

From Research to Practice: Lessons Learned from Developing Inclusive Teaching Toolkits in STEM Education

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Introduction

Group and team-based learning is a cornerstone of engineering and STEM education, reflecting the collaborative nature of professional practice and the increasing emphasis on employability skills. Graduates are expected not only to demonstrate technical competence, but also to work effectively in diverse teams, manage conflict, communicate clearly, and share responsibility for complex problem-solving. Research consistently demonstrates that collaborative learning can enhance motivation, creativity, deeper learning, and reflective practice when implemented effectively [1,2]. As a result, groupwork has become a common feature of engineering curricula, from laboratory work to capstone design projects. The benefits of collaborative learning are not automatically realised and without explicit structure and support, groupwork can exacerbate inequities, generate frustration, and negatively affect both learning outcomes and student wellbeing. Common challenges include unclear roles and expectations, uneven task distribution, poor communication, and limited psychological safety within teams [3, 4]. These issues are particularly noticeable in STEM contexts, where strong disciplinary identities and performance pressures can discourage seeking help and open dialogue.

For marginalised students, these challenges can be further intensified. Research highlights how stereotype threat, unequal role allocation, and socially patterned participation can undermine students' sense of belonging and limit access to meaningful learning opportunities [5, 6]. For example, gendered task division in laboratory and project work can restrict participation in high-value technical tasks, reinforcing inequities even within seemingly collaborative environments. These dynamics not only affect academic outcomes but also shape students' confidence and professional identity development. In parallel, instructors also report challenges in designing, facilitating, and assessing effective teamwork. Educators often struggle with structuring collaborative activities, assigning and rotating roles, supporting team dynamics, intervening in conflict, and assessing individual contributions fairly. Despite the centrality of teamwork in curricula, many educators, particularly in engineering, receive little formal preparation in groupwork pedagogy. Teamwork is frequently assessed as an assumed skill rather than taught as a learnable capability.

At Queen Mary University of London (QMUL), these challenges intersect with a strategic commitment to inclusion. QMUL's strategy articulates an ambition to become "an inclusive, diverse environment where students and staff thrive [7]. Collaborative learning environments are therefore critical sites for advancing institutional values around inclusion, belonging, and wellbeing. However, there remains a gap in both faculty- and student-facing resources that translate research on inclusive teamwork into practical, scalable tools that can be embedded within everyday teaching practice.

In response, this project was situated within a STEM teaching context where group and team-based assessments are widely used, particularly in engineering programmes. While

collaborative learning is embedded across curricula, formal support for educators in facilitating inclusive and effective teamwork remains uneven. Many instructors rely on ad hoc strategies or personal experience when managing team dynamics, conflict, and assessment fairness. This context highlights the need for practical, evidence-informed resources to support educators in designing, facilitating, and evaluating groupwork more equitably. To address this need, a participatory design approach was adopted to develop an inclusive teamwork toolkit and institutional web resource. This paper presents the development and early-stage insights from this intervention, focusing on feasibility, usability, and educator perceptions rather than student learning outcomes.

Conceptual Framing

While collaborative learning is widely recognised as beneficial, research consistently demonstrates that its effectiveness depends on how it is structured and facilitated. Foundational work on cooperative learning emphasises the importance of elements such as positive interdependence, individual accountability, and structured interaction in supporting effective teamwork [1]. In engineering education, frameworks such as structured team design [8] and peer evaluation systems have been developed to address common groupwork challenges. However, these approaches primarily focus on team effectiveness and performance, rather than on issues of inclusion and equity. Research in STEM education highlights persistent inequities in collaborative environments, including gendered division of labour, uneven participation, and differential access to leadership roles [6,8]. These dynamics can limit both learning opportunities and students' sense of belonging, particularly for those from underrepresented groups. Although concepts such as psychological safety and inclusive participation are increasingly recognised as important, they are often treated as abstract principles rather than operationalised practices. As a result, educators may be aware of these concepts but lack concrete strategies for embedding them within teaching.

Existing tools, such as CATME and teamwork diagnostic frameworks [9], provide valuable support for assessing team functioning and individual contribution. However, they are primarily oriented toward assessment rather than supporting the development of teamwork practices during learning. They offer limited guidance on low-threshold, classroom-integrated activities that enable educators to proactively foster inclusive teamwork. This points to a persistent gap between research-informed principles and their application in everyday teaching. While the literature offers strong theoretical and structural foundations, there remains a need for practical, educator-facing resources that translate inclusive teamwork into actionable teaching strategies. This study addresses this gap through the development of an embedded toolkit designed to integrate inclusive practices directly into teaching workflows.

Within this study, inclusive teamwork is operationalised through a set of observable teaching and learning practices. These include structured role rotation, explicit discussions of shared values, guided communication activities, and the use of team charters to establish accountability. Together, these practices distinguish the approach from general teamwork support by making expectations around participation, communication, and responsibility

explicit, transparent, and open to reflection. This study contributes to existing work on teamwork in engineering education in three ways. First, it shifts focus from assessment and team effectiveness to the operationalisation of inclusive teamwork practices. Second, it adopts an embedded approach that integrates teamwork development into teaching workflows, rather than relying on ad hoc interventions. Third, it combines instructor-facing and institutional-level resources developed through participatory design, addressing both individual teaching practice and systemic support.

Method

This study adopts a practice-oriented, exploratory design focused on the development of an educational intervention to support inclusive teamwork in engineering education. A participatory design approach was used to ensure that the resulting resources were relevant, usable, and aligned with authentic teaching contexts. Rather than producing prescriptive guidance, the project engaged educators, educational developers, and student representatives at multiple stages of development, enabling iterative refinement based on stakeholder input.

The study included 22 instructors who took part in an initial exploratory workshop, a smaller group of educators and educational developers who contributed through follow-up discussions and feedback activities, and 20 student programme representatives who reviewed the staff-facing web resource. Table 1 shows the mapping from data source to design decision. Participation across all stages was voluntary.

Table 1: Data to design table

Data source	Purpose	Analysis Approach	Design Output
Workshop (n=22)	Identify challenges	Thematic analysis	Toolkit and web resource themes
Focus group (n=9)	Evaluate usability	Thematic analysis	Refinement
Student representatives (n=20)	Assess clarity	Feedback synthesis	Web resource improvement

Data collection

Data collection was carried out through a series of formative engagement activities designed to both inform the design of the resources and generate insights into current groupwork practices. The exploratory workshop with 22 instructors served as a key starting point. The workshop functioned not only as a data collection activity but also as a co-design space, shaping both the structure and pedagogical focus of the toolkit and web resource. This session was structured to include individual reflection, small-group discussions, and facilitated whole-group sharing. Participants were asked to reflect on their experiences of designing, facilitating, and assessing groupwork, and to identify common challenges encountered in practice. Discussions focused on key areas such as group formation, role allocation, conflict management, student wellbeing, and the assessment of individual

contributions. The workshop also included initial exposure to emerging ideas for resources, allowing participants to comment on potential usefulness and applicability. The themes generated through this workshop directly informed the structure and content of the subsequent SharePoint-based web resource.

In parallel, an instructor-facing toolkit comprising a slide deck and accompanying lesson plans was developed by a doctoral researcher acting as a research assistant on the project. Drawing on relevant literature on collaborative learning and inclusive practice, these materials were designed to support educators in facilitating structured classroom discussions around shared values, psychological safety, communication, and reflection within group-based assessments. The development process was iterative, with feedback from academic staff used to refine the content, tone, and facilitation guidance to ensure accessibility and practical relevance for instructors with varying levels of experience in groupwork pedagogy.

Additional feedback was gathered through informal follow-up discussions and a focus group involving educators and educational developers, which provided further insight into the usability and feasibility of the resources. Student perspectives were incorporated through the review of the web-based resource by 20 student programme representatives. Their feedback focused on clarity, accessibility, and transparency, particularly in relation to how expectations around teamwork are communicated to students. This input informed revisions to the structure and language of the web resource. At this stage, direct student feedback on the instructor-facing slide-based materials has not yet been collected.

Data from these activities were analysed using a thematic analysis approach. The analysis focused on identifying recurring patterns related to challenges in collaborative learning, perceptions of resource usability, feasibility of implementation, and educator confidence in facilitating teamwork. Insights from each data source were used both to inform iterative refinement of the resources and to develop an understanding of the conditions that support or constrain their use in practice. By linking stakeholder input directly to design decisions, the study aimed to ensure transparency in how the resources were developed and grounded in real teaching contexts.

Toolkit outputs: From research to practice

The project produced two complementary outputs designed to support inclusive and effective teamwork in STEM education: an instructor-facing teaching toolkit and a university-wide, staff-facing web resource. Together, these resources aim to translate research-informed principles into practical tools that can be embedded within existing teaching and assessment practices.

1. Instructor toolkit

The instructor toolkit comprises a slide deck, lesson plans, and instructor script intended for use ahead of, or alongside, group-based assessments. The materials are designed to support educators in explicitly addressing teamwork as a learnable skill, rather than an assumed

competence. Core components include structured activities focused on shared value setting, psychological safety, inclusive communication, conflict resolution, and reflection. A central feature is a values-to-actions team charter, which guides student teams in translating agreed principles into concrete behaviours, roles, and accountability mechanisms.

The toolkit is designed to be adaptable across disciplines and levels, with engineering specific examples used to illustrate relevance to professional practice. The script is included to support educators with varying levels of experience in groupwork pedagogy.

2. University-Wide Web Resource

The staff-facing web resource was developed as a centralised institutional platform to support decision-making around the design, management, and assessment of groupwork. Hosted on SharePoint, it provides principles of effective teamwork, guidance on inclusive practice, and downloadable materials aligned with the instructor toolkit. By situating the resource within an institutional platform, the project sought to enhance visibility and long-term sustainability of inclusive teamwork practices.

Results: Early insights and lessons learnt

Although formal evaluation of teaching implementation and student outcomes is ongoing, early insights reported here are drawn from multiple formative feedback activities detailed above. Together, these activities informed iterative refinement of the resources and surfaced recurring themes relevant to inclusive teamwork practice.

1. Widespread recognition of groupwork challenges

Across the initial workshop and subsequent focus group discussions, participants consistently recognised groupwork as both essential for employability and one of the most challenging aspects of assessment. Educators reported limited confidence in facilitating team dynamics, addressing conflict, or supporting equitable participation. This highlights a gap between curricular expectations and pedagogical preparation.

2. Shared Values as an accessible entry point for inclusion

Feedback from focus group indicated that framing teamwork through shared values was perceived as a practical and non-threatening way to address issues of fairness, responsibility, and participation. This approach resonated with both engineering academics and educational developers, as it aligned with professional practice while implicitly embedding inclusion and wellbeing.

3. Making psychological safety practical

Abstract concepts such as psychological safety were better received when embedded in concrete teaching tools, including team charters, feedback-rephrasing activities, and reflection prompts. These tools provided a shared language for challenges that students often experience but struggle to articulate.

4. What makes resources usable in practice

Ease of use, time demands, and adaptability were central to educators' perceptions of feasibility. Resources that integrated smoothly into existing teaching structures were viewed as more likely to be adopted, particularly by staff without formal training in groupwork pedagogy.

5. The need for complementary Student-Facing Resources

Across staff feedback and student representative review of the web resource, there was a shared view that instructor-facing tools alone are insufficient. Many groupwork challenges stem from students' lack of explicit guidance on how to collaborate effectively, indicating a clear need for a complementary student-facing toolkit.

Discussion and limitations

This study highlights the importance of treating teamwork as an explicit, teachable capability. The findings suggest that practical, embedded resources can support educators in integrating inclusive teamwork practices into everyday teaching. The participatory design approach ensured alignment with real teaching contexts, supporting usability and relevance. Unlike ad hoc methods that address issues as they emerge, the embedded approach integrates teamwork development proactively within teaching design, minimising the need for reactive interventions. This shift from reactive problem-solving to proactive skill development is a key distinction between the two approaches. However, factors such as assessment design, time constraints, and student preparedness still influence implementation. This study has several limitations. The sample size is small and based on voluntary participation, introducing potential self-selection bias. Findings are based on educator perceptions and early-stage feedback, with no direct student data included. As such, conclusions are exploratory and focused on feasibility and usability.

Conclusion

This paper presents the development of an inclusive teamwork toolkit designed to support educators in embedding structured and inclusive collaborative practices within engineering education. The findings indicate that practical, adaptable resources can enhance educator confidence and support the integration of teamwork as a teachable capability within existing curricula. At the same time, the study highlights that the effectiveness of such interventions is shaped by broader factors, including curriculum design, educator preparedness, and the availability of complementary student support.

Future work will focus on the systematic evaluation of the toolkit's impact on student experience, participation, and perceptions of fairness in groupwork. In addition, the findings point to the need for a complementary student-facing toolkit to support the development of shared language, expectations, and collaboration skills. Together, these efforts aim to strengthen institutional capacity to support inclusive and equitable teamwork practices in STEM education.

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