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Engineering Students' Conceptions of Collaboration, Group-Based Strategy Use, and Perceptions of Assessment in PBL: A Case Study in Qatar*

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This study has investigated the natures of collaboration, group-based strategy use, and perception of assessment, as well as interactions among these aspects, by examining group performance in engineering students' first experiences of a problem and project-based learning (PBL) method. Empirical evidence was gathered from focus groups and observations of 91 engineering students in Qatar who worked in 17 project teams. Qualitative analysis results identified three patterns of conceptions of collaboration and five categories of group-based strategies in a hierarchical order. Findings of the study extended the current understanding of self-regulated learning by providing evidence from a group form in a collaborative learning setting. Characteristics of Middle Eastern students are highlighted regarding their favoring division of tasks and relying on seniors as major sources of knowledge authority. Quantitative analysis identified a significant relation among conceptions of collaboration, group-based strategy use, and team performance. Students' perceptions of assessment remain diverse, suggesting it may take longer than expected for students to gain a deep understanding of constructively aligned alternative assessment in PBL. The results provide a few implications for instructional design in general and PBL implementation in particular.

Keywords: conceptions of collaboration; group-based strategy use; perception of assessment; PBL; Qatar

1. Introduction

Over the past two decades, the inclusion of collaborative learning in engineering curricula has been suggested as a means of preparation for future professional practice [1–3]. In particular, problem and/or project-based learning (PBL) has been highlighted as a viable option, since in such an environment, teamwork is specifically emphasized to promote a process of peer learning and co-construction of new knowledge [4]. While a rich body of literature has reported the effectiveness of teamwork on engineering students' academic achievements [1, 5, p. 3], several studies have reported how engineering students have also improved self-satisfaction, enjoyment, motivation, and potential for developing competencies for future engineering work through collaborative learning [6–10]. Nevertheless, little is known about how engineering students' experience the teamwork process, such as how they conceive of collaboration and develop collaborative learning strategies in a PBL environment. While the past decade observed several debates on ways to assess team projects effectively, little consensus has been reached [1]. Although numerous studies suggested alternative assessment methods to enhance teamwork [4, 11], little has been reported on how students perceive these methods and what types of assessment they believe to be appropriate. Accordingly, more studies are necessary to examine students' collaborative strategy use, conceptions of collaboration, and perceptions of alternative assessment methods in a team project setting, particularly in a situative and context-sensitive approach [11, 12].

In the Middle Eastern context, although problem-based learning has been practiced in a few medical schools [13], project-based learning (PBL) remains a new phenomenon in engineering education. Over the past few years, the Australian College of Kuwait has adopted PBL in their engineering curriculum and reported positive experiences from students' points of view [14], but further educational and research attention is needed on implementing PBL in the Middle Eastern context. Qatar University (QU), being the country's foremost higher

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educational institution, is engaged in promoting educational innovation. Following this initiative and due to compliance requirements set by the Accreditation Board for Engineering Technology (ABET), the College of Engineering encouraged instructors to implement PBL in engineering courses within the current curriculum. In 2018, three courses in Civil Engineering were taught using PBL pedagogy in response to such an initiative. Therefore, there is a pressing need for more efforts to understand how students experience the process of their first PBL encounters [9].

To enhance pedagogical innovation successfully, particularly for students from a context where lectures are the prevailing teaching method in a teacher-centered environment, it is important to gain a profound understanding of how students traverse the learning process and what challenges they encounter [15]. Therefore, this study aims to explore how engineering students develop learning strategies in a team project setting, what forms of collaboration they develop, and how they perceive alternative assessments for team projects during their first experience of such. Another purpose of the study is to investigate the interactions among the above-mentioned factors and their relation to student academic performance. The study takes its theoretical departure from the notions of self-regulated learning and a social mode of regulation from a sociocognitive perspective, as well as social constructivism approach to learning and assessment. The empirical sources of the study were three engineering courses which implemented a problem and project-based learning method. Qualitative data was generated from participant observation and focus groups conducted with 91 students working in 17 project teams. A qualitative approach was used to identify patterns of conceptions of collaboration and group-based learning strategies, and a "quantifying qualitative data approach" [16] was used to analyze the correlation among concepts of collaboration, group-based strategy use, and team performance.

2. Literature Review

2.1 Learning Strategies – from Individual to Collaborative

Having emerged from a sociocognitive perspective [17, 18], the notion of self-regulated learning (SRL) emphasizes learners' active participation in the learning process, considering learners as constructors of knowledge rather than recipients of information [19–21]. According to Zimmerman, "students can be described as self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning process" [20, p. 329]. SRL is a useful tool for individuals to develop strategies in their individual learning process within certain contexts and situations [22]. For this to apply, a self-regulated learner shall have skills including: setting specific proximal goals for oneself; adopting powerful strategies for attaining the goals; monitoring one' s performance selectively for signs of progress; restructuring one's physical and social context to make it compatible with one's goals; managing one's time use efficiently; self-evaluating one's methods; attributing causation to results; and adapting future methods [23]. Further, Pintrich [19] has identified a four-phase model including learners' development of cognitive, metacognitive, and motivational strategies: (1) goal setting, forethought, planning, and activating prior knowledge; (2) monitoring, elaboration, and organization; (3) controlling, adaptation, and critical thinking; and (4) reaction and reflection.

Existing literature has provided abundant evidence on development and interaction among aspects including individual performance, strategies, efficacy, behaviors, goal-setting, and self-evaluation with targeted intervention such as PBL [15, 24, 25]. While the role of social context has evolved over the decade, little empirical evidence has been documented on the social nature of learning [12, 26], and even less is known on how learners develop strategies in a group form [11]. Taking a bidirectional view of the interaction between evolved factors and human adaptation and change, social cognitive theory emphasizes the mutual influence between learners and their environment while also acknowledging the increasing complexity in the evolutionary process [18]. Thus, social context is central in shaping and influencing student self-regulation regarding defining conditions for tasks, establishing standards, feedback, modeling, and self-evaluation [26]. Therefore, increased research efforts are called for to address SRL strategy use in a collaborative learning setting such as PBL, particularly in a sociocultural context where lectures remain the prevailing teaching method [11].

2.2 Conceptions of Collaboration

Collaborative and cooperative learning are being increasingly adopted in classroom instruction at all educational levels, based on the premise that not only self-regulation but also social modes of regulation arise in the learning process [27, 28]. Although there is no agreed-upon way to define and distinguish between collaborative and cooperative learning, it is argued that collaborative learning emphasizes "truly joint efforts" [29, p. 2] while cooperative learning focuses on "the labour [being] divided in a systematic way" [29 p. 2]. With no intention to distinguish between these two terms, collaborative learning is used in the current study to indicate a process with an ultimate goal of encouraging learners to share and co-construct knowledge among team members [27, 29, 30].

The social mode of regulation may appear in many settings, but in this study, we mainly focus on collaborative learning in a social context of project teamwork and exclude settings such as parent-child and teacher-student interactions [28]. A project team, referring to a group of individuals working on interdependent tasks within a defined time period with shared responsibilities and goals such as achieving certain results or generating a specific product [31, pp. 390–91], is a major format of organizing collaborative learning in engineering PBL. A rich body of literature has reported benefits of collaborative learning on students' attitude and motivation [3], academic achievements, and retention in engineering programs [1, 5, 32]. Previous studies also suggested that collaborative learning activities are not successful unconditionally, but are rather related to a variety of factors, including students' ability, numbers of collaborations, gender, and engagement in cognitive processes such as working toward a common goal, peer questioning, and elaboration, among others [3, 5].

2.3 Collaborative Learning in PBL in Engineering Education

While a prevailing interest in research on collaborative learning in engineering education lies on team effectiveness, there is less research on understanding how students conceive of and develop ideas on collaboration. In addition, although the literature agrees that collaboration is coordinated, synchronous goal-oriented activities require active participation, negotiation of meanings, dealing with social conflicts, and co-construction of deep understanding and knowledge [1, 33]. Furthermore, recent studies have suggested that learners' views on collaboration are culturally sensitive. For example, Zhao and Zheng [11] found that Chinese students' conceptions of collaboration are surrounded by the diverse roles of group leaders, and Du, Su and Liu [6] found Chinese engineering students tended to rely on the instructors and seniors as the major authority and prime information source in their team projects. Refeque, Balakrishnan, Inan, and Harji [34], in their survey focused on diploma degree students in Oman, found that over 64.6% of 274 participants preferred having one group leader to coordinate and divide tasks among members. Our recent comparative study [9] also suggested that despite the improved acknowledgment of the role of knowledge building and collaborative learning through their first PBL experience, engineering students in Qatar and China reported concerns of potential consequences of team work influencing their individual achievements. Therefore, while collaborative learning is being increasingly integrated into engineering programs in diverse social and cultural contexts, there is a need to better understand how engineering students conceive collaboration and develop collaborative work in a project team setting.

Definitions of PBL vary, referring to either problem or project-based learning. In this study, PBL is used to refer to a problem and project-based learning method. The emphasis on a problem refers to "an instructional learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" [35, p. 7]. The focus on a project links the contexts of teamwork and collaborative learning into the process of shared project work. Taking its departure from social constructivism, PBL emphasizes meanings generated by learners rather than the mere memorizing of the "right" answers. Problem-solving, which is relevant to the learners' interests and needs, plays a central role in learning. Learning is not only an outcome but also a process of experiencing things in the world through solving problems and generating meanings [36], and through transforming the experiences of living into knowledge, skills, attitudes, and beliefs so that individuals might develop [37]. With an emphasis on dialogue and interaction among learners, social constructivism also highlights collaborative learning. The role of learners as constructors of interaction is highlighted for cognitive development through interfacing with other people in processes of engaging in activities to co-construct understanding and new knowledge [38]. Through the interaction, learners encounter conflicts or different opinions, so they are encouraged to search for more information, explanation, discussion, justification, assimilation, and accommodation, which involves a meaningful process of learning together.

In particular, collaborative learning is regarded as essential for profession-oriented educational programs, as stated by Michaelsen, Parmelee, McMahon, Levine, and Bilings in the assertion that "students need to learn and apply the power of reason gained through critical thinking before offering viewpoints and to apply this same approach when evaluating statements made by others" [39, p. 80]. The authors also argue that the process of accomplishing this demands an interactive process of learning and reflecting together with peers, which is highly important for developing profession-related competencies. In engineering classrooms, collaborative activities can be provided through activities organized by the instructors or in informal forms volunteered by students [40]. In a PBL setting, collaborative learning is central to teaching and learning activities and often organized through project teams, and the instructors' role shifts from providing correct answers and factual information to designing and facilitating learning [41].

2.4 Alternative Assessment and Teamwork

The assessment remains an essential concern when implementing teaching and learning innovation. Embedded in a constructivism approach, the model of constructive alignment [42] underlines agreement among intended learning outcomes, assessment methods, and the learning process. While the concept of constructive alignment has been influential in helping instructors with course designs across various disciplines in higher education [43], it is also in line with the principles of PBL design and practice. This means when implementing PBL, alternative assessment shall be adapted to be compatible with the goals and principles of PBL in order to better facilitate deep learning and higher-level learning outcomes. Relating this framework to PBL designs and practices, the principles include: (1) developing learning goals and outcomes, including student needs, interests, motivation, and context; (2) organizing teaching activities (e.g., PBL) to reach these goals, including adjusting the curriculum and syllabus to address students' prior experience, using problems that are relevant to students, constructing learning around principal concepts, and appreciating students' perspectives; and (3) linking assessment tools to learning goals and student learning activities (PBL).

Multiple sources of assessment are often encouraged, with emphasis on context-based learning and the learning process in a PBL environment [44]. As an alternative to conventional summative assessments, formative assessment intending to generate feedback on learner performance to improve learning is often used to facilitate self-regulated learning [41, 44]. In particular, using well-tailored assessment rubrics and criteria is highly encouraged to help students in engineering programs focus on learning objectives rather than only on marks [45, 46]. In addition, a computer-supported learning management systems model is also reported to be a useful tool to assess PBL learning processes and outcomes in engineering programs, integrating diverse skills such as communication, interaction among team members and with the instructor, engagement with active learning, feedback, and peer evaluation [47].

While previous studies provided evidence of the connection between team effectiveness and engineering students' academic achievements [1, 5], and earlier studies have suggested an association between students' views on collaboration and the approaches and strategies they develop in team projects [9, 11], limited empirical evidence has been reported on the interaction among all these aspects. Therefore, more research is needed to examine the relationship between students' reported engagement in collaborative learning and their academic achievement [3].

Embedded in learning theories that focus on social and situated processes [37], the present study was conducted in a context of initial implementation of PBL in engineering education to yield a deep understanding of interactions between students' conceptions of collaboration, their strategy use in a collaborative learning setting, and their perception of assessment, as well as the association of these interactions with the outcomes of their team projects. This study is centered on the following research questions:

1. How do engineering students conceive collaboration in their team projects?
2. How do engineering students develop group-based strategies in their initial experience of PBL?
3. How do students perceive the alternative assessment practices in PBL?
4. Is there a significant correlation among students' strategy use, forms of collaboration, and the outcome of their team project performance?

3. Methods

3.1 Research Context

The study was carried out during the spring and fall semesters of 2018 in three third-year/fourth-year civil engineering courses at the College of Engineering, Qatar University. The course instructors first participated in a professional learning program for the problem-and project-based learning method (PBL), after which they volunteered to implement PBL in their own classes. All three courses were designed collaboratively by researchers of this study, following PBL principles suggested for engineering education in general [4]. The three courses in the current study were the first PBL experiences for both instructors and students, who were otherwise used to a lecture-based teaching method. Considering this background, course instructors designated an overall theme based on a real-life engineering design problem in the construction and civil engineering field. Students worked in teams to focus on a particular aspect of the theme, pushing toward the same learning objectives in each course. Lecture time was reduced to less than one-third of the total contact hours, the instructors provided materials on

Blackboard (online sources), and two thirds of the overall classroom time was spent on team projects. The instructors walked around the groups as they worked, providing discussion and advice for the students. Alternative assessment methods were designed to be constructively aligned with the course objectives and PBL activities [42]. Instead of using 100% individual written exams, the PBL course exams consisted of 70% group project assessments throughout the semester (divided into stages of project progression) and 30% individual assessments.

3.2 Participants

All civil engineering students from the three courses (n = 93) were invited to participate in this study. A total of 88 (95%) students participated in 17 focus groups. Participants were only male, as the undergraduate civil engineering program is not available for female students. Table 1 provides an overview of participant information.

3.3 Data Sources

The prevailing method for SRL, a measurement by student self-reported questionnaire survey, has been criticized for not providing opportunities to adequately capture the contextual and emerging nature of strategy use [12]. To address the complex nature of strategy use in a group-based form and to be able to identify emerging patterns in a unique instructional context in the current study, a qualitative approach to data generation was employed. To gain multiple sources of data, participant observations [48] and focus groups [49] were conducted and analyzed to reveal the contextual and dynamic nature of how engineering students in Qatar develop SRL strategy and teamwork in their initial PBL encounter.

Participant observation was conducted to gain a deep understanding of students' experiences in the process of implementing PBL. Two of the coauthors, who were also instructors of the three courses, played a dual role in the classroom: PBL facilitator and observer of students' reactions, progression, strategy use, interactions, discourses, and practices [50]. This intensity of time spent with students helped the authors to better understand the students' experiences, which were used for an overall judgment of students' strategy use and forms of teamwork, and for triangulation with focus group data.

Focus groups were conducted at the end of the program as a method of understanding participants' overall experiences and promoting further reflection. For the purpose of understanding group-based strategies and forms of teamwork, the focus groups were organized by project teams. Following interview techniques suggested by Kvale and Brinkmann [49], the focus groups included semi-structured questions and emerging topics for conversation to promote further reflection. During the focus groups, participants were invited to share their first experiences of participating in PBL: how they formed groups and how they structured their project process and group work, including goals, project planning, learning sources, communication forms, team dynamism, challenges, and coping strategies. Probing and confirming questions were asked, allowing opportunities for the participants to elaborate on individual thoughts in addition to group decisions. The focus groups, conducted in English (same as their study language) and lasting 40–60 minutes each, were audio-recorded and transcribed for content analysis.

3.4 Data Analysis

This study adopted a "quantifying qualitative data" approach for data analysis [16]. The method has been well-used in cognitive sciences and was recently introduced to educational studies [7, 11]. Qualitative data was analyzed in an inductive and deductive approach. First, following Pintrich's 4-phase model of SRL strategy use [19], all answers to the same questions were grouped together to discern patterns. Next, a bottom-up approach [49] was used to identify themes and condensed meanings. Special attention was paid to contextual analysis with the purpose of identifying group-based strategy use in the given context. In this process, five categories of strategy use were identified: goal setting and planning, task division, source of information, monitoring and controlling of the learning process, and reflecting together. Rating criteria were established to distinguish the strategy use in three levels: high, medium, and low. All focus group data was coded and rated by the first author following the scheme

Table 1. Overview of the Participants

Class number	Name of course	Number of class participants	Number of project teams	Number of focus group participants
1	Design of RC Structures	32	6	30 (93%)
2	Design of RC Members	24	4	23 (96%)
3	Selected topics in Construction Engineering	35	7	34 (97%)
Total: Total	3	91	17	87 (96%)

Table 2. Overview rating results for collaboration and strategy use

Class	Group	Collaboration			Strategy use (focus groups)					Strategy use (observation)				
		1	**2**	**3**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
1	1	x			1	1	1	1	1	1	1	1	1	1
	2		x		2	2	1	2	1	2	2	1	2	1
	3	x			2	1	2	2	1	2	2	2	3	2
	4		x		2	2	2	2	2	3	3	2	3	3
	5		x		3	3	2	2	2	3	3	2	2	3
	6		x		2	2	2	2	2	2	2	1	2	1
2	7			x	3	3	3	3	3	3	3	3	3	3
	8		x		3	3	2	2	2	3	3	2	3	2
	9	x			3	2	2	2	2	2	2	2	2	2
	10	x			2	2	2	2	2	1	1	1	2	2
3	11	x			2	2	2	2	2	2	2	1	2	2
	12		x		2	2	3	2	1	2	2	3	2	1
	13			x	3	3	3	3	2	3	3	3	3	2
	14			x	3	3	3	3	2	3	3	3	3	3
	15		x		2	2	2	2	2	2	2	1	2	2
	16		x		3	3	3	3	3	3	3	2	3	3
	17		x		2	2	2	2	1	2	2	1	2	1

(see Tables 2 and 3). The same rating criteria was used for the two course instructors to rate the observation data. The authors discussed the rating criteria in detail to reach a common understanding of how to relate it to several rounds of reading transcripts and observation notes. Then, rating of two types of data was conducted separately for a few rounds. Intra-reliability was calculated comparing results of different rounds of analysis respectively. Afterwards, initial results of both data sources were compared and discussed before a few more rounds of careful consideration of the ratings established final results. A similar approach was also utilized for students' responses to and observation of classroom practice on forms of collaboration and teamwork. The results of Intra-rater Correlation Coefficient (ICC) of focus group data were: strategy use 0.97 in total (0.92, 0.86, 0.87, 0.89, 0.92 for the five categories respectively), and collaboration 0.79. ICC results of observation data were: 0.98 in total (0.94, 0.77, 0.83, 0.92, 1.00 for the five categories respectively), and collaboration 0.66.

A non-parametric correlation test (Spearman's rank-order correlation) was conducted, due to its suitability for small sample data, in order to explore the relation between strategy use and forms of collaboration. The overall project performance was measured utilizing an alternative assessment wherein 70% of grades were based on teamwork. The sum of students' grades from two assignments and one final project report was computed as an indicator for students' group-based project performance. The grading rubrics emphasized overall goals of the course and aligned with the PBL method. Students were provided with the rubrics at the beginning of the courses and encouraged to use them to guide their project work. The two sources of data were also compared to their group-based grades, which were coded as A = 4, B+ = 3.5, B = 3.00, C+ = 2.5, and C = 2.00 as per the grading policy of Qatar University. The results are illustrated in the Findings section.

4. Findings

4.1 Conceptions of Collaboration

A coding scheme of conceptions of collaboration was developed from the focus group data using an inductive approach. Three major aspects were identified in students' report of their teamwork: division of work, with a leader or not, and with a common goal or not. Three major patterns were identified regarding how each team worked together: (1) no leader, no common goals, individual task division, and putting individual work together as a teamwork outcome; (2) leader initiation and with clear division of work by sub-team or pair; (3) collective delegation for achieving a common goal, no obvious leader. Final results of focus group and observation data reported a high level of similarity on collaboration, and after discussion, we reached an agreement on the forms of collaboration in each team. Follow-

Table 3. Examples of strategy use by levels

Rating	Lower-level strategy use (level 1)	Medium-level strategy use (level 2)	Higher-level strategy use (level 3)
Goal-setting and planning	No goal "We did not really talk about the goal, maybe just to get the project finished at the end, we hope." (G1)	". . .We had some goals at the beginning, but we realized that the situation is so different now. . ." (G3)	". . .We used the course objectives and the rubrics provided by the instructor to guide our learning, and we targeted A as the goal of the project" (G7)
	"We don't need plans because we follow our own speed and the meetings can be by needs." (G10)	"We live so far away from each other and everyone is busy so not always we can all come to the same meeting, so sometimes the plan can be delayed. . ." (G11)	". . .We firstly use the milestones suggested by the instructor to make a plan, then we made weekly and bi-weekly plan for our own group. We meet twice a week to check the status. . ." (G14)
Task division in team	"We divide all tasks and then put them together. Each one has to do something." (G1)	"Our leader divided the tasks to each of us and set up a time for us to submit" (G9)	"This is a big project so we need to sit together a lot to go through the procedures to ensure we all agree and learn. . ..we also divide the tasks but mostly working together and ensure we follow each other's results and keep the same pace. . ." (G8)
	"We divide the tasks among the six of us, each responsible for one aspect. So I only understand the aspect I work on and they only understand the aspects they work on." (G10)	"We divide tasks but not in a strict way, maybe more spontaneously; we agree on who does what depending on the situation, then we update each other." (G15)	"Our project report is supposed to look like done by one person, so we sometimes do the tasks together in front of one computer, and sometimes divide the tasks but afterwards we take turn to go through each one's task so we learn each task." (G16)
Source of authority	"We follow the instructors' slides on Blackboard." (G2)	"Sometimes we search for information ourselves, but it is most safe to ask the instructor to know what the correct way is. . ." (G4)	"We search information from internet, from materials provided on the Blackboard, we ask other professors, sometimes we ask engineering companies. . ..and we can always go to our instructor to discuss; his feedbacks are very valuable." (G12)
	"It is so hard for us to find any information on the project, it is better to take a lecture and receive correct information." (G1)	"It is the first time we do such a big project; we are not sure whether we do is correct or not, so we need the instructor to confirm us this is ok." (G17)	"We gather all the information and discuss them through to see what the best solution is to move on, then we sometimes confirm this from our instructor." (G7)
Monitoring and controlling learning process	"We did not agree on the calculation part, but we had no time and we had to submit." (G1)	"We think our project under control . . .there are always challenges but we will make it." (G11)	"We experienced some challenges due to a software. . .we have to learn how to use the new software which delayed our design plan a couple days but we worked harder to catch it up, like instead of three hours per day we added to five then we managed." (G13)
		"We mainly follow the project description provided by the instructor. . ." (G15)	"We firstly expected to just pass, but now we are so motivated and we adjusted our goals and plans so we can aim for A or B. This also means lots of efforts but it is worth because we have learned so much in the process." (G16)
Reflecting together	"We don't need to reflect as long as we easily agree on how to move on." (G17)	"We talked sometimes if needed, if there is something that needs to be fixed we will do it." (G8)	"We try to ensure that our project stays in good condition towards our goal." (G7)
	"We don't really know . . . our problem is none of us know the correct answer . . . just hope we can pass." (G12)	"We talked among groups sometimes to see the status of each other, sometimes we can see oh that is the point we have missed or we may also learn from there. . ." (G13)	"We talk a lot about the project together, what's the problem, how can we improve it? What recommendation each of us can provide?" (G16)

ing the three forms of collaboration identified, an overview of rating results for the 17 groups is presented in Table 2.

As Table 2 shows, five out of the 17 groups were found to have a relatively poor collaboration form; they lacked agreement on a shared goal, a leader, and a sense of shared work, instead putting together tasks performed individually as the teamwork outcome. As discussed in one group:

> "In our group we go by needs. We divided the tasks to each of us. If there is a need for meeting or discussion, someone may raise his hand in our WhatsApp group,

> then we find out what to do, do we need a meeting or not. . ." (G9)

Nine groups were identified to be in category two, which had a relatively agreed-upon goal and selected a leader who had the major task of dividing tasks for pairs or small groups and coordinating meetings to communicate and update the progress of the divided tasks. One illustrative excerpt states:

> "We have a group leader. His job is to divide the tasks and ensure all individuals finish the tasks and collect them . . . if needed he would call for a meeting and in case someone is delayed he would remind them . . ." (G6)

Three groups were found to be in category 3. Well-functioning, although without clearly appointed group leaders, they demonstrated collective delegation and engagement to reach their well-defined common goals in terms of project outcomes and achievements. As one group stated:

> "We had a clear goal about our project in terms of what we wanted to learn through the course and our targeted outcome. We don't need a leader in this group because each of us is leading. We are learning from each other's part of the project." (G13)

4.2 Group Based SRL Strategy Use

Inspired by the four-phase model of SRL strategy use by Pintrich [19], we analyzed strategies students reported during the focus groups in an integrated deductive and inductive approach. Focus group and observation data agreed on five categories of group-based strategy use: (1) goal-setting and planning; (2) task division in team; (3) source of authority; (4) monitoring and controlling the learning process; and (5) reflecting together. To obtain a better understanding of students' learning experiences, we also distinguished three levels of their strategy use in a team setting. High-level learning strategies (level 3) include: (1) clear goal setting and formulating and following systematic plans; (2) ensuring teamwork on a common project and that division of work is based on learning from each other and learning together; (3) using superior and peer authority, generating knowledge together through integrating diverse sources of information; (4) making predictions, then monitoring and justifying the plans and strategies in a situation of unexpected issues and emergencies; (5) regularly and frequently reflecting together, self-evaluating, and discussing how to improve from the experiences. We also identified medium-level strategy use (level 2), which is illustrated by: (1) setting up goals and plans but not clarifying or following them; (2) dividing the task for the sake of finishing the work; (3) using only superior authority and mainly relying on instructors as an information source; (4) not swiftly adjusting project proceedings in a situation of emergency, resulting in delays; (5) rarely reflecting on and discussing the team situation. Low-level strategy (level 1) users reported little use of these techniques. An overview of the results of rating the 17 groups is presented in Table 2. Table 3 presents a coding scheme with examples of focus group excerpts illustrating the different levels under each of the identified categories.

4.3 Correlation Among the Aspects

Spearman's rank order correlation test was conducted with the following results. First, the results indicate a significant correlation between collaboration and group grades (r = 0.675 from focus group data, r = 0.675 from observation data). Second, correlation results between strategy use with collaboration and grades are presented in Table 5 with comparison with both data sources. The results show that strategy use is significantly correlated (α = 0.05) with collaboration in four out of the five categories by both data sources, excepting category five – reflection (r = 0.355 from focus group data, r = 0.328 from observation data). Nevertheless, a correlation is identified between the total number of the five categories for both data sources and collaboration (r = 0.608 from focus group data, r = 0.650 observation data). Finally, the results also identified a statistically significant correlation between strategy use and student performance by group-based grades in four of the five categories, excepting focus group

Table 4. Correlation results between strategy use with collaboration and grades

Strategy use	Collaboration		Grade	
Five categories	**Focus group data**	**Observation data**	**Focus group data**	**Observation data**
1	0.531	0.735	0.636	0.763
2	0.739	0.735	0.586	0.763
3	0.622	0.580	0.792	0.906
4	0.727	0.531	0.734	0.739
5	0.355	0.328	0.433	0.640
Total	0.608	0.650	0.689	0.900

Table 5. Students' perception of assessment method for PBL

		Preferred grading method for the team project		
	Focus group participants	Individual grade	A combination of group and individual grades	Group grade
Class 1	30 (93%)	6 (20%)	6 (20%)	18 (60%)
Class 2	23 (96%)	0	10 (43.5%)	13 (56.5%)
Class 3	34 (97%)	4 (11.4%)	18 (51.4%)	12 (35.2%)
Total	87 (95%)	10 (11.4%)	34 (38.6%)	43 (49.4%)

data for category five – reflection (r = 0.433). However, a correlation is identified between the total number of the five categories for both data sources and student performance (r = 0.689 from focus group data, r = 0.900 observation data).

4.4 Triangulation of Two Sources of Data

Results of Spearman's rank order correlation test show that there were no significant differences identified between two sources of data – focus group and observation – regarding strategy use in four (1, 2, 4, 5) out of the five categories. A significant difference was identified only in category 3 – sources of authority with $t = 2.954$, $df = 16$, $p = 0.009$. Nevertheless, no significant difference was identified between the two sources comparing a total number of the five categories.

4.5 Students' Perceptions of Assessment of PBL

During the focus groups, participants were asked their individual opinions on the alternative assessment methods and what types of assessment they believed to be appropriate for the PBL course. Three major opinions were observed from their responses, including individual grades, a combination of group and individual grades, and group grades as the outcome of their team projects. An overview is illustrated in Table 5.

5. Discussion

This study investigated the nature of conception of collaboration, group-based strategy use, and perception of assessment in students' first experiences of PBL, as well as the interactions among these aspects and with students' performance. Empirical evidence was provided based on group interviews and observations of 91 civil engineering students' in Qatar working in 17 project teams. Results of the study are discussed in the following.

5.1 Students' Conceptions of Collaboration

The study provided insight into students' conceptions of collaboration in a context of engineering education in Qatar. Findings are generally consistent with the patterns identified by previous studies with empirical work in Western contexts in that collaboration requires coordination, synchrony of goal-oriented activities, active participation, negotiation of meanings, coping with disagreement, and co-construction of knowledge [1, 33]. The study also supports findings from non-Western contexts in that the group leader [11] and task-division [34] play important roles in developing collaboration in project teams. Three forms of collaboration identified in this study indicate a hierarchical order of how well-functioning a project team can be, which may provide additional perspectives and evidence to the ongoing inconclusive discussion on team effectiveness in engineering education [1]. A previous study [9] reported how engineering students improved their recognition and appreciation of knowledge building by working in a collaborative team to complete a project. Nevertheless, the current study found a gap between the perception and practice, as only three out of the 17 groups were found to have a high level of developing collaboration, while five project teams were found to be at the low level. Although nine groups selected leaders, the role of leadership was mainly to divide tasks, a role more resembling the "servant leader" concept rather than the updated concept of an engineering leader, the latter of which includes three dimensions of technical expertise – mentorship, process optimization and team catalyzation, and innovation with realization, as suggested by Rottmann, Sacks, and Reeve [51, p. 363]. This indicates that more educational activities are needed to facilitate engineering students in developing management and collaborative skills in order to improve team effectiveness [52]. For example, student engagement in teamwork may be improved through activities supporting team formation and teambuilding [53], reflection [54], gaming [55], and alternative assessments [56, 57].

5.2 Group-Based Strategy Use

SRL strategies identified from the qualitative data of the study suggested five categories, the majority of which were generally in line with Pintrich's model of strategy development [19]; students were found to be most engaged with goal-setting, planning, monitoring, and controlling. This may be related to the characteristics of PBL demanding students develop management skills involving such strategies [2, 6, 7, 9]. Using rubrics also serves as a guide for student learning processes by providing clear goals and a monitoring guideline [45, 46]. In addition, the study outcome also extended the model by identifying more characteristics of a group setting; for example, task division was found to be a well-used strategy by engineering students in the current study. This strategy is also in line with the characteristics of group work styles preferred by students in a Middle Eastern context [34]. Another identified pattern that did not appear in previous studies [11] was the source of authority, as although peer authority is an important value for successful teamwork, students in the current study mainly relied on instructors as the authority of knowledge. This may be due to their feelings of insecurity given that this was their first PBL encounter [6, 9]. Although reflection has been identified as a group-based strategy, only three groups were found in focus group data and four groups in observation data to use it at a high level, while the majority of the groups were found to reflect at a rather low level. This result is in line with previous studies finding that reflection is a practice to which engineering students are not accustomed [54], particularly when they are from lecture-prevailing learning environments [9], and that it takes time to develop skills for meaningful reflection [15].

5.3 Students' Perceptions of Alternative Assessment

This study also explored students' perception of alternative assessment. While the instructors made efforts to design alternative assessment methods and rubrics in alignment with the course objectives and PBL method, students reported a wide range of opinions regarding whether assessment should be individual, mixed, or group based. This indicates it is a challenging task to help students develop a deep understanding of constructive alignment [42] and use of assessment as a way to enhance learning, especially for those who are used to multiple-choice-based and memorization-focused assessment forms [41]; this remains a challenge for initial implementation of PBL [6, 9, 53]. It also suggests that more educational practice and research are needed to further explore and validate effective assessment methods in a PBL environment [58].

5.4 Correlation between Collaboration, Group-Based Strategy Use, and Team Performance

Previous studies found a correlation between strategy use and performance for individual learners [15, 19], and earlier studies have suggested an association between students' teamwork efficiency and performance [1, 5, p. 3]. The current study has extended the literature with evidence suggesting a correlation between group-based strategies, conceptions of collaboration, and group-based performance in a PBL environment. This result has important implications for future PBL design, implementation, and research. However, there are more considerations that can be factored into future instructional design and PBL implementation, including the use of collaborative strategy in alignment with social constructivism and a collaborative learning approach to co-construction of knowledge [11].

This study is explorative, and therefore results of the study shall be further reviewed. First, although the study provides insights into the PBL beginners' experiences concerning collaborative strategy use with identified patterns in its unique context, the results of the study remain impermanent because learners may change their strategies and perceptions when they gain more experience in PBL environments and when there is a change in learning context, such as a different course. Therefore, further longitudinal studies to observe students' growth and development would be meaningful, and a broader scope of learning settings (e.g., more courses or other types of contexts) may further validate the results. Second, the current study mainly examined group strategy and group grades, whereas future studies may examine the comparison between group results and individual strategy and performance in a collaborative learning setting in order to gain more insights into teamwork assessment. Third, the study heavily relied on qualitative data from two sources, which are regarded as highly insightful data generation tools for exploring student learning [59]. Although quantifying qualitative data was used as a potentially rich data source together with qualitative data to constitute a mixed methods research design [16], and the authors have tried to adopt a severe attitude involving collaborative analysis, consistency checks, and triangulation, there may remain potential bias. Additionally, while the current study has reported a high agreement between two sources of data and a high intra-reliability of analysis of strategy use, suggesting that this evidence is valid, the result of intra-reliability of collaboration from both sources, observation data in particular, remains moderate (0.66). Although final results of both data sources reported a high level of similarity on collaboration, and we reached an agreement on the final rating of each project team after discussion, the results of the study in this aspect remain provisional. This also suggests that conceptions of collaboration may be a difficult topic in which to quantify qualitative data. Additional study may further validate results of the current study through other sources of data such as students' self-reported questionnaire surveys and written reflections. Using other qualitative data analysis tools such as Nvivo or WebQDA software may also provide interesting angles from which to analyze the qualitative data. Furthermore, although the total number of participants in this study was 91, only 17 groups were counted for data analysis, which represents a small sample size. While our analysis did report significant results, future studies may include analysis of a larger number of participant groups. Lastly, it may be worthwhile for future studies to explore other social contexts of regulation such as scaffolding, cognitive apprenticeship, or tutoring.

6. Conclusion

This study has investigated the natures of the conception of collaboration, group-based strategy use, and the perception of assessment, as well as interactions among these aspects, by studying group performance in engineering students' first experiences of a problem and project-based learning (PBL) method in a Middle Eastern context. Empirical evidence was generated based on observations and focus groups of 91 engineering students in Qatar who worked in 17 project teams. Qualitative analysis results identified three patterns of conceptions of collaboration and five categories of group-based strategies in a hierarchical order. Findings of the study extended the current understanding of self-regulated learning by providing evidence from groups in a PBL and collaborative learning setting in engineering education. Adding to the current literature, the study highlighted characteristics of Middle Eastern students regarding their favoring division of tasks and relying on their superiors as major sources of knowledge authority. Quantitative analysis identified a significant relation among conceptions of collaboration, group-based strategy use, and team performance. However, results of students' perceptions of assessment remained diverse, suggesting it may take longer than expected for students to gain a deep understanding of constructively aligned alternative assessment in PBL. Outcomes offer several implications for instructional design in general and PBL implementation in particular. Having identified the situative and contextual nature of students' conceptions and forms of collaboration and strategy use in PBL engineering courses, the study contributes to the current research by characterizing patterns of strategy use and collaboration in a collaborative learning setting. The study also sheds light on current knowledge of student learning in a Middle Eastern context, particularly in engineering education. The results underscore the important role of self-regulated learning in a collaborative form and learning setting, and also offer implications for future PBL implementation and research aiming at improving student learning strategy and collaboration not only in engineering programs, but also in the broader scope of higher education.

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