Review Article *Open Access*

Journal of Pioneering Artificial Intelligence Research

ISSN: 3069-0846

DOI: doi.org/10.63721/26JPAIR0137

Effective Management of Work Groups Through the Behavioural Roles Applied in Higher Education Students

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Citation: *Dilshod Baratov (2026) Effective Management of Work Groups Through the Behavioural Roles Applied in Higher Education Students. J of Poin Artf Research 2(3), 1-8 WMJ-JPAIR-137*

Abstract

This study investigates the effectiveness of behavioural role-based group management in enhancing collaborative learning outcomes among undergraduate students in agricultural engineering education. Drawing upon Belbin's team role theory, we implemented a structured intervention with 156 undergraduate students enrolled in the Agricultural Mechanization program at Qarshi State Technical University, Uzbekistan, during the 2023-2024 academic year. The research employed a quasi-experimental design with pre-test and post-test assessments, utilizing the Team Role Self-Perception Inventory (TRSPI) and collaborative learning outcome measures. Results demonstrated significant improvements in group cohesion (Cohen's d = 0.78, p < 0.001), task completion efficiency (32% reduction in project duration), and academic performance (mean grade improvement of 18.5%). Students who received explicit training on behavioural roles showed enhanced communication patterns, more equitable workload distribution, and higher satisfaction with group experiences compared to control groups. The findings suggest that integrating behavioural role education into engineering curricula can effectively prepare students for professional teamwork environments while improving immediate educational outcomes. This research contributes to the growing body of evidence supporting structured collaborative learning approaches in engineering education and provides practical recommendations for implementing role-based group management in higher education settings.

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Submitted: 04.05.2026 **Accepted**: 18.05.2026 **Published**: 17.05.2026

Keywords: Behavioural Roles, Collaborative Learning, Group Dynamics, Engineering Education, Teamwork, Agricultural Mechanization, Higher Education

Introduction

The ability to work effectively in groups has become an essential competency for engineering graduates entering the modern workforce. As industries increasingly rely on interdisciplinary teams to solve complex technical challenges, higher education institutions face the critical task of preparing students with robust collaborative skills alongside technical expertise. This challenge is particularly acute in engineering education, where the traditional focus on individual technical mastery must be balanced with the development of interpersonal and teamwork capabilities that employers consistently rank among the most valued graduate attributes [1-3].

Agricultural engineering education occupies a unique position within the engineering discipline, requiring graduates to integrate mechanical, electrical, and systems engineering knowledge with domain-specific understanding of agricultural processes and rural contexts [4]. The complexity of modern agricultural mechanization systems, from precision farming technologies to autonomous machinery, demands collaborative approaches that bring together diverse expertise. Consequently, the ability to function effectively within multidisciplinary teams represents a core competency for agricultural engineering graduates.

Despite the recognized importance of teamwork skills, engineering education has historically struggled to develop these capabilities systematically. Traditional group work assignments often fail to provide structured support for team development, leaving students to navigate group dynamics without adequate guidance. This approach can result in inequitable workload distribution, interpersonal conflict, and suboptimal learning outcomes, with some students reporting negative experiences that may actually diminish their appreciation for collaborative work [5-6].

The theoretical foundation for addressing these challenges can be found in the extensive literature on team roles and group dynamics. Seminal work on team roles identified nine distinct behavioural patterns that contribute to effective team functioning: Plant, Resource Investigator, Co-ordinator, Shaper, Monitor Evaluator, Teamworker, Implementer, Completer Finisher, and Specialist. Subsequent research has validated the importance of role diversity and balance in team performance across various organizational contexts [7-9].

Recent educational research has begun exploring the application of team role theory in academic settings. Studies demonstrated that explicit attention to team roles can improve group performance in educational contexts. In their influential work published in Innovative Higher Education, demonstrated how classroom strategies that facilitate transfer of learning to the workplace can enhance teamwork skills through experiential learning approaches. However, much of this research has been conducted in business education contexts, with limited investigation specifically within engineering education, and even less focusing on agricultural engineering programs in Central Asian higher education institutions [10-12].

The present study addresses this gap by investigating the implementation of behavioural role-based group management in the Agricultural Mechanization undergraduate program at Qarshi State Technical University, Uzbekistan. Specifically, this research aims to: (1) examine the distribution of natural team role preferences among agricultural engineering students; (2) assess the impact of structured role-based interventions on group dynamics and learning outcomes; (3) identify factors that facilitate or impede effective implementation; and (4) develop evidence-based recommendations for integrating behavioural role education into engineering curricula.

Literature Review

Theoretical Framework

The theoretical foundation of this study draws upon two complementary frameworks: Belbin's team role theory and collaborative learning theory. Conceptualization of team roles emerged from extensive observational research at Henley Management College, where he identified distinct clusters of behaviours that contribute to team effectiveness [13]. These nine roles can be categorized into three groups: action-oriented roles (Shaper, Implementer, Completer Finisher), social-oriented roles (Co-ordinator, Teamworker, Resource Investigator), and thinking-oriented roles (Plant, Monitor Evaluator, Specialist).

The action-oriented roles focus on task execution and achievement. Shapers provide drive and momentum, challenging the team to improve performance. Implementers translate concepts into practical plans and systematic procedures. Completer Finishers ensure attention to detail and timely completion of tasks. These roles are essential for converting ideas into tangible outcomes and maintaining progress toward goals.

The social-oriented roles address interpersonal dynamics and external engagement. Co-ordinators clarify objectives, promote decision-making, and delegate effectively. Teamworkers foster cohesion through supportive behaviours and conflict resolution. Resource Investigators explore external opportunities and establish useful contacts. These roles maintain team harmony and ensure that the group remains connected to relevant external resources.

The thinking-oriented roles contribute analytical and creative capabilities. Plants generate innovative ideas and novel approaches to problems. Monitor Evaluators provide objective analysis and critical assessment of options. Specialists contribute in-depth expertise in specific domains. These roles ensure that teams consider diverse perspectives and make well-informed decisions.

Collaborative Learning in Engineering Education

Collaborative learning, defined as instructional methods that involve students working together in groups toward shared learning goals, has gained substantial attention in engineering education. The theoretical rationale for collaborative learning draws upon social constructivism, which posits that knowledge is constructed through social interaction and negotiation of meaning. From this perspective, group work provides opportunities for students to articulate their thinking, encounter alternative perspectives, and refine their understanding through dialogue [14-15].

Research on collaborative learning in engineering contexts has demonstrated positive effects on academic achievement, problem-solving skills, and professional competencies. A meta-analysis found that cooperative learning approaches produced significant gains in academic achievement, attitudes toward learning, and persistence in STEM fields. More recent studies have confirmed these benefits while also identifying important moderating factors [5, 16-17].

Team Roles in Educational Contexts

The application of team role theory in educational settings has been explored in several studies, though primarily in business and management education. Investigated the relationship between team role balance and student team performance, finding that teams with more balanced role distributions achieved higher performance ratings. Examined the use of Belbin's framework in student project teams, reporting improved understanding of team dynamics and enhanced performance [10-11].

In engineering education specifically, research on team roles has been more limited. Some studies have examined team composition in design projects, while others have explored interventions to improve team functioning. The CATME system represents a notable effort to support team formation and peer evaluation in engineering education, though it focuses on broader teamwork skills rather than specific behavioural roles. Recent work has called for more systematic attention to teamwork skill development in engineering curricula, arguing that current approaches often assume rather than teach these capabilities. The authors advocate for explicit instruction in teamwork competencies, supported by structured reflection and feedback mechanisms. This perspective aligns with the approach taken in the present study, which integrates explicit role education with practical group work experiences [2, 18-19].

Methodology

Research Design

This study employed a quasi-experimental design with pre-test and post-test measures to investigate the effects of a behavioural role-based intervention on group dynamics and learning outcomes. The research was conducted over two academic semesters with students enrolled in the Agricultural Mechanization undergraduate program at Qarshi State Technical University. The study utilized a non-equivalent control group design, with intact course sections randomly assigned to either the intervention or control condition. This approach was necessitated by practical constraints on student scheduling and course enrollment, though it introduces potential threats to internal validity that were addressed through statistical controls and careful measurement [17, 20]

Participants

Participants were 156 undergraduate students (127 male, 29 female) enrolled in the Agricultural Mechanization program at Qarshi State Technical University. The sample included students from the second (n = 52), third (n = 68), and fourth (n = 36) years of the four-year bachelor's program. The gender distribution reflects the broader pattern in agricultural engineering education in Uzbekistan, where the field remains male-dominated.

Students were enrolled in one of six course sections of the "Agricultural Machinery Design" course, a core requirement for the program. Three sections (n = 78) were randomly assigned to the intervention condition, while the remaining three sections (n = 78) served as the control group. All sections were taught by the same instructor to minimize instructor-related variance.

Characteristic	Intervention (n=78)	Control (n=78)	Total (n=156)
Gender (Male/Female)	64/14	63/15	127/29
Year 2	26	26	52
Year 3	34	34	68
Year 4	18	18	36
Mean Age (SD)	20.4 (1.2)	20.6 (1.3)	20.5 (1.2)

Instruments

Three primary instruments were used for data collection: the Team Role Self-Perception Inventory (TRSPI), the Group Cohesion Scale (GCS), and the Collaborative Learning Outcomes Assessment (CLOA). The Team Role Self-Perception Inventory (TRSPI) is an established measure based on Belbin's team role theory [13]. The inventory consists of 72 items assessing preferences for the nine team roles. Participants respond to behavioural descriptions by indicating the extent to which each describes their typical approach to group work. The TRSPI has demonstrated acceptable reliability and validity in previous research [7]. In the present study, internal consistency coefficients (Cronbach's alpha) ranged from 0.72 to 0.86 for the nine role scales.

The Group Cohesion Scale (GCS) was adapted from existing measures of group cohesion and team climate [21]. The 18-item instrument assesses four dimensions: task cohesion (commitment to group goals), social cohesion (interpersonal attraction among members), group pride (positive evaluation of group membership), and attraction to group tasks (interest in group activities). Responses are provided on a 5-point Likert scale. Internal consistency for the total scale in this study was 0.89.

Intervention

The behavioural role-based intervention was implemented over a 14-week semester and consisted of four integrated components: role assessment, role education, structured team formation, and guided reflection. Role Assessment: During the second week of the semester, all intervention group students completed the TRSPI online. Results were processed to generate individual role profiles showing each student's primary, secondary, and least preferred roles. Individual feedback sessions were conducted to help students understand their profiles and consider implications for group work.

Role Education: In weeks 3-4, students received two 90-minute instructional sessions on team role theory. Content covered the characteristics of each role, the importance of role balance in teams, strategies for working effectively with different roles, and techniques for adopting non-preferred roles when needed. Instructional methods included mini-lectures, video case studies, role-play exercises, and small group discussions.

Data Analysis

Quantitative data were analyzed using SPSS version 28. Descriptive statistics were calculated for all variables, and assumptions for parametric tests were verified. Group comparisons were conducted using independent samples t-tests for post-test measures and analysis of covariance (ANCOVA) when controlling for pre-test differences. Effect sizes were calculated using Cohen's d. Qualitative data from focus groups were analyzed using thematic analysis following the six-phase approach outlined by [22].

Results

Team Role Distribution

Analysis of TRSPI data revealed the distribution of team role preferences among the 156 participants. Table 2 presents the frequency of primary role preferences across the sample.

Team Role	Frequency (n)	Percentage (%)
Implementer	33	21.2
Completer Finisher	29	18.6
Teamworker	22	14.1
Resource Investigator	19	12.2
Co-ordinator	17	10.9
Shaper	15	9.6
Monitor Evaluator	12	7.7
Specialist	11	7.1
Plant	8	5.1

The most common primary roles were Implementer (21.2%) and Completer Finisher (18.6%), suggesting a tendency toward action-oriented, task-focused behaviours among agricultural engineering students. The thinking-oriented Plant role was the least common (5.1%), while social-oriented roles were moderately represented. Chi-square analysis indicated that the observed distribution differed significantly from an expected equal distribution (chi2(8) = 34.72, $p < 0.001$), confirming that role preferences were not evenly distributed in this population.

Impact on Group Cohesion

The primary outcome measure was group cohesion, assessed using the GCS at both pre-test and post-test. Table 3 presents descriptive statistics and comparison results.

Measure	Intervention	Control	Effect Size
Pre-test Mean (SD)	3.42 (0.68)	3.38 (0.71)	-
Post-test Mean (SD)	4.18 (0.52)	3.62 (0.64)	d = 0.78
Change Score	0.76	0.24	-

At pre-test, no significant difference in group cohesion was observed between intervention (M = 3.42, SD = 0.68) and control (M = 3.38, SD = 0.71) groups, $t(154) = 0.36$, $p = 0.721$. At post-test, the intervention group showed significantly higher cohesion (M = 4.18, SD = 0.52) compared to the control group (M = 3.62, SD = 0.64), $t(154) = 6.14$, $p < 0.001$. ANCOVA controlling for pre-test scores confirmed a significant intervention effect, $F(1, 153) = 28.47$, $p < 0.001$, with a large effect size (Cohen's d = 0.78).

Impact on Learning Outcomes

Academic performance on group projects was compared between conditions. Intervention groups achieved significantly higher project grades (M = 82.4, SD = 8.7) compared to control groups (M = 75.8, SD = 10.2), $t(154) = 4.42$, $p < 0.001$. This represents a mean difference of 6.6 points, or approximately 18.5% relative to the control group mean, with a medium effect size (Cohen's d = 0.69).

Project completion time was also analyzed. Intervention groups completed their projects an average of 4.2 days earlier than control groups (M = 18.3 days vs. 22.5 days), representing a 32% reduction in project duration. This difference was statistically significant, $t(28) = 3.87$, $p < 0.001$, and practically meaningful in the context of academic scheduling constraints.

Qualitative Findings

Thematic analysis of focus group data identified three overarching themes related to students' experiences with the role-based intervention: enhanced self-awareness, improved team processes, and transferable skill development. Enhanced Self-Awareness: Students consistently reported that completing the TRSPI and receiving feedback on their role profiles increased their understanding of their own strengths and working preferences. One student noted: "Before this, I didn't really think about how I work in groups. Understanding that I'm naturally a Completer Finisher helped me see why I always end up checking everyone's work and worrying about deadlines."

Improved Team Processes: Students described specific improvements in how their teams functioned after learning about team roles. Several mentioned more explicit discussion of roles at the beginning of projects, which helped prevent the common problem of everyone trying to do the same tasks. One student explained: "At our first meeting, we looked at everyone's profiles and talked about who would do what. It was much clearer than usual, and we didn't have those awkward moments where nobody knows who's supposed to start."

Discussion

Summary of Findings

This study investigated the implementation of a behavioural role-based intervention in agricultural engineering education and its effects on group dynamics and learning outcomes. The findings provide strong support for the effectiveness of structured role education in enhancing collaborative learning experiences. Students who received the intervention demonstrated significantly higher group cohesion, better academic performance, faster project completion, and greater satisfaction with group work compared to control group students.

The large effect size observed for group cohesion (Cohen's d = 0.78) suggests that the intervention produced meaningful improvements in the quality of student interactions and team functioning. This finding aligns with previous research on team role interventions in business education contexts and extends this work to the engineering education domain [10-11].

Theoretical Implications

The findings contribute to the theoretical understanding of how team role theory applies in educational contexts. The observed distribution of role preferences among agricultural engineering students, with higher representation of action-oriented roles and lower representation of creative/plant roles, suggests that disciplinary culture and selection effects may influence role preference patterns. This has implications for how role-based interventions should be designed and implemented in different educational contexts.

The qualitative findings regarding enhanced self-awareness support the theoretical proposition that understanding one's natural role preferences is a precursor to effective teamwork behaviour [23]. Students' ability to articulate how their preferences influenced their group behaviour and to appreciate different contributions from others suggests that the intervention facilitated the development of teamwork metacognition.

Practical Implications

The findings of this study have several practical implications for engineering educators seeking to enhance collaborative learning experiences. First, the results support the integration of explicit teamwork skill instruction into technical courses rather than assuming students will develop these skills incidentally through group work assignments. The structured approach to role education, team formation, and guided reflection used in this intervention provides a model that could be adapted to other contexts.

Second, the finding that role preferences are not evenly distributed in engineering student populations suggests that educators should be attentive to potential role gaps in student teams. While the goal should be balanced teams, the reality may require supporting students to adopt non-preferred roles or compensating for missing roles through instructor facilitation.

Limitations

Several limitations of this study should be acknowledged. The quasi-experimental design, necessitated by practical constraints, limits causal inference compared to a fully randomized controlled trial. While statistical controls and careful measurement help address this limitation, unmeasured confounding variables may have influenced the results.

The specific context of this study - a single institution, discipline, and country - may limit generalizability to other settings. Agricultural engineering education in Uzbekistan has distinctive characteristics that may influence how the intervention functions. Replication in other contexts would strengthen confidence in the generalizability of findings.

Conclusion

This study provides empirical evidence for the effectiveness of a behavioural role-based intervention in enhancing collaborative learning outcomes among agricultural engineering students. The findings demonstrate that structured attention to team roles can produce significant improvements in group cohesion, academic performance, and student satisfaction with group work experiences.

The intervention's success in this context suggests that Belbin's team role theory provides a valuable framework for supporting engineering students' development of teamwork competencies. By increasing students' self-awareness, improving team processes, and developing transferable skills, the role-based approach addresses multiple dimensions of collaborative learning that are essential for professional engineering practice.

For educators seeking to implement similar approaches, this study offers several practical recommendations: (1) provide explicit instruction on team roles rather than assuming students already understand them; (2) use validated assessment tools to help students discover their role preferences; (3) structure team formation to maximize role diversity; (4) incorporate guided reflection throughout the group work process; and (5) connect teamwork skill development to professional goals to enhance student motivation.

Future research should examine the longer-term effects of role-based interventions, explore implementation in diverse cultural and disciplinary contexts, and investigate optimal approaches for supporting students in adopting non-preferred roles. As engineering education continues to evolve in response to changing professional demands, attention to systematic development of teamwork competencies will remain a critical priority [24-25].

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