International Journal of Engineering Education Vol. 39, No. 1, pp. 263–276, 2023
Printed in Great Britain

0949-149X/91 $3.00+0.00

Impact of Work Experience on Engineering Graduate Students' Teamwork Skills, Knowledge, and Terminology Usage*

OLIVIA GETTEL
Kettering University, Department of Electrical and Computer Engineering, Flint, MI 48504, USA. E-mail: gett7554@kettering.edu

DIANE L. PETERS
Kettering University, Department of Mechanical Engineering, Flint, MI 48504, USA. E-mail: dpeters@kettering.edu

ELIZABETH GROSS
Sam Houston State University, Department of Library Science and Technology, Huntsville, TX 77341, USA. E-mail: eag041@shsu.edu

Many studies seek to understand teamwork skill development, and teamwork is a core concept in engineering education. Whether teamwork skills are effectively developed in the classroom or whether additional training is needed, however, is not always clear. This study seeks to answer this question by examining the understanding and implementation of teamwork skills by two groups of engineering master's degree students. The first group is defined as Returners, individuals who spent five or more years in industry before returning to university to obtain a master's degree. The second group is defined as Direct Pathway students, who spent less than five years between degrees. Several comments in the data collected in a study comparing Returners and Direct Pathway students indicated a potential difference in how the two groups work in teams. Thus, this work sought to determine whether work experience has an impact on how teamwork skills are developed. A survey was completed by approximately 300 engineering master's degree students at multiple universities throughout the United States, and 41 students were interviewed. Fixed choice survey questions asked participants to rank their confidence in various team- and group-related activities. Free-response questions and interviews were used for further insight on teamwork skills and knowledge. Returners were more confident in their skills for every teamwork-related activity. Returners were also more likely to use the word "team" in survey responses, as opposed to Direct Pathway students who largely used "group." Interviews showed that group work is common in academia, whereas teamwork is a central concept of engineering in industry. Academic institutions should develop programs that better prepare students for teamwork in industry. Current programs focus primarily on group work, rather than teamwork. Significant differences exist in terminology used to describe multi-person collaboration depending on work experience levels and the collaborative context.

Keywords: team; teamwork; group; academia; engineering; industry

1. Introduction and Background

Teamwork is a significant component of many fields, and engineering is no exception. Engineers often work in teams to complete projects, develop innovations, and perform other daily tasks. The importance of teamwork is reflected in the criteria used by ABET to accredit engineering programs. One of ABET's required student outcomes for bachelor's degrees is "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" [1]. This requirement is mirrored in master's degree criteria. Although all ABET-accredited programs must incorporate teamwork, views on what "teamwork" means can vary between programs and between individuals. Additionally, different individuals may have different thoughts on the importance and implementation of teamwork skills in the engineering profession. Thus, trends in how different individuals and groups perceive teamwork can yield important insights that can be used to improve teamwork training in academia.

This study focuses on the perspectives of two distinct groups: Returning and Direct Pathway students. Returning students, also referred to as "Returners," are defined in this study as students who took a gap of five or more years between the completion of their undergraduate degree and the start of their graduate program [2–4]. This five-year timeframe was selected as the cutoff for Returners because several other programs use that approximate time frame for their cutoff. For example, GRE scores are accepted for five years, the PE exam can be taken after four years, and ABET accreditation renewal occurs every six years. Direct Pathway students, in contrast, enrolled in a graduate program directly after or within five years of completing an undergraduate program [2–5].

* Accepted 10 November 2022.

The study also defines work experience as any paid or unpaid time spent at a job in the individual's field, while educational experience is academic time spent in courses.

The goal of this study was to explore how work experience and educational experience impact an engineer's perspective on teamwork by investigating how Returners and Direct Pathway students in engineering Master's degree programs perceive teamwork, its value in their field, and their own confidence in team activities. The research questions that this study sought to answer were as follows:

1. What differences, if any, exist between views of or approaches to teamwork for Returners and Direct Pathway students?
2. What differences, if any, exist between terminology used to discuss multi-person collaboration by Returners and Direct Pathway students?
3. Does work experience help students develop teamwork skills and understanding? If so, what level of work experience is necessary to build teamwork skills?
4. How can the findings from this study be used to inform pedagogy?

We wanted to understand whether work experience helps students to develop their teamwork skills and understanding, as well as what level of work experience would be necessary to build those skills. An understanding of how the ability to work on a team could be better developed in an academic environment can help engineering educators generate curricula that teaches students this skill in the classroom. With employers seeking workers who are innovative, critical thinkers, and team players, insights on how to improve teamwork skills are important [6].

2. Literature Review

The purpose of this paper is to contribute to the current literature on groups and teams in order to determine how teamwork skills are developed by engineering students and practitioners so that academic institutions may be better equipped to develop those skills in the classroom.

2.1 Differences Between Returners and Direct Pathway Students

The first appearance in the literature of work specifically focused on engineering returners in graduate programs was in 2008; Schilling [7] published an account of issues that were observed to occur among the author's own student advisees, with a specific focus on doctoral students. Further work on engineering returners did not appear until 2011, when two different studies appeared in the literature. Strutz et al. [8] conducted a qualitative study, in which ten engineering returners in a single university's Engineering Education doctoral program were interviewed. The study focused on what the authors termed "experience capital", which they identified as the students' lifetime accumulation of expertise, both personal and professional, and indicated that there was a need for this experience capital to be respected and better utilized. At the same time, Peters and Daly conducted a qualitative study focused on the challenges faced by returners at a different university, with ten participants in both master's and doctoral programs across a range of STEM fields. In the initial publication of this work, focused on a subset of the participants that were ultimately included in the study, the change in identity from professional to student was examined [2]. Subsequent work focused on the motivation for returning, seen through the lens of Expectancy Value Theory (EVT), and on the overall returning experience in terms of EVT; in this analysis, furthermore, different cost categories were set forth, as well as strategies used to mitigate them [4].

Based on this work, an additional study was carried out, with a broader focus, larger scope, and a focus specifically on doctoral returners. In this study, led by Daly, a nationwide survey was conducted, with a follow-up interview phase, including both returners and direct-pathway students [9]. In this study, the Returner population was characterized, and various aspects of their experiences were studied, including their needs from a doctoral advisor [10], but with a particular focus on the intersection of work experience and research [11–15]. Further analysis was carried out within the framework of EVT, including factor analysis, which resulted in confirmation of four of the five cost categories seen in the previous study [16]. An additional study phase involved interviews with employers, giving perspective on what their views were on returners and their value to the organization [17].

A similar study was also conducted, with a focus on master's students and specific attention on the learning process in the classroom and how it intersected with work experience. It also drew from a nationwide sample, with a survey phase followed by interviews, a concept mapping activity, and the use of a concept inventory. The study population included both returners and direct-pathway students, and a comprehensive comparison was conducted [18]. Findings from this study indicated that returners were equally proficient in common software tools as were their direct-pathway peers,

despite the view of the younger students as "digital natives" [19]. Furthermore, these students' approaches to learning were impacted by their work experience [20]. A sub-set of the data was also analyzed to understand the unique features of military experience, as it has some features that differ from typical industrial employment [21].

Additional small-scale studies have been conducted as well; in one such study, a small group of returners were interviewed and the ways in which their writing changed as they transitioned from industry to graduate school were studied [22]. Another study focused on professional societies, and the ways in which their membership policies and structures impacted returners [23]. Many questions remain to be answered, as set forth in [24].

2.2 Teamwork vs. Group Work

Fisher et al. [25] sought to understand the difference between teams and groups in industry. They found that the two terms are often used interchangeably in literature, but their study showed a clear difference between the implications of the words "group" and "team." The researchers found that teams were identified as "creative," "innovative," and "well rounded," with groups being associated with the adjectives "negotiating," "networking," "persuasive," and "the sum of individual goals." The researchers hypothesized that their results implied that teams are composed of well-adjusted members who are comfortable in their role and have built interpersonal relationships, while interpersonal relationships and roles in groups were not fully formed. Fisher's definitions of "team" and "group" are used in this paper to differentiate between terminology used by Returners and Direct Pathway students.

Katzenbach and Smith [26] found that work groups share information and insights to help the individuals gain the knowledge necessary to complete their tasks, while teams focus on collaborative efforts and a common commitment that engenders belief in some sort of driving cause. Additional delineations between groups and teams include that groups have defined leaders, while teams share leadership; groups are individually accountable and produce individual work, while teams have both individual and mutual accountability and work; groups run efficient meetings and teams participate in open discussion and problem-solving meetings; and groups have a purpose synonymous with the overall organization's mission, but teams have a specific purpose only for their team [26]. In order to be effective, teams must also consist of members with complementary skills.

Baker et al. [27] characterize teams as consisting of "two or more individuals who must interact to achieve one or more common goals that are directed toward the accomplishment of a productive outcome(s)." They identified the following important teamwork skills, along with several others: identify problems; gather, evaluate, and share information; reallocate tasks, provide assistance, provide and accept feedback, monitor and adjust performance, share work, seek mutually agreeable solutions, consider different ways of doing things, and manage and influence disputes [27]. Although they did not differentiate between groups and teams in their study, the teamwork concepts may be used to describe teams.

2.3 Teamwork in Academia

Suk Kim Chin conducted research on teamwork in academia by developing a special framework for teams in a MATLAB course [28]. Chin perceived a significant difference between team performance in academia versus industry in part due to the fact that people in industry are paid to work in teams, whereas team projects in courses are given in a different environment. Academic teams are not often selected in an organized manner, like they would be through hiring processes in industry, so teamwork experiences in academia are not always as positive as industrial teams. Chin identified that the majority of students at her institution think that teamwork effectively shares workloads, but the small percent who disagreed represented the highest performing students in the class. In her proposed framework, Chin organized student teams based on a student team formation software that was designed to group similar students together to generate a cohesive and high-performing team. To solve problems that high performers identified with teams, Chin proposed giving bonus points to students who could demonstrate that they offered peer support and explanations to less motivated and knowledgeable teammates, which was expected to significantly improve views on teamwork from the high performing students.

Teaching teamwork is another area that must be understood for this research. Matusovich et al. [29] sought to identify how faculty understand the concept of teamwork. The identified trends include: having more structured methods for teaching communication and more ad hoc methods for teaching teamwork skills, displaying a tendency to believe that "someone else" teaches communication skills, indicating that they do not teach teamwork, and a belief that teamwork is a skill that students can learn only by "doing it." Although many faculty responses indicated these beliefs, with 41 of 50 participants indicating that students learn teamwork by "doing it," 20% of the interviewees also acknowledged that they did not know where stu-

dents are able to learn teamwork and communication. Thus, they found that there exists a significant need for more structured and intentional approaches for teaching teamwork in the classroom [29].

Aside from teaching teamwork skills, it may also be important for educators to help students improve their attitudes toward teamwork, specifically by developing a mindset that encourages concept mastery. Garcia-Martin et al. [30] hypothesized and fully or partially confirmed that students can improve their teamwork abilities through teamwork training and performing teamwork activities integrated into the coursework, students with ''higher mastery motivation'' have more positive attitudes toward teamwork, and students with different types of motivations achieve varying academic performance. Thus, this work indicates that it is important to integrate teamwork training in coursework. Additionally, high levels of motivation can improve student attitudes toward teamwork; therefore, it would be beneficial for educators to find methods of motivating students to master topics.

Finally, the notion of communities of practice may be useful to consider when looking at teamwork skill development. According to Wenger [31], ''Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.'' Communities of practice depend on a shared domain of interest, engagement of members in joint activities, and regular shared practice with shared resources. Building communities of practice in universities by offering the ability to consistently participate in activities related to shared interests could give students the opportunity to develop teamwork and other skills in ways that are interesting to them. Wenger stated that communities of practices can be used in education to change learning theory to recognize that schools are not contained, closed areas of learning; instead, students learn through life, rather than only a classroom [31]. Providing opportunities for students to gain life experiences outside of the classroom could begin changing learning theory in universities.

Han and Newell [32] applied team-based learning (TBL), a learning method focused on small groups that focuses on optimizing student participation and promotes active learning, to coursework in Journalism & Mass Communication to determine how TBL impacted students' learning in the course. In the study, students indicated that discussions with their teams assisted them in better learning the key concepts from assigned course reading. The study also found that students were significantly more accurate in answering knowledge-based questions after going through the course with a TBL structure. Overall, the students reflected positively on the course experience, their own learning, and their teammates, indicating that TBL can be an effective method to increase course mastery.

In an assessment of which factors influence the success of industry-sponsored capstone courses, researchers found that ''Fit within Cohort'' (i.e. how well students' skills complemented each other's within the team) was among 10 factors that were shown to influence project success [33]. This finding corresponds with Katzenbach & Smith [26], which found that a team must consist of members with complementary skills.

In another study about teaching teamwork in engineering programs, the authors used a business simulation to put students into a high-pressure environment and build their teamwork skills [34]. When forming their teams for the simulation, one group of students was asked to create teams with diverse backgrounds and skills and another group was assigned to diverse teams. While engaging in the simulation, the teams were encouraged to reflect on their performance and team structures. Student feedback after the simulation indicated that the simulation was highly useful in teaching students about teamwork and group dynamics [34]. Overall, the results indicated that the simulation prepared and motivated students well for future courses.

Diversity can also have an impact on the effectiveness of teaching teamwork in engineering academia. Studies have indicated that female and underrepresented minority students felt excluded from their teams and experienced more team-related problems, including patronization [35, 36]. Students felt that they would have learned more if they had been assigned to work on a different portion of the project and were excluded from the ''main work'' of the team [35]. These studies demonstrate that different demographics may experience teamwork differently, which can also be applied to the discussion of Returner and Direct Pathway groups.

2.4 Teamwork in Industry

Goller et al. [37] conducted a study to explore how students learn in internships. The study found that the job demands found in work experience significantly impacts students' abilities to ask for feedback and their self-regulated learning abilities. Job demands of internships were also found to drive students to connect classroom theory to actual practice and taught students to adapt to varying work environments. Social support, which the study defined as ''relations between colleagues and supervisors or mentors,'' helped students to develop their abilities to ask for help and feedback. Students

who work closely with others in internships are better able to rely on others when they are unable to solve problems alone, which demonstrates an implied improvement in teamwork skills.

Similarly, Eraut [38] examined how learning takes place in the workplace, discovering that confidence was extremely important in learning. Confidence was found to be developed in the workplace through meeting challenges and the extent to which workers felt supported by their teammates. In addition to numerous other factors that impacted learning, relationships, support, and trust from teammates were found to aid learning. Numerous interviewees indicated that they learned through participation in group processes, working with others, and consulting others within or outside their team or group.

3. Method

The work presented in this paper is part of a larger study that is intended to investigate the effect of work experience on learning in master's students. This study included both a survey and an interview phase, with participants drawn throughout the country. The overall study was based on a constructivist framework, in which it is assumed that participants construct their knowledge in the context of prior experience. The study involved domestic engineering students pursuing master's degrees in the United States and was approved by an Institutional Review Board.

The survey was developed and piloted to ensure that the questions would be understood as intended. It was implemented through Qualtrics and administered as a web-based survey. The interview protocol was also piloted, with revisions made after piloting. Interviews were conducted in person and accompanied by a concept mapping activity and a concept inventory. Data from the concept inventory were not used in this paper.

In order to recruit participants, approximately 80 universities throughout the United States were contacted and asked to send anonymized survey information to their students. Screening questions were used to ensure that the data received was from domestic students, as that was the population selected for the study. A rolling recruitment method was used in order to ensure that a sufficient population of Returners was included in the data. 81 participants self-identified as Returners, while 219 participants identified as Direct Pathway students.

As part of the survey, participants were asked if they were willing to participate in the interview phase of the study. Based on those results, an approximately equal number of Returners and Direct Pathway students were chosen for interviews. The choice of interview subjects was based on willingness to be interviewed and Returner status. 41 interviews were conducted, 20 with Direct Pathway students and 21 with Returners.

Throughout this paper, all interview participants will be referred to by pseudonyms. Because the survey respondents were too numerous for pseudonyms, they will be referred to by their classification, Direct Pathway (DP) or Returner (R), and their survey number.

Both fixed choice and free response questions were included in the surveys, with several of those questions pertaining to teamwork or group work. The fixed choice questions that pertained to teamwork asked for participants' confidence in various team-related concepts. These responses were analyzed qualitatively using histograms to identify potential differences in confidence between Returners and Direct pathway students in each question. The free response questions and interview responses were analyzed using an open coding method to identify themes.

4. Results

The study contained several types of data and questions that pertained to teamwork: fixed choice questions, free response questions, and interviews. These data were analyzed using varying methods in order to answer the key research questions posed by this study. The breakdown of which data were used to answer each research question is shown in Table 1.

The fixed choice questions that pertained to or

Table 1. Analyses/results used to answer key research questions

Research Question	Analyses to Answer
What differences, if any, exist between views of or approaches to teamwork for Returners and Direct Pathway students?	Qualitative analysis of free response questions, Open coding analysis of interview data.
What differences, if any, exist between terminology used to discuss multi-person collaboration by Returners and Direct Pathway students?	Qualitative analysis of free response questions, Open coding analysis of interview data.
Does work experience help students develop teamwork skills and understanding? If so, what level of work experience is necessary to build teamwork skills?	Qualitative analysis of fixed choice questions and free response questions, Open coding analysis of interview data.

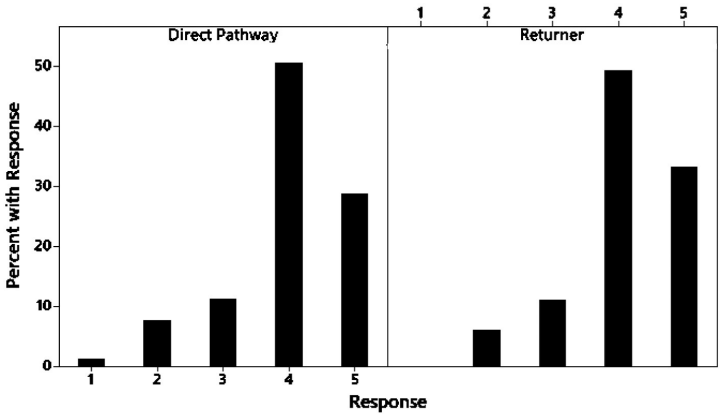

Fig. 1. Responses to "How confident are you in your ability to review your team's strengths and weaknesses and tell others where the team might need help" based on percent of Returner and Direct Pathway respondents.

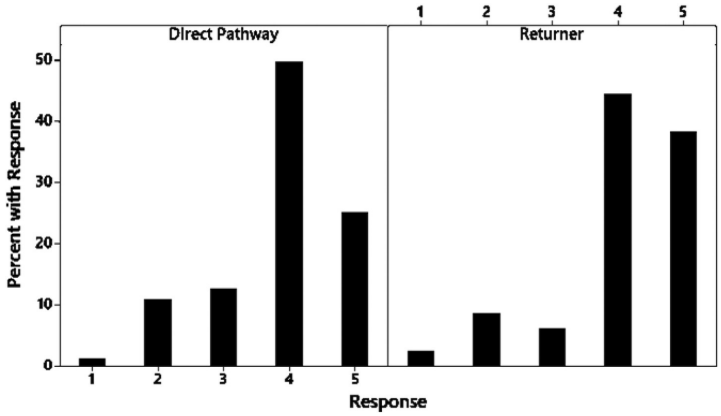

Fig. 2. Responses to "How confident are you in your ability to use your technical knowledge to participate in a design discussion" based on percent of Returner and Direct Pathway respondents.

implied a connection to teams, teamwork, and group work asked respondents "How confident are you in your ability to:"

1. "Review your team's strengths and weaknesses and tell others where the team might need help."
2. "Use your technical knowledge to participate in a design discussion."
3. "Work with others to establish project objectives when different project tasks must be completed."
4. "Identify your professional responsibilities within a large engineering project."

Respondents could select "Not at all confident," "Somewhat confident," "Neither confident nor unconfident," "Fairly confident," or "Totally confident" for each question.

For all of the fixed choice team-related questions, more Direct Pathway students selected the response "Fairly Confident" than did Returners. In contrast, the number of Returners who selected "Totally Confident" was higher than the number of Direct Pathway students who selected that option for all team-related questions. Because the quantities of Returners and Direct Pathway students who responded to the survey were not equal due to the fewer numbers of Returners in academia, the histograms in Figures 1–4 were generated using the percent of respondents rather than the number of respondents. In the following charts, responses are categorized as follows:

1. Not at all confident.
2. Somewhat confident.
3. Neither confident nor unconfident.
4. Fairly confident.
5. Totally confident.

Three free-response questions that could have generated responses related to teamwork, teams, and groups were also included in the survey. These questions were:

1. How do you think your work experience (including any internships and co-op experi-

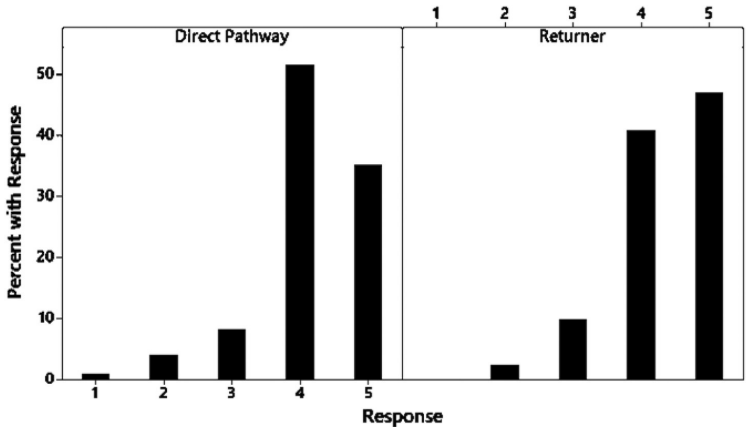

Fig. 3. Responses to "How confident are you in your ability to work with others to establish project objectives when different project tasks must be completed" based on percent of Returner and Direct Pathway respondents.

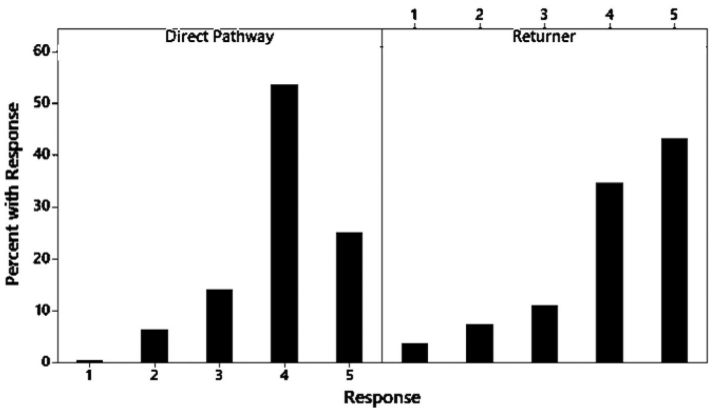

Fig. 4. Responses to "How confident are you in your ability to identify your professional responsibilities within a large engineering project" based on percent of Returner and Direct Pathway respondents.

ence) has contributed to your success in your coursework?
2. How do you think your work experience (including any internships and co-op experience) has influenced or impacted your approach to learning in general?
3. Is there any other information you would like to share about your experience in a Master's degree program that was not covered in this questionnaire? If so, please take the opportunity to share it below.

Responses were identified that directly or indirectly referred to teamwork or working in groups or teams, with 10 Returners and 16 Direct Pathway students giving a response of this type. Indirect references referred to collaboration, asking questions and being vocal, and working with people. These types of references to teams and group work, which occurred 3 times, were all given by Direct Pathway students. The other 23 responses directly used the words "team," "group," or "teamwork." Of the 10 Returner responses, only one used a variation of the word "group," while the other nine responses used a variation of the word "team." This was found to be in contrast with Direct Pathway responses; of the 13 Direct Pathway responses that directly referred to the words under investigation, nine used a variation of the word "group," while only four used a variation of the word "team." Direct Pathway respondents who used variants of "team" had varying levels of work experience, ranging from approximately a year of total work experience to 3.5 years. Respondents in both groups indicated that work experience was important in building their abilities to work in a group or team, especially when discussing how work experience influenced their coursework success. Some of these responses are shown in Table 2.

When analyzing interview responses, several trends emerged. First, as shown in Table 3, multiple interviewees made statements that reflected their belief that teamwork is a core concept in the field of engineering.

Table 2. Sample Survey Responses Related to Teams and Groups

Classification	Number	Response
Returner	110	Instrumental, particularly in understanding how to work as a team.
Returner	257	I worked in teams constantly, which makes me a strong contributor in school on team projects.
Direct Pathway	104	It helped keep me sharp in the principles and taught me teamwork.
Direct Pathway	237	It has given me the ability to work well in groups and solve problems collaboratively
Direct Pathway	284	Superior group management. Many methods successfully use in undergrad courses are not appropriate for masters courses. It is very clear when mixing group of students fresh from undergrad and working professionals that the younger students are used to group work as opposed to team work. With the more experienced students meetings are brief, progress is review, decisions made, and tasks assigned. With the younger students there is a tendency to want to sit around a table for hours and work the problem together.

Table 3. Sample Interview Responses on Teamwork as a Core Engineering Concept

Classification	Pseudonym	Response
Direct Pathway	James	(In response to whether engineering aligned with what they thought before becoming an engineer) Yeah. I don't think so, because after I started my jobs, then I realized that working in a team and working together was very important to being successful . . . and during my undergrad classes, we didn't really work in a team a lot . . . But, yeah, as I said before, there's always working in teams, and actually learning how industry works. There's always stuff that would've been helpful, if I knew.
Direct Pathway	Tim	Well, as a kid, you always think engineering is a person trying to solve a problem. Then it's developed into knowing that there's a lot more teamwork involved.

This trend was also present in the concept maps drawn by interviewees in both groups. When asked to draw concept maps that show how participants view the field of engineering, eight of 20 Direct Pathway students and seven of 21 Returners mentioned teams or teamwork, one Returner mentioned groups or group work. Therefore, somewhat equal ratios of both Direct Pathway and Returner students view multi-person collaboration as a fundamental concept in the field of engineering.

Several students also talked in interviews about the use of teams and groups in academia, working in study groups, and how academia prepares students for industry with respect to teams, groups, and teamwork.

With respect to how teams and groups are used in academia, both Returners and Direct Pathway students indicated that they frequently participated in group and team projects within their courses, summarized in Table 4.

Outside of required team or group projects, some students also indicated that they choose to work in study groups, even when they are not required for a

Table 4. Sample Interview Responses on Team and Group Projects in Courses

Classification	Name	Response
Returner	Molly	We were assigned team projects and I'm trying to interact with someone with a really different background. You have to learn, because I was only interacting with engineers for so long, I didn't know how to talk to somebody else.
Returner	Molly	And the ones [classes] where there was a group project, that really helped me keep on schedule, because I understood the impact. It wasn't just hurting myself. I know if an assignment is due and you're running late, so you have to pull an all-nighter. But if somebody else is counting on you, it's a whole different ballgame.
Direct Pathway	Abraham	In undergrad, I worked in groups all the time, and on homeworks . . . I think that, in the way that I had to learn from, I learned in groups for five years in undergrad. Everything was done in groups, like the little things. Then the little things had to be taken care of me, homeworks those things, but there were more group projects in graduate school . . . Everything ends with a group project or the whole class is a group project.
Direct Pathway	Abraham	Again, a lot of it's group project based . . . So a lot of my grades have been group ones, which are a lot easier.
Direct Pathway	Brian	A lot of courses now and projects require group effort or team projects, and that prepares you for working on a team in the real world.
Direct Pathway	Michael	. . . [A]ctually my instructors were fairly impressed with the way that I was managing my team for that. . . and so being able to identify weaknesses within the team, and then being able to address those, and then have retrospectives every few weeks and say, "Okay, this is what we did, you know, that worked well for us as a team in the past few weeks, and here's what didn't work. Now let's go back and address what didn't work."

Table 5. Sample Interview Responses on Collaborative Studying

Classification	Name	Response
Returner	Gerald	(Regarding study habits) I would also work in groups. A lot of our projects were group work.
Direct Pathway	Sherry	My study habits are still changing. At the moment, they are a mix between group focused and individual . . . I like to do group studying because the way that these classes are structured is that they overlap a little bit.
Direct Pathway	Sherry	We'll do group study sessions with the undergrads, but the thing with undergrads is that undergrads don't have any confidence whatsoever. The whole purpose of your undergrad is to destroy you and then show you, you can still make it. So when you study with undergrads, it'll be nice because they'll listen to the graduate students. We can sort of lead a study session, you know what I'm saying? Which is beneficial to me, because I really feel like if you can explain the information, you understand the information. It gives me an opportunity to test my own self and then, if I know I'm going to be doing this group study session, I don't want to look like an idiot.
Direct Pathway	Terry	And then people form, kind of naturally, their own study groups, and so you just ask someone who has a different background than you, and hopefully between the two of you, you can figure it out.
Direct Pathway	Terry	We review the material, and we start the homework in groups . . . I really like studying in a group.

course. Table 5 highlights some of these results. Direct Pathway students seemed more apt to study in groups, with five Direct Pathway interviewees talking about study groups compared to only one Returner.

Finally, as summarized in Table 6, when directly or indirectly reflecting on how their academic experience prepared them for the workforce, nine students indicated that teamwork or group work is relevant in industry but expressed varying sentiments on how well academia prepared them for that environment.

As these responses demonstrate, some students felt that their academic experience adequately prepared them for industry teamwork, while others felt that their academic experience was not enough or did not show them the level of importance that teamwork has in the engineering profession.

In the interviews, the divide between the use of "team" and "group" between Returners and Direct

Table 6. Sample Interview Responses on Academic Preparation for Industry Collaboration

Classification	Name	Response
Returner	Mark	Undergrad can only do so much to prepare you for that setting, and how to communicate, how to interact, even group projects are very different in school.
Returner	Maryanne	I think something like broader concepts were relevant. A lot of those like how to work in teams, because in engineering school we worked a lot in teams. And so how to be a good team member, and pull your weight, and lead teams was useful. I remember my boss telling me my first year, we would do evaluations every year. And he was like, "You're one of my best team players we've ever had." I'm like, "Really?" I'm just doing my job, but I guess there's many people who work that don't work well on a team . . . Some engineers tend to be loners, and that's okay. And so I think more of these soft skills like how to work on a team, and how to manage projects or lead projects was more valuable to me, and prepared me for my work at the Navy than the technical work.
Returner	Susan	I think in the graduate, some of the programs, of course it's all basic. But they do not always teach you that communication skills about how to convey something without being offensive. And this comes from experience, not book learning, or teamwork learning.
Direct Pathway	Brian	I think very well, yeah. Especially with going back to the discipline of how we approach studying and doing research and just being a good student and good, I guess, team player goes with it, as well. A lot of courses now and projects require group effort or team projects, and that prepares you for working on a team in the real world.
Direct Pathway	James	Yeah, I don't think so, because after I started my jobs, then I realized that working in a team and working together was very important to being successful . . . and during my undergrad classes, we didn't really work in a team a lot . . . But, yeah, as I said before, there's always working in teams, and actually learning how industry works. There's always stuff that would've been helpful, if I knew.
Direct Pathway	Madelyn	It's just they don't prepare you for as much as you wanted to, but if you just go to class every day, and you don't really try to participate or be the group leader, or different things like that, I'm not sure. I think it would so prepare you, but just not as well.
Direct Pathway	Michael	It's, I guess it prepares you in a generalist way in order to have you thinking like an engineer, and to prepare you for I guess some of the soft skills in terms of being able to work on a team, being able to manage your time better . . .

Table 7. Uses of "Team" and "Group" Variants when Discussing Different Contexts for Multi-Person Work

Context of Multi-Person Collaboration	Variation of "Team"	Variation of "Group"
Core engineering concepts	15	3
Academia	38	34
Collaborative Studying	3	21
Preparation for Industry	18	6

Pathway students was not as defined as in survey responses: a variation of "team" was used 39 times by Returners and 51 times by Direct Pathway students and a variation of "group" was used 35 times by returners and 42 times by Direct Pathway students. An interesting trend, however, arose in an analysis of how students used variations of "work" and "team" in the different contexts of multi-person collaboration. This trend is shown in Table 7.

5. Discussion

The analysis of responses to the fixed choice questions in the survey indicates that Returners are more likely to self-identify as "Totally confident" on teamwork-related questions than Direct Pathway students, while Direct Pathway students were more likely than Returners to identify as "Fairly Confident." Although biases can be introduced when individuals are asked to rate their own abilities, the results of this analysis still presented an interesting trend. Having more Returners self-identify as "Totally Confident" on team-based abilities implies that one or both of the following may be true:

1. Students with more work experience display better mastery of teamwork skills than students with little or no work experience.
2. Students with more work experience have higher confidence in their mastery of teamwork skills than students with little or no work experience.

These implications go toward answering the question of whether work experience helps students develop teamwork skills. Due to the design of the original study, which was originally intended to identify potential impacts of work experience that are not related to teamwork, it was not possible to use the gathered data to confirm whether students with work experience display better mastery of teamwork skills. However, there was a clear trend that demonstrated that students with work experience are more confident in their abilities to perform in collaborative environments.

Using variants of the word "team," as opposed to "group," was also more common for Returners than Direct Pathway students when responding to free-response survey questions. This analysis of written responses was the first step in identifying whether the two classifications of students used different terminology to discuss multi-person collaboration, which was a question that this study sought to answer. The differences in terminology used between Returners and Direct Pathway students in the free-response questions indicates that work experience may have an impact on how students describe multi-person collaboration. The statement of DP284 highlighted a potential reason for this: students who transition directly from their undergraduate degree are accustomed to "group work," but not "teamwork." This thought was supported by associated literature; Chin found that the lack of organized selection of groups for coursework can lead to poor experiences with teamwork, and many group projects are not designed in a manner conducive to teamwork [28]. In contrast, Returners may be more familiar with teamwork than group work, partially due to the careful selection of teams that typically occurs in industry. In their responses, several Returners also indicated that their work experience helped them to contribute better in team projects. Multiple Direct Pathway students also used team-based terms in their responses, and the varying experience levels of those students indicates that even small amounts of work experience may be sufficient in building a team-centric view.

Another finding of this study is that similar percentages of both Direct Pathway and Returner students view teamwork as a core component of engineering. This trend was shown both in interviews and in concept maps. Multiple students reflected on the idea that they had been unaware of the amount of teamwork in the engineering profession prior to gaining experience in industry; some of these students were categorized as Direct Pathway, again indicating that even small amounts of work experience can be valuable for understanding teamwork. This also demonstrates that there is potential to improve instruction on teamwork in academia, since many students who had experience both in academia and industry identified a gap in their preparation for teamwork prior to entering the profession. When talking about multi-person collaboration as a central requirement for engineering, the terminology used by both Returners and Direct Pathway students trended toward team-centric rather than group-centric.

In contrast, when discussing multi-person collaboration in academia, a clear trend toward team-centric terminology did not arise. Both "team" and "group" word variants were used in this case, which showed that the delineation between the two is not as clear in the classroom as it is in the workplace.

This contrast is supported by teamwork literature. As Fisher et al. found, teams are perceived as "creative," "innovative," and "well rounded," while groups are considered "negotiating," "networking," "persuasive," and "the sum of individual goals." With these adjectives in mind, the use of team-centric language to describe core engineering activities is understandable. A primary goal of the engineering profession is to develop creative and innovative solutions, and this is the objective of many teams in industry. When thinking of the central themes of engineering, students in both Returner and Direct Pathway categories may have been inclined to use team-centric language because of the association of teams with more inventive activities. The differences in how teams are selected between industry and academia may further contribute to the differences in terminology. In academic work, groups are not always expected to innovate. Instead, they may be analyzing papers, completing course projects that are done by students every semester, or other minimally innovative activities because original research and design projects may be too lengthy for a single semester. Additionally, the short length of most academic semesters coupled with the methods of group formation used in academia make it difficult for groups to fully develop their interpersonal structure and decision-making framework. Therefore, many academic groups may not fully evolve the interpersonal relationships necessary to be classified as a team. [25].

When discussing collaboration for independent study purposes, rather than coursework requirements, the term "group" was significantly more common than variants of "team." The reason for this may again be related to the descriptions of teams and groups developed by Fisher et al. Study groups are not typically innovative or creative. Instead, they seek to work together in order to better understand materials, so their work is the "sum of individual goals," which is one of the adjective sets used to describe groups [25]. Similarly, relationships and power structures between individuals in those groups may not be fully formed, or even necessary, which further aligns with characterizations of groups. An additional characteristic of groups that is demonstrated by these multi-person collaborations is that they may need to look outside of that collection of people in order to find certain answers or understand some concepts; all of the necessary knowledge is not always contained within the group, so external networking can be required.

6. Pedagogical Implications

Experienced engineers are acquainted with the notion that work happens in teams because that is the current model in industry. Team members usually have different skills, and this can create a better product than may have been possible otherwise [26]. Each team member's implicit knowledge contributes to the success of the project because of the depth of understanding each can bring. Team-based learning is not a new concept. The notion that team members learn better with and from peers has been documented not only in technical courses, but also in the social sciences [32]. Learning within a team can be understood as students co-creating knowledge rather than an instructor's providing concepts that students are then tested on. It is critical that teams are composed intentionally; that is, instructors who wish to see the greatest success within a team-based learning scenario will form teams with the most diverse skillsets. The criteria for sorting can include students' previous and current work experiences, undergraduate (and other) degrees, demographics, and so forth. This will allow the team to draw upon implicit knowledge not available to the individual student [39]. If Returner and Direct Pathway students are teamed up, the possibility for each to learn from the other can be maximized by observation and modeling, as Social Learning Theory predicts [40]. While being on a team is ostensibly a group, teams are a more intentional way for knowledge co-creation to occur.

One potential method that could bridge the gap in team abilities is using team contracts for class projects. When students are paired or grouped in order to complete course projects, a team contract can serve several purposes. First, it can protect against a specific individual being forced to do all of the project work, which would negatively impact that individual's view of teamwork and would prevent other members from learning about effective teamwork [28]. Additionally, a team contract can help to integrate the team and group knowledge from both Direct Pathway and Returner students. The benefits of team contracts were identified in Pertegal-Felices et al. [41]. In this study, students were divided into groups and asked to develop team contracts with rules for individual member contributions, how communication would occur, leadership roles, and how to deal with members who are not adequately performing, with several example strategies provided for dealing with nonperformance. In this study, students who signed a team

contract performed better in many teamwork-related areas. More students who signed a team contract believed that work was equitably distributed, and the teams who signed contracts demonstrated lower levels of conflict than groups who did not sign contracts. Communication levels in groups with contracts were also higher [41].

To add to the findings of Pertegal-Felices et al. and take advantage of the teamwork knowledge gained by individuals with work experience, several changes to the team contract process could be made. Before dividing the class into groups to develop the contract, a full-class discussion should be conducted in order to gain multiple perspectives on teamwork. Following this discussion, the individual groups would work on developing their contract based on their own needs and knowledge. Developing definitions of interpersonal roles should be encouraged for this process, since a solid interpersonal foundation is necessary for team formation. Finally, the class should be brought back together in order to compare contracts. Through these steps, Direct Pathway students with no work experience could gain the benefits of communicating with Returners and other students with work experience to help develop their own understanding of teamwork. This ability to communicate with other students would not be hindered by whether or not the group has a Returner or other individual with work experience in their group; however, attempting to include individuals with and without work experience in each group may also result in a favorable outcome. In courses with few students who have work experience, separating groups in that way would become more difficult.

Another method that educators could use to enhance teamwork learning in academic settings is the implementation of co-curricular activities. One study of how engineering students transition from academia to industry indicated that co-curricular activities could provide skills that are not often developed in the classroom [42]. The study suggested that communication, time management, leadership, and interpersonal skills may be better developed in co-curricular activities than in engineering curriculum. Some students who participated in this study indicated that the professional skills that they gained through internships, cooperative education, and co-curricular activities were often more important during their job search than the skills that they gained in the classroom, which may indicate a need to incorporate a larger variety of experience types in engineering education [42]. Co-curricular activities could be one method through which diverse extracurricular experiences outside of the classroom are integrated into the engineering curriculum. By combining extracurricular and curricular activities together, students can take advantage of both soft-skill development – including teamwork-type skills – from extracurricular activities and technical learning in the classroom.

Because many participants in this study identified teamwork as a fundamental component of engineering, it is imperative that academic institutions seek new methods for transitioning the classroom from group-based to team-based work. A recognition that groups and teams operate differently and have different uses is also important, since some groups will not require a transition to being a team in order to effectively meet their purpose. Study groups are an example of groups that do not need to become teams in order to be effective. Course projects, however, could be altered in order to encourage team-centric mindsets. In addition to requiring team contracts that better define interpersonal roles and how the team will function, projects could also focus on more innovative activities that must be highly collaborative. Structuring projects so that they are not merely the sum of the individual students' efforts on separate parts could help to form a more cohesive team.

The time required to form a cohesive team and to work on a more innovative or creative project may be substantial. Therefore, it may not be prudent for every course to be structured in this way. Some courses within a degree program would still benefit from the use of groups in order to decrease the workload on both students and faculty, while other course material may be more conducive to teams and innovation. Degree programs should be evaluated carefully in order to determine where teamwork would be most effective in the curriculum.

7. Conclusion

The results of this study showed that work experience is extremely important for engineers to build teamwork skills and team-centric mindsets. Academic experience is valuable for gaining knowledge of how to work in groups, but the variance between academic and industrial environments leads to a deficit in true "teamwork," based on survey and interview responses. Small amounts of work experience, including internships, seem to confer some level of teamwork knowledge to students, leading to the conclusion that Direct Pathway students can also develop team-centered mindsets depending on their level of work experience. Students with work experience show higher levels of confidence or mastery in teamwork skills, and team-based language is less common when describing academic settings than when describing an industrial envir-

onment. Teamwork was identified as a central concept in engineering, and it is therefore important for academic institutions help Direct Pathway students with no work experience develop an understanding of teams and teamwork.

Acknowledgements – This work was funded by the National Science Foundation under Grant #1463825. Additional funding for undergraduate research was received from the Kettering University Office of the Provost. The authors gratefully acknowledge this support.

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Olivia Gettel received her BS in electrical engineering from Kettering University in Flint, MI in 2020. She is a current MS student through Kettering University Online pursuing a degree in Electrical and Computer Engineering. Olivia works as a Manufacturing Controls Engineer at Nexteer Automotive, where she has been working since 2016. Her research interests include the impact of work experience on graduate engineering education and ethical and societal impacts of autonomous vehicle technology. She is a member of SWE and SAE.

Diane L. Peters received her PhD degree in mechanical engineering from the University of Michigan, Ann Arbor, MI in 2010. Her work experience prior to the doctorate included positions as an Engineer with A. B. Dick Company (1993–1995), as a Designer/Senior Designer for Mid-West Automation Systems (1995–1999), and as a Project Engineer at Western Printing Machinery Company (1999–2006). After her doctorate, she worked as a Senior Control Systems Engineer for LMS International from 2011 to 2013. She is currently an Associate Professor of mechanical engineering at Kettering University in Flint, MI. Her engineering education research interests focus on the impact of work experience on graduate engineering education. She is a member of ASEE, ASME, and SAE, a senior member of IEEE, and a Fellow of SWE.

Elizabeth A. Gross is Assistant Professor of Library Science and Technology at Sam Houston State University. She has a B. A. in History and German from Northern Michigan University, a Master's in Library and Information Science and a PhD in Learning Design and Technology from Wayne State University. Elizabeth was also Post-Doctoral Fellow at Kettering University. Prior to her current work, Elizabeth taught for twenty years in the Michigan Public School system. Her research interests include graduate engineering education, information needs of master's level and early career school librarians, perceptions of school librarianship, social justice in the school library, and the use of augmented reality in library navigation. She is a member of TLA (Innovation & Technology Roundtable Chair), TCEA, IASL, and ASEE.