp. 24-26.

Barkley, E.F., Major, C.H., Cross, K.P. (2014). Collaborative Learning Techniques: A Handbook for College Faculty. 2nd ed. John Willey & Sons.

Bordogna, J. Ernst, E. (1993). Engineering Education: Innovation Through Integration. Journal of Engineering Education. Vol.82, No.1. Pp. 3-8.

Bruffee, K. (1993). Collaborative Learning, Higher education, Interdependence, and the Authority of Knowledge. The Johns Hopkins University Press. Baltimore & London.

Bruffee, K. (1984). Collaborative Learning and the "Conversation of Mankind." College English, Vol. 46. No. 7. Nov. Pp. 635-652.

Bill and Melinda Gates Foundation. (2018). (Available at https://postsecondary.gatesfoundation.org/who-we-are/?gclid=EAIaIQobChMI3r-ysM6U2AIVnYWzCh0wgQL9EAMYAiAAEgJA3_D_BwE)

Burns, M. (2016). 5 Strategies to Deepen Student Collaboration. Nov. 22. (Available at https://www.edutopia.org/article/5-strategies-deepen-student-collaboration-mary-burns)

Carr, S.D., Herman. E.D., Sarotney Keldsen S., Miller J.G., Arkinstall Wakefield P. (2005). "The Team Learning Assistant Workbook." McGraw-Hill. Irwin. New York. NY 10020.

Clark, S. and Maher, M.L. (2006). Collaborative learning in a 3-D virtual place: investigating the role of place in a virtual learning environment. Advanced Technology for Learning. 3, 4. Pp. 250-254.

Deutsch, M. (1949). A theory of cooperation and competition. Human Relations, 2. Pp 129-152.

Evans, D., Linder, D. (1993). The role of Teams in Engineering Education. Penn State University – Team Training Workshop. University Park. Dec. 2-3.

Felder, R.M. (2010). Are Learning Styles Invalid? (Hint: No!) On-course Newsletter. Sep.t 27. (Available at http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/LS_Validity(On-Course).pdf)

Felder, R.M., Silverman, L.K. (1987). Learning and Teaching Styles in Engineering Education. Annual Meeting of the American Institute of Chemical Engineers. New York, NY.

Felder, R.M., Silverman L.K. (1988). Learning and Teaching Styles In Engineering Education. Engr. Education, 78(7). Pp. 674–681.

Fitzgerald, J.T., White, C., and Gruppen, L.D. (2003). A Longitudinal Study of Self-Assessment Accuracy. Medical Education. 37: 645-649, doi: 10.1046/j.1365-2923.2003.01567.x.

Gapinski, A. (2017). Teaching Ethics in an Engineering Program. The Journal of Management and Engineering Integration. Vol. 10. No. 1. Summer. Pp. 29-41.

Gapinski A. (2012a). Automation of Functionalities. Examples of EET Student Projects. Proceedings of IEMS Conference. Cocoa Beach. FL. March 26-29. Pp.74-79.

Gapinski A. (2012b). Online Education: an Instructor Perspective. LACCEI Conf. Proceedings. Panama City. Panama. ISBN-10 978 -0-9822896-5-5. July 23-26. Pp.1-8.

Gapinski A. (1997). Collaborative Projects: Programmable Logic Controllers. Journal of Industrial Technology. Vol 13. No.2. April. 1997. Pp. 35-36.

Gapinski, A. (1994). Collaborative Learning in Technology Program. ORSA/TIMS National Conference. Detroit. Oct. 23-26.

Gapinski A. and Sokol J. (1994). Electrical Engineering Technology Curriculum: Meeting the Industry Expectation. APICS International Conference, San Diego, October 30-31.

Gillies, R.M., Asham, A., Terwel, J. (eds). (2008). The Teacher's Role in Implementing Cooperative Learning in the Classroom. Springer.

Glenn, D. (2009). Matching Teaching Style to Learning Style May Not Help Students. The Chronicle of Higher Education. Dec. 15. (Available at https://www.chronicle.com/article/Matching-Teaching-Style-to/49497)

Goodsell, A.S., Maher, M.R., Tinto, V. and Leigh, B. MacGregor, J. (eds) (1992). Collaborative Learning: A Sourcebook for Higher Education. National Center on Postsecondary Teaching, Learning, and Assessment. Pennsylvania State University. University Park.

Göl, Ö., and Nafalski, A. (2007). Collaborative Learning in Engineering Education. Global J. of Engineering Education. Australia. Vol. 11. No.2. Pp. 173-180.

Granger, M.J. & Lippert, S.K. (1999). Peer Learning Across the Undergraduate Information Systems Curriculum. Journal of Computers in Mathematics and Science Teaching, *18*(3), 267-285. Charlottesville, VA: Association for the Advancement of Computing in Education (AACE).

Griesbaum, J. and Görtz, M. (2010). Using feedback to enhance collaborative learning: an exploratory study concerning the added value of self- and peer-assessment by first-year students in a blended learning lecture. *International Journal on E-Learning, 9*(4), 481-503. Waynesville, NC USA: Association for the Advancement of Computing in Education (AACE).

Heffernan, M. (2015). Bigger Prize: Why no one wins unless everyone wins. Simon & Schuster. UK.

Johnson, D.W., Johnson, R.T. (2017). Cooperative Learning. Innovacion Educacion. I Congreso International. Sept. 22-23. Zaragoza. Spain.

Johnson, D. W., Johnson, R. T. (2013). The impact of cooperative, competitive, and individualistic learning environments on achievement. In J. Hattie & E. Anderman (Eds.), International handbook of student achievement. New York: Routledge. Pp. 272-274.

Johnson, D.W., Johnson, R.T. (2005). Cooperative Learning, Values, and Culturally Plural Classrooms. In Classroom Issues: Practice, Pedagogy and Curriculum. Leicester M., Modgil C., and Modgil S. (editors). RoutledgeFalmer. New York and London.

Johnson, D.W., Johnson, R.T. and Johnson Holubec, E. (2013). Cooperation in the Classroom. 9th ed. Interaction Book Company. Edina, MN.

Johnson, D.W., Johnson, R.T, Holubec, E., Roy, P. (1984). Circles of Learning: Cooperation in the classroom. Alexandria, VA. Association for Supervision and Curriculum Development.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative Learning: Improving University Instruction by Basing Practice on Validated Theory. Journal on Excellence in College Teaching. Vol. 25. N. 3-4. Pp. 85-118.

Johnson, D.W., Johnson, R.T., and K. Smith, K.A. (1998). Active Learning: Cooperation in the College Classroom, second ed., Edina, MN: Interaction Book Company.

Kagan, S. (1994). Kagan cooperative learning. San Capistrano, CA. Kagan Cooperative Learning.

Keefe, J.W. (1988). Profiling and utilizing learning styles. NASSP learning styles series. Reston. VA: National Association of Secondary Schools Principles.

Kirschner, P., Sweller, J., Clark, R.E. (2004). Why Unguided Learning Does Not Work: An Analysis of the Failure of Discovery Learning, Problem-Based Learning, Experiential Learning and Inquiry-Based Learning. Open University of Netherlands. Heerlen. Netherlands. (Available at http://projects.ict.usc.edu/dlxxi/materials/clark/Constructivism_EP_05_Kirschner_Sweller_Clark_Ss.pdf)

Kolb, D.A. (1984). Experiential Learning: Experience as the Source of Learning and Development. Prentice Hall. Englewood Cliffs, NJ.

Lazakidou, G. and Retalis, S. (2010). Using computer supported collaborative learning strategies for helping students acquire self-regulated problem-solving skills in mathematics. Computers & Education. Vol 54, Issue 1. Jan. Pp. 3-13.

Leake, W. (1999). Most Likely To Succeed. ASEE Prism. April. P.9.

Levine, A., Weingart, J. (1973). Reform of Undergraduate Education. Jossey-Bass Publ. San Francisco, CA.

MacGregor. J. (1992). Collaborative Learning: Reframing the Classroom. In Goodsell, A.S., Maher, M.R., Tinto, V. and Leigh, B. MacGregor, J. (eds) (1992). Collaborative Learning: A Sourcebook for Higher Education. National Center on Postsecondary Teaching, Learning, and Assessment. Pennsylvania State University. University Park.

Major, M.J. (1994). Surviving the Crunch. ASEE Prism. March. Pp.15-19.

Mason, E. (1972). Collaborative Learning. Agathon Press. New York.

McCown, R. (1994). Key Elements For Cooperative Learning. Cooperative Learning Conference. Duquesne University. Center for teaching Excellence. May 9. Pittsburgh, PA.

Meade, J. (1991). Feeling the Squeeze. ASEE Prism. Oct. Pp. 20-24.

Meyers, Ch. and Jones, T. B. (1993). Promoting Active Learning: Strategies for the College Classroom. San Francisco: Jossey-Bass.

Miller, R.L., Olds, B.M. (1992). Multidisciplinary Model for Teaching Undergraduate Engineering Design. Colorado School of Mines. Golden. Colorado. ED 414 827.

Miller, C.K., Peterson, R.L. (2002). Cooperative Learning. (Available at www.indiana.edu/~safeschl)

Mitchell, M, Leachman, M, and Masterson, K. (2017). A Lost Decade in Higher Education Funding. State Cuts Have Driven Up Tuition and Reduced Quality. Center on Budget and Policy Priorities. August 23. Washington DC. (available at www.cbpp.org)

Nerona, G.G. (2017). Enhancing students' achievement and self-assessed learning outcomes through collaborative learning strategies in various engineering courses. Global Journal of Engineering Education. Vol. 19, Number 3. Pp. 231-236.

Pascarella, E., Terenzini, P. (1991). How college affects students. San Francisco: Jossey-Bass.

Pashler, H., McDaniel, M., Rohrer, D. and Bjork, R. (2008). Learning Styles: Concepts and Evidence. Journal of the Association for Psychological Science. Vol. 9, No. 3. December. Pp. 105-119. (Available at https://www.psychologicalscience.org/journals/pspi/PSPI_9_3.pdf)

Pashler K.E. (1993). Collaborative Learning Experiences. Proceedings of ASEE Annual Conference. Urbana, IL. Pp.2088-2092.

Ruiz-Gallardo, J.R., Lopez-Cirugeda, I., Moreno-Rubio, C. (2012). Influence of Cooperative Learning on Students' Self-Perception on Leadership Skills: A Case Study in Science Education. Higher Education Studies. Vol. 2, No. 4. Canadian Center of Science and education. Pp. 40-48. DOI: 10.5539/hes.v2n4p40.

Slavin, R.E. (1990). Cooperative learning: Theory, research, and practice. Englewood Cliffs, NJ. Prentice Hall.

Smith, K.A. (1986). Cooperative Learning Groups. In Schomberg, S.F. (ed.). Strategies For Active Teaching and Learning in University Classroom. University of Minnesota. 1986. Pp.18-26.

Smith, K.A. (1989). The Craft of Teaching Cooperative Learning: An Active Learning Strategy. Frontiers in Education Conference Proceedings. ASEE. Pp. 188-192.

Smith, B.L., MacGregor, J. (1992). What is Collaborative Learning? In Goodsell, A.S., Maher, M.R., Tinto, V. and Leigh, B. MacGregor, J. (eds) (1992). Collaborative Learning: A Sourcebook for Higher Education. National Center on Postsecondary Teaching, Learning, and Assessment. Pennsylvania State University. University Park.

Smith, K., Johnson, D.W., Johnson, R.T. (1992). Cooperative and Positive Change in Higher Education. In Goodsell, A.S., Maher, M.R., Tinto, V. and Leigh, B. MacGregor, J. (eds) (1992). Collaborative Learning: A Sourcebook for Higher Education. National Center on Postsecondary Teaching, Learning, and Assessment. Pennsylvania State University. University Park.

Sternberg, R.J., Grigorenko, E.L., Ferrari, M., and Clinkenbeard, P. (1999). A triarchic analysis of an aptitude-treatment interaction. European Journal of Psychological Assessment. 15, 1-11.

Sternberg, R.J. Grigorenko, E.L., and Zhang, L. (2008). Styles of learning and thinking matter in instruction and assessment. Perspectives on Psychological Science. 3, 486-506.

Stice, J.E. (1987). Using Kolb's Learning Cycle to Improve Student Learning. Engineering Education. 77(5). Feb. Pp. 291-296.

Varma-Nelson, P. (2018). Replicating Peer-Led Team Learning in Cyberspace: Research, Opportunities, and Challenges. Science Education Brown Bag Seminar. Penn State University. University Park. March 3.

Wankat, P.C., Oreovicz, F.S. (1994). A Different Way of Teaching. ASEE Prism. Jan. Pp. 15-18.

Weismann, J. (2014). America's Awful College Dropout Rates, in Four Charts. Nov. 19. (available at http://www.slate.com/blogs/moneybox/2014/11/19/u_s_college_dropouts_rates_explained_in_4_charts.html)

Appendix A

Item	I need to improve:	1 SD	2 D	3 SD	4 N	5 SA	6 A	7 SA
1	Listening skills							
2	Skills to evaluate the performance of other team members							
3	Skills to provide constructive feedback to team members							
4	Skills to receive feedback from other team members							
5	Coaching skills							
6	Negotiating skills							
7	Skills to communicate with other team members							
8	Skills to manage a team project							
9	Skills to be a team leader							
10	Skills to adapt to differences in team members' work styles							
11	Skills to adapt to different cultural norms of team members							

Scale: 1-Strongly Disagree 2-Disagree 3-Somewhat Disagree 4-Neutral 5-Somewhat Agree 6-Agree 7-Strongly Agree. Source: Carr et al. (2005)

View publication stats